Borrowing capacity and house prices

DNB Analysis

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EUROSYSTEEM

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With thanks to DNB colleagues and in particular Robert-Paul Berben, Bouke Bergsma, Paolo Bonomolo, Peter van Els, Thijs Hinskens, Íde Kearney, Tjerk Kroes, Olaf Sleijpen, Sophie Steins Bisschop and Edi Vording for their comments. Thanks are also due to René Bierdrager for his statistical support. Any errors that remain are our sole responsibility.

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Summary and conclusion

What is driving house prices?

The autumn of 2022 marks a tipping point for the housing market. House prices almost doubled between the previous low point in June 2013 and June 2022, driven mainly by interest rate and income trends (see Chapter 1). Mortgage interest rates fell by about 2 percentage points from 3.7% to 1.7%[1] during that period, partly due to long-term trends such as ageing and globalisation, but also due to the ECB's interest rate policy. Dutch people's average nominal income increased by more than 30% over the same period. More income means households can spend more money on a home and lower interest rates increase the amount they can borrow. In other words, their borrowing capacity increased. As the housing supply in the Netherlands is largely unresponsive to changes in demand over the short and long term[2], greater borrowing capacity leads to higher house prices. The almost constant rising trend in house prices over the past decade came to an end last August. According to Statistics Netherlands, house prices fell by 4.5% between August last year and February 2023.

Although the higher interest rates are pushing house prices lower, the impact is attenuated by the tight labour market. The labour market remains robust, with unemployment at a historic low of 3.5%. Due to this tight labour market and high inflation, nominal income growth is expected to be high in 2023. According to the latest projections by CPB Netherlands Bureau for Economic Policy Analysis,[3] wages will rise by around 5% in both 2023 and 2024. People are also less likely to lose their jobs and be unemployed for long periods than during the financial crisis, so payment arrears or fire sales are less likely. Whereas the rise in mortgage rates causes a decrease in borrowing capacity, the rise in wages causes an increase in borrowing capacity. The initial decline in borrowing capacity is thus cushioned by the rise in incomes.

In this analysis, we model the relationship between borrowing capacity and house prices. Chapter 2 shows that borrowing capacity is indeed the main driver of house prices. Other factors, such as new housing supply, do not appear significant in the model. A one-off 3.5% increase in borrowing capacity in our model leads to a 3.9% rise in house prices after around 20 quarters. This indicates a borrowing capacity elasticity of close to unity. We use various scenarios for interest rate and income trends to show the impact on house prices. In the scenario of rising interest rates that we broadly saw in 2022 (2.5 percentage points) and the forecasted annual income growth of around 5% in 2023 and 2024, house prices would fall by around 3% in the short term compared to the fourth quarter of 2021, just before interest rates started rising. In the longer term, higher incomes drive up prices.

What is the impact of the recent price fall?

For most homeowners, the fall in prices has not so far led to major financial risks, but some households may face substantially higher interest charges. Due to the sharp rise in house prices in recent years and stricter mortgage repayment requirements, the number of houses at risk of negative equity[4] is much lower than in the aftermath of the financial crisis. In a scenario of house prices falling by 20% from the peak in 2022, 8% of mortgaged owner-occupied homes would have negative equity. These would include particularly homes purchased in the recent past. At the trough of the Dutch housing market in 2013, when prices had fallen by around 20% overall, this was the case for almost 30% of mortgage holders. The 8% still comprises around

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[1] This is the average mortgage interest rate across all maturities on new contracts at the time of recognition on the lender's balance sheet and rose by 1.7pp from 2021Q4 to 2022Q4. This statistic lags behind the mortgage rates currently available in the market, which are around 2.5pp higher than at the start of 2022.

[2] Caldera & Johansson (2013). The price responsiveness of housing supply in OECD countries. Journal of Housing Economics, 22(3), 231-249.

[3] CPB Projections CEP 2023, March 2023.

[4] Negative equity is where mortgage debt exceeds the value of the home.

300,000 households, however.[5] Households may also face potentially steep rises in monthly costs, for instance due to the expiry of their mortgage or fixed-interest period. 75% of mortgages have interest rates on the outstanding mortgage debt that are fixed for more than five years. If the mortgage rates of the remaining 25% rise by 3 percentage points in the coming years, the proportion of households spending more than a quarter of their disposable income on monthly mortgage payments will rise from 12% to 26%.[6] This stress test does not take into account any changes in income. A potentially greater risk lies in the combination of negative equity and rollover risk or the expiry of the fixed-interest period.[7] However, this combined risk is now lower than average because recent buyers at risk of negative equity have often fixed their mortgage rate for a long period or will not have to refinance it until a time in the distant future.

