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Abstract

The link between mortgage credit and the housing market is central to the objectives of macroprudential policy. In this *Note* we describe the role that macroprudential policy plays in guarding against the emergence of an unsustainable relationship between credit and house prices, and introduce two models available to the Central Bank of Ireland to assess the likely effects of changes in the calibration of LTI or LTV limits on the aggregate house price to income ratio. Relative to a baseline projection, the recalibration of the mortgage measures for 2023 onward is estimated to increase the aggregate HPI by between 2.8