Housing market accessibility remains poor, but affordability is set to improve slightly in the period ahead. Although house prices have fallen since the second half of 2022 and will probably continue to do so for some time, it is still difficult for first-time buyers to find an affordable home. In 2022, a household with an income of €67,500[8] could borrow a maximum of €312,000 at an interest rate of 4%. The average selling price in the fourth quarter of 2022 was €415,000 (Statistics Netherlands). Research by Calcasa shows that at the end of 2022 the average first-time buyer could only finance 3.4% of owner-occupied homes.[9] In 2022, borrowing capacity decreased due to rising interest rates, while the expected income growth due to high inflation and the tight labour market had not yet materialised, causing affordability to deteriorate. If prices fall further and incomes rise, affordability may improve. The expected income growth and the delayed fall in house prices will eventually cause affordability to improve compared to the end of 2021, before interest rates started rising. According to the model, affordability in 2024 could be around 6% better than at the end of 2021.

Policy recommendations

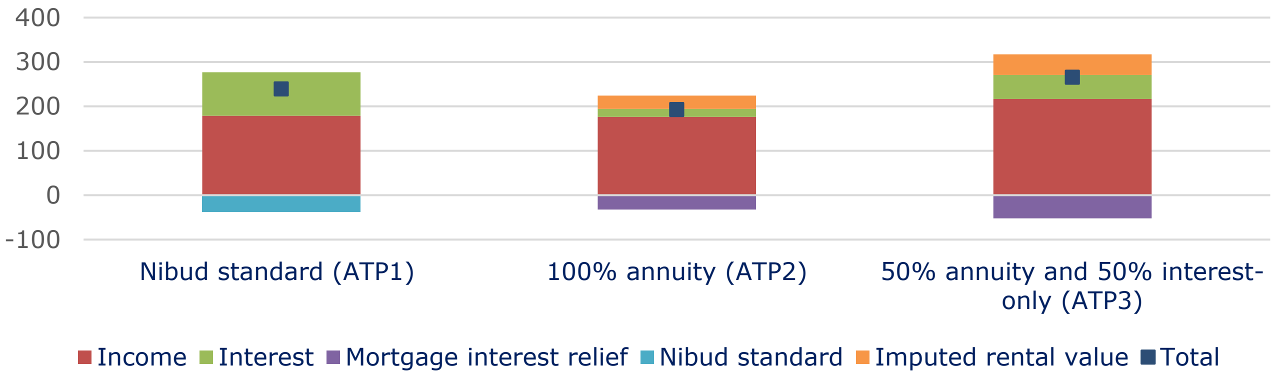
Structural reforms remain necessary to improve accessibility; additional borrowing capacity for first-time buyers would be counterproductive. As the housing market cools, there may be a desire to give first-time buyers a tax inventive to boost demand. However, this analysis shows that looser lending standards ultimately translate one-on-one into higher prices. Demand may be buoyed by looser lending standards in the short term, but in the longer term a fiscal stimulus will drive house prices higher and worsen accessibility. It therefore remains important to avoid policies that push prices higher, such as looser lending standards or subsidies for home purchases. Looser lending standards could increase households' vulnerabilities due to higher borrowing costs and risks of payment difficulties, potentially amplifying cyclical movements and posing additional risks for financial institutions. We therefore continue to stress the importance of buffers in the financial sector, including for mortgage loans.[10] A lasting improvement in accessibility to the housing market requires structural measures, such as sufficient housing production. Although housing production does not affect house prices in the models, it does make a structural contribution to improved accessibility. The government could take various measures to counter declining construction activity, such as offering financial incentives to municipalities and property developers to develop land holdings. More equal tax treatment of renting and buying would also structurally improve the housing market[11].

[5] In 2021, there were 3.79 million households with a mortgage.
[6] Seethe Autumn 2022 Financial Stability Report.
[7] Rollover risk is the risk associated with the refinancing of debt. If interest rates have risen in the meantime, households will have to refinance their mortgage at a higher rate
[8] Average gross household income of homebuyers aged 30-35 in 2020 adjusted for wage growth in 2021 and 2022.
[9] Calcasa 2023. Only 3% of owner-occupied homes in the Netherlands are within reach of first-time buyers.
[10] In 2022, for example, we extended the measures that set a floor for the risk weighting that banks can use to determine the capital they must hold as a buffer against mortgage loans.
[11] See DNBulletin Four key elements for achieving a more balanced housing market, 15 April 2021.

1. What determines households' borrowing capacity?

There are various ways to measure households' borrowing capacity. In this analysis, we examine the relationship between borrowing capacity and house price developments. We define borrowing capacity as the amount of money a household can spend on buying a home, assuming a loan-to-value (LTV) ratio of 100%, which is the current maximum under the temporary rules on mortgage lending (*Tijdelijke Regeling Hypothecair Krediet*). The assumption is that households will not fund any of the house purchase themselves, so the model reasonably reflects the position of a first-time buyer.[12] We use three different methods to calculate the borrowing capacity (ability to pay, ATP). The first, ATP1, is based on the maximum mortgage loan a household with an average gross income can obtain given the level of mortgage interest rates, according to Nibud standards. The other two methods are not based on Nibud standards, but assume that households will spend a fixed portion of their net income on housing costs[13]. ATP2 assumes a 100% annuity mortgage, while ATP3 assumes a 50% annuity and 50% interest-only mortgage. The model assumes that before 2014 owners received mortgage interest relief at the highest marginal rate.[14] From 2014, we use the maximum permitted rate (40% in 2022).

Figure 1: Breakdown of increase in borrowing capacity (1995-2022)



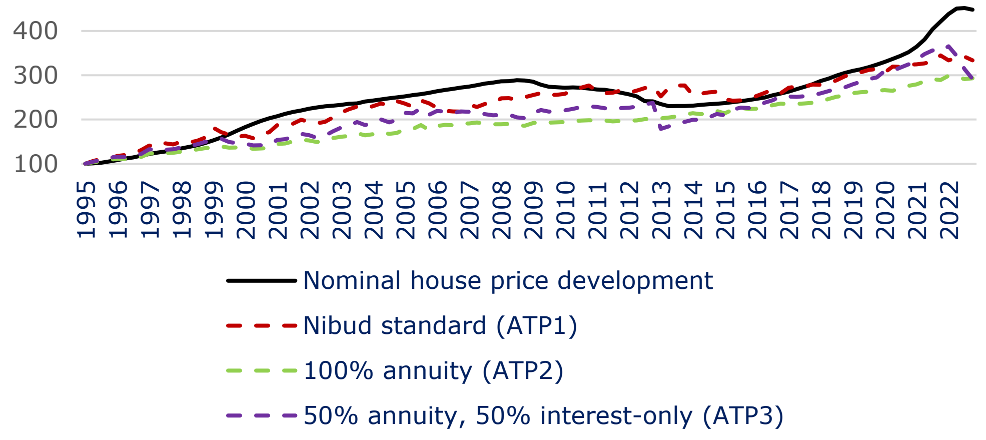
Source: DNB calculations. Y-axis shows cumulative percentage growth over 1995-2022. As a result, it only includes changes since 1995. For example, as the mortgage rate already existed in 1995 and has only been tightened, it contributes negatively to the development of borrowing capacity.

Developments in borrowing capacity are determined mainly by interest rates and income developments. Between 1995 and 2022, households' borrowing capacity increased substantially (ATP1 by 239%, ATP2 by 192% and ATP3 by 265%). Figure 1 shows the factors behind this increase. In the case of ATP1, income and interest made strong positive contributions to the growth of borrowing capacity.[15] The Nibud standard had a negative effect on the development of borrowing capacity. This is not due to adjustments to the Nibud standards over time, but to the operation of mortgage interest relief. This is because when mortgage interest decreases, mortgage interest relief also decreases. This reduces the proportion of gross income that can be spent on mortgage payments, partly negating the large positive contribution of the decrease in interest rates. The same

[12] In practice this is not the case and the average LTV of a first-time buyer (buyers under the age of 36) was around 85% in 2021.
[13] Because we assume an index over time, the actual percentage spent on housing is not relevant for the calculations. Nonetheless, here is an illustration: in 2021, first-time buyers spent an average of 26.4% of their income on housing (Woononderzoek, 2021)
[14] In practice, there are also homeowners in lower income brackets. The ATP2 and ATP3 for 2014 may therefore be slightly overstated.
[15] Note that we use average household income; the income share of the lower-earning partner counted less in the past, so the borrowing capacity was somewhat overstated.

can be seen in the case of ATP2 and ATP3. Here, the effect of the mortgage interest relief is included in the effect of the decrease in interest rates, so the interest rate has much less impact in these two measures than in ATP1. We also see in ATP2 and ATP3 that the tightening of mortgage interest relief has reduced households' borrowing capacity, while the decrease in the imputed rental value has led to an increase in borrowing capacity.

Fig. 2: Borrowing capacity and house prices
Indices, 1995=100



Source: DNB calculations

At first glance, there appears to be a correlation between house prices and borrowing capacity. The development of these three measures of borrowing capacity is shown in Figure 2. This figure shows that the three measures move closely in line with house prices over the long term. We see the fall in house prices from 2008 to 2013 reflected to a lesser extent in the development of borrowing capacity. This may be due to prolonged negative sentiment in the housing market due to the financial crisis. This model does not take account of developments in sentiment.[16] In addition, lending standards were gradually tightened from 2012 by reducing the maximum LTV, first to 106% in 2012 and then to 100% from 2018. Tighter bank lending conditions also played a role, making it harder to get a mortgage. The model takes no account of the tightening of lending conditions and LTV limits.[17]

House prices have grown faster than borrowing capacity since 2020. Mortgage rates rose in 2022, but income growth remained limited. This led to a decrease in households' borrowing capacity, and house prices have grown faster than borrowing capacity since 2020. This can also be seen in Figure 2. The widening gap between the borrowing capacity index and the house price index over the past year indicates that the housing market has become less affordable, since the maximum amount an average household was able to borrow has not kept pace with average house prices.

[16] On the basis of Van Dijk & De Winter (2023) we have tried to include housing market sentiment in the models; the relationship was found to be insignificant in the vector error correction model (VECM).
[17] Before 2012, there was no LTV limit, so we cannot include this trajectory in the models. The implicit assumption is that LTI is the binding constraint, not LTV.

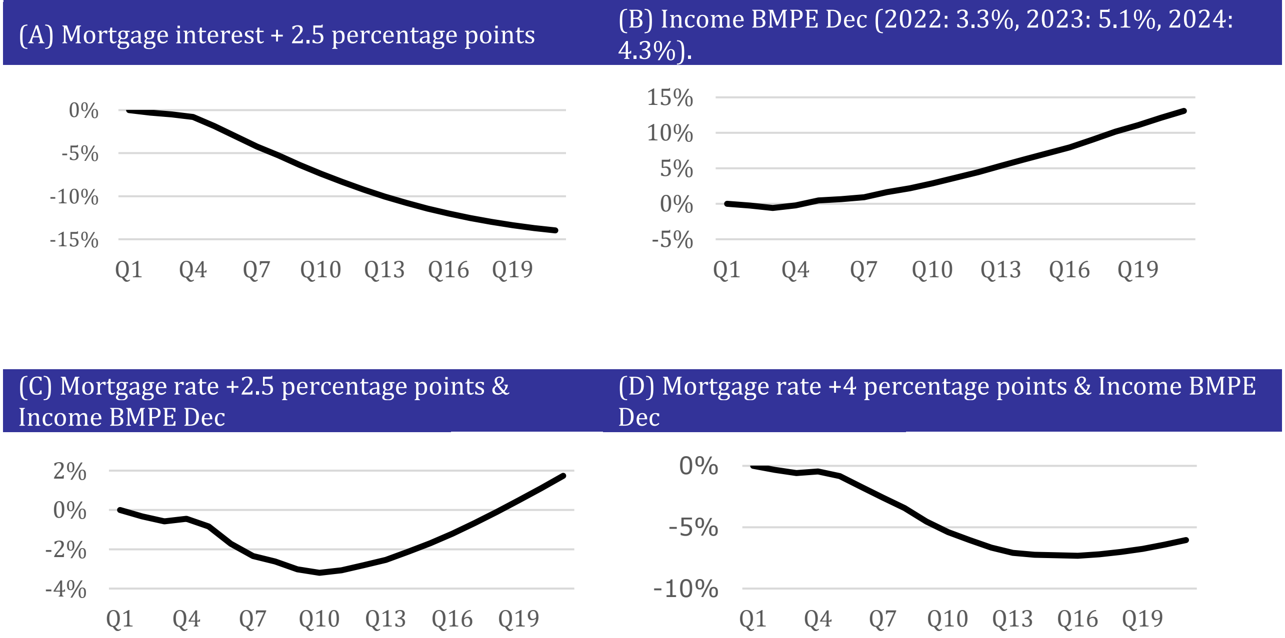
2. The relationship between borrowing capacity and house prices

Our model shows that borrowing capacity is indeed a key driver of house prices, in contrast to housing supply. We use the measures of borrowing capacity referred to in Chapter 2 to show the relationship between borrowing capacity and house prices. We do this by means of a vector error correction model (VECM). This shows that all three measures of borrowing capacity correlate positively with the development of house prices (see explanation in Appendix 1). In this chapter, we highlight the relationship between the first measure of borrowing capacity (ATP1) and house prices[18]. We use ATP1 as an explanatory variable in the model, and also include historical house prices and construction costs in addition to the borrowing capacity. Supply-side variables (such as housing stock and new housing production) have no significant effect in the model and have therefore been omitted.[19] In our model, a one-off rise of 3.5% in the borrowing capacity (one standard deviation) leads to a 3.9% increase in house prices after about 20 quarters. This indicates borrowing capacity elasticity close to unity. It also explains how the combination of falling interest rates and income growth can drive house prices sharply higher, as we have seen in recent years. Furthermore, the relationship between borrowing capacity and house prices is stable over time and the elasticity does not differ significantly from 1 over the long term.[20]

According to our model, an interest rate rise of 2.5 percentage points leads to a house price fall of 14% after five years; if income effects are also taken into account, the fall is considerably smaller, at 3% after three years. We ran through four scenarios with our model. As our starting point we use the first quarter of 2022, which was when mortgage rates started to rise. In scenario (A), we looked at the effect of a 2.5 percentage point rise in mortgage rates with no income growth. This is broadly equivalent to the interest rate rise we saw in 2022 and is consistent with market expectations in the interest rate term structure.[21] According to our model, this rise in interest rates leads to a house price fall of about 14% after five years. The 14% effect falls within the range we find in the literature[22] (5.2 - 8.6% per percentage point; see Table 2 in the technical appendix). In scenario (B), we study the effect of the income development based on our latest projections.[23] In the absence of an interest rate shock, this income growth results in house price growth of 12.7% after five years. In the remaining two scenarios, we combine this income scenario with two interest rate shocks, one of 2.5 percentage points (C), and one of 4 percentage points (D). These scenarios are detailed in Figure 3. In scenario (C), house prices fall by over 3% after two years, but as a result of the income effect nominal house prices return to the previous level after about four years and then continue to rise. In scenario (D)[24], we see a fall of around 7% after three years and prices are still 6% lower after five years.

[18] This method is similar to that of Damen et al. (2016).
[19] This is common in housing market models for the Netherlands, since the Netherlands has a highly inelastic housing supply (see Table 2 in appendix). Demographic factors have also been found not to work well in the model.
[20] The 90% confidence interval of the response rate after 20 quarters ranges from 1.4% to 5.4%. We have used a Bayesian VAR model to test the stability of the relationship, among other things. See the technical appendix for a more detailed explanation.
[21] For the first four quarters, we use the actual development of mortgage interest rates in 2022: 1.70%, 2.04%, 2.62% and 3.35%. We then assume a rise to 4.15% in the fifth quarter. That is 2.5 percentage points higher than the interest rate in 2021Q4 (1.65%).
[22] Based on various studies of the Dutch housing market, this range is around 5.2-8.6% per percentage point. See Table 2 in the technical appendix for an overview of the estimates in the studies consulted.
[23] This is based on gross income growth averaging 3.3% in 2022, 5.1% in 2023 and 4.3% in 2024. For the years after 2024, we assume income growth of 2%. This is based on the development of the series of gross wages and salary per person.
[24] Here we assume an additional 0.5 percentage point shock in quarters 6-8 resulting in a mortgage rate of 5.65% in the eighth quarter.

Fig. 3: Impact on house prices in four borrowing capacity scenarios

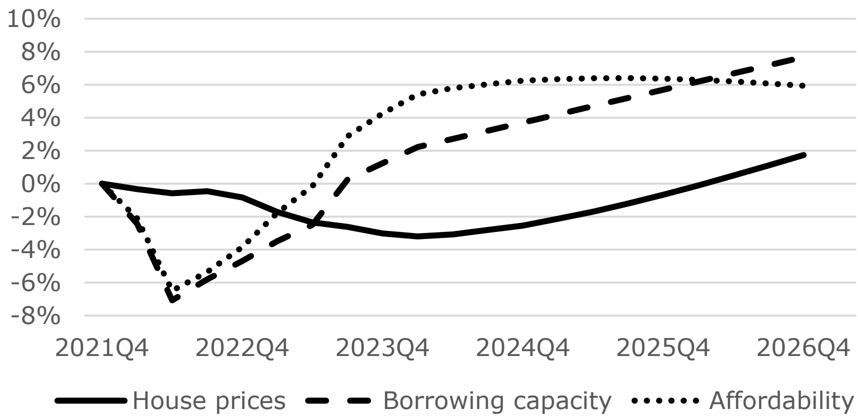


Source: DNB calculations. Y-axis shows the cumulative effect on nominal house prices; X-axis shows the number of quarters since the shock.

3. Developments in accessibility and affordability

Using the results of the model in Chapter 3, we look at the developments in accessibility in the housing market. The strong rises in house prices in recent years have worsened the accessibility of the housing market. Research by Calcasa shows that at the end of 2022 the average first-time buyer could only finance 3.4% of owner-occupied homes. A further 5% fall in house prices would increase the proportion of financeable owner-occupied homes for first-time buyers to 4.6%, according to Calcasa.[25] First-time buyers have borrowed increasing sums relative to their income in order to enter the housing market As an illustration, between the end of 2016 and the end of 2021 the percentage of young households (aged <36) with a debt-to-income ratio above 4.5 (a high ratio) more than doubled from 25% to 58%. The loan-to-value (LTV) ratio in the Netherlands also remains high compared to other European countries. In the case of first-time buyers (defined as households below the age of 36) who bought their homes in mid-2021, the average LTV was over 85% and more than half had an LTV over 90%. High debts make first-time buyers vulnerable to fluctuations in the housing market and pose risks to the financial stability of the Dutch economy.[26]

Fig. 4: Borrowing capacity, house prices and affordability
Development according to scenario (C) from Figure 3



Source: DNB calculations. Y-axis shows cumulative nominal effects.

Developments in borrowing capacity and house prices may diverge in the short term, temporarily improving or worsening affordability. Although house prices move in line with borrowing capacity in the long term, they may diverge in the short term. Figure 4 shows the short-term development of house prices, borrowing capacity and affordability (difference between the development of borrowing capacity and prices) for scenario C (mortgage rate +2.5 percentage points and income development from the December 2022 Broad Macroeconomic Projection Exercise) from Chapter 3. This shows that borrowing capacity decreases almost immediately in

[25] "Starter heeft slechts kans op 3% van de koopwoningen in Nederland" (Only 3% of owner-occupied homes in the Netherlands are within reach of first-time buyers) (Calcasa, 2023).
[26] See for example Economisch perspectief voor een grondige renovatie van de woningmarkt (Economic outlook for a thorough overhaul of the housing market).

response to rising interest rates, while house prices show a delayed reaction. As a result, affordability decreases significantly (dotted line in Figure 4). This is also what we saw in practice in 2022 The expected income growth due to high inflation and a tight labour market did not yet materialise in 2022 and hence did not translate into a rise in borrowing capacity. With house prices failing (so far) to match the fall in borrowing capacity, affordability has decreased. If income develops according to scenario (C), this will lead to an increase in borrowing capacity in the period ahead and hence to an increase in affordability. In this scenario, from mid-2023 (quarter 6), the combination of a house price fall that has materialised by then and the rise in incomes would improve affordability. This is a stylised scenario. Actual developments in the housing market may differ, for instance because of a downturn in market sentiment or policy changes. The model does not take this into account.

Technical appendix

(Vector) error correction models are commonly used for empirical studies in housing prices. These models have a long-run equation, including fundamentals such as income, demographics and the interest rate, and a short-run equation, which captures the deviations from the long-run trend. For a more extensive explanation of (conditions and extensions of) ECMs in the housing market, see e.g. Francke et al. (2009). For a list of studies using (V)ECM models for the Netherlands, see Table 1. In particular, the methodology of De Vries and Boelhouwer (2004) relates very closely to our approach using the 'Ability to Pay'.

We estimate a vector error correction model (VECM) where multiple dependent variables are jointly determined. In our main model, we follow De Wit et al. (2013) and estimate a VECM model using the Johansen approach that can be written in the following reduced form equation:

$$\Delta y_t = \mu + \boldsymbol{\alpha\beta_{t-1}}' + \sum_{i=1}^{p-1} \theta_{\boldsymbol{i}}\, \Delta \mathrm{y}_{\mathrm{t-i}} + \varepsilon_t.$$

Here, $\boldsymbol{y_t}$ is a Kx1 vector containing the K endogenous variables. The matrices $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$ are the loading and cointegration matrix; $\theta_i$is a vector that includes the short-run coefficients on lagged differenced endogenous variables, and *i* denotes the lag length. The elements of the error term vector ε_t are assumed to be i.i.d. and normally distributed. We are able to find a single cointegrating relationship according to the Trace statistic between house prices, ability to pay (ATP1, ATP2 or ATP3) and construction costs. A crucial assumption is that there is no serial correlation in ε_t, otherwise the model will have endogeneity issues. A portmanteau test shows no serial correlation in the residuals if we include four lags of the endogenous variables at 5%. We estimate the model with the Johansen (1992) procedure. According to the trace statistic we are able to find a maximum cointegrating rank of 1. For the full cointegrating relationship, see Table 1. Note that the coefficients are normalised to 1 with respect to the first variable (house prices), so a coefficient of -1.31 indicates a *positive* long-run effect.

Table 1: Cointegrating relations (normalised to 1 with respect to first variable – house prices).

	House prices	ATP	Output price	Constant
House prices	1	1	1	1
ATP	-1.31	-0.65	-0.97	-0.33
Output price	-0.16	-1.92	-4.35	-1.97
Constant	3.64	7.29	19.00	6.14

We use quarterly data ranging from 1980Q1 to 2022Q4. Nominal variables (house prices, ATP, construction costs) are converted to real values using the HICP. In the VECM model, all variables enter in log levels. The variables, sources and corresponding transformations are described in Table 2. For the ability-to-pay calculations, we additionally require income, mortgage interest rates, DSTI requirements, the maximum tax rate to deduct mortgage rate payments, and the imputed rent tax. ATP1 requires gross household income and ATP2 requires net household income. Both are available at an annual level from 1990 to 2020. We use net disposable income of households from DNB to inter- and extrapolate net income to other periods. To interpolate and extrapolate gross household income, we use gross salaries and wages from DNB. We have access to NIBUD tables from 1995-2022; before 1995 we assume the tables are equivalent to those of 1995. Note that this only applies to ATP1. For ATP2 and ATP3, the NIBUD tables are not required. See below for the ATP calculations. Variables for the imputed rent tax and maximum tax rate for the MID are hand collected from historical sources.

For impulse response analysis in both the VECM and the BVAR, we use a Cholesky identification scheme with the ordering ability to pay, construction costs and house prices. Figure 5 shows the response of house prices to a permanent standard deviation shock in the ATP. Note that this assumes that house prices do not contemporaneously influence borrowing capacity or its components such as income. There may still be intertemporal endogenous effects between house prices and borrowing capacity. The literature shows that these endogenous effects may exist.[27] Because we include the ability to pay as a single variable, we potentially lose some endogenous effects that may exist within this variable (e.g. income and interest rates). The advantage is that we end up with a much more parsimonious model specification, which is relevant for tractability.

Fig. 5: Impulse-response ATP->House prices
Shock 1 of Std. dev. in ATP (dotted line)

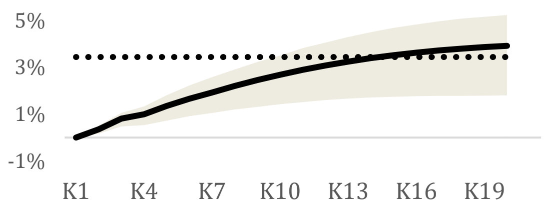


Table 2: Summary of other studies on housing price using Dutch data

Study	De Vries & Boelhouwer (2004)	Verbruggen et al. (2005)	De Wit et al. (2013)	Francke et al. (2009)	Van Dalen & de Vries (2015)
Long-term equation					
Real disposable income		X			X
Real (mortgage) interest rate		X	X	X	X
Net interest expenses	X				
Volume of houses		X			
Real household income				X	
Consumer price index					
Net nominal other financial wealth		X			
Rate of Entry*			X		
Rate of Exit*			X		
Unemployment			X		
Short-term equation					
Real disposable income	x	X		X	X
Real (mortgage) interest rates	x		X	X	
Nominal (mortgage) interest rate		X			X
Consumer price index		X			
Historical house price developments	x		X	X	X
Unemployment			X		
Volume of houses		X			

[27] See e.g. Oikarinen, E. (2009). Interaction between housing prices and household borrowing: The Finnish case.

Seasonality	x				
Error Correction Term	x	X		X	X
Dummy for asymmetric ECT		X			
Rate of Entry*			X		
Rate of Exit**			X		
Frequency	Biannually	Quarterly	Monthly	Yearly	Quarterly
Period	1975-2002	1981-2003	1985-2007	1965-2009	1975-2015
Effect of 1pp increase in mortgage interest rate on house prices	n/a	5.2-5.9%	6.5%***	8.6%	6.5%

** Rate of Entry = #houses for sale/total stock of houses, rate of exit = #houses sold/#houses on the market*
**** Interest rate modelled in logs, shock at average mortgage rate*

Our main results are robust to other specifications**.** The models with the different versions of the borrowing capacity (ATP1, ATP2 and ATP3) show comparable results, but are not shown in this appendix to conserve space. In the main specifications we will use ATP1. However, we are not able to find significant cointegrating relationships with other variables used in the literature, such as financial wealth, transaction volume, demographic variables, supply measures or housing market sentiment.[28] We do find a cointegrating relationship when unemployment is added, but this does not alter the effect of borrowing capacity on house prices.

We have additionally estimated a Bayesian VAR (BVAR) with time-varying parameters. In particular, we are using the specification of the TVP-VAR with stochastic volatility (SV) from Primiceri (2005) with one lag. The time-varying structure and SV features imply that impulse response functions from the model are also time-varying, allowing us to verify whether housing prices respond differently to shocks of variables in different periods. For example, it may be expected that the responses to borrowing capacity are different during times of crisis. However, we are not able to find any time variation in the relationship between borrowing capacity and house prices. Moreover, the elasticity between borrowing capacity and house prices from the BVAR is quantitatively similar to that found in the VECM.

Table 3: Variables used in the models

	Variable	**Long description**	**Transformation**	**Source**	**Currency**	**Sample (Freq)**
1	House prices	Housing price existing dwellings	Log, Real with HICP	Statistics Netherlands/Land Registry	Index 1995=100	1980-2022 (Q)
2	Output price	Output construction price index	Log, Real with HICP	Statistics Netherlands	Index 1995=100	1980-2022 (Q)
3	ATP	Ability–to pay - Maximum borrowing capacity (ATP1)	Log, Real with HICP	DNB calculations	Index 1995=100	1980-2022 (Q)
	Other variables used in calculations:					
	GI	Gross income per household		Statistics Netherlands	EUR	1990-2021 (A)
	NI	Net disposable income per household		Statistics Netherlands	EUR	1990-2021 (A)
	DHI	Disposable household income per household		DNB	EUR	1980-2022 (Q)
	GWS	Gross wages and salaries per person		DNB	EUR	1980-2022 (Q)

[28] We did not examine all variables in the short-run equations.

r	Mortgage interest rate	DNB	%	1980-2022 (Q)
IRT	Imputed rent tax	Hand collected	%	1980-2022 (A)
MID	Maximum tax rate for MID	Hand collected	%	1980-2022 (A)
DSTI	DSTI tables	NIBUD	n/a	1995-2022 (A)
HICP	HICP inflation	DNB	Index 2015=100	1980-2022 (Q)

Calculating the maximum borrowing capacity (ATP1)

The first measure (ATP1) is the maximum borrowing amount according to the DSTI[29], given the level of *gross household income* and interest rates. The implicit assumption here is that households are credit constrained and borrow the full amount for the house (LTV of 100%).

$$Maximum\ borrowing\ amount = \frac{DSTI * GI}{r} * (1 - (1 + r)^{-T})$$

Where

GI = Gross household income

r = mortgage rate

T = maturity of loan

DSTI = Debt service to income, corresponding to level of gross household income and current mortgage interest rate according to the Nibud tables.

Calculating borrowing amount assuming fixed ratio between net housing expenses and net income (ATP2/ATP3)

Additionally, we define two measures (ATP2 and ATP3) that do not assume a DSTI cap. Here, we assume that households always spend a fixed share of *net income* on their mortgage.[30] We calculate how the borrowed amount develops over time, considering changes in income, interest rates and taxes.

ATP2 considers a fully amortising mortgage:

$$Borrowing\ amount = \frac{GME}{r} * (1 - (1 + r)^{-T})$$

Where

$$GME\ =\ Gross\ mortgage\ expenditure = Net\ mortgage\ expenditure\ (NME) + tax\ advantage$$

Where

$$NME = Net\ income * share\ of\ income\ allocated\ to\ housing = NI * HQ$$

$$tax\ advantage = borrowing\ amount * (r * MID - IRT)$$

Where

NI = Net income

HQ = share of net income allocated towards mortgage expenditures

MID = marginal rate at which interest can be deducted

IRT = imputed rent tax rate = marginal tax rate * imputed rent

[29] Debt-service-to-income; these are determined by Nibud.

[30] Because we calculate an index over time, the actual share of housing costs over income that we assume is not relevant for our calculations (i.e. it does not impact the changes).

This yields:

$$Borrowing\ amount = \frac{NI * HQ}{(\frac{r}{1-(1+r)^{-T}} - r * MID + IRT)}$$

ATP3 considers a 50% annuity and 50% interest-only mortgage for a household in the highest tax bracket. We have included this, as (partial) interest-only mortgages have been, and still are, quite common in the Netherlands.
This yields:

$$Borrowing\ amount = \frac{NI * HQ}{\frac{r}{2} * \frac{1+A}{A} - r * MID + IRT}$$

Where
A = Annuity factor = $1-(1+r)^{-T}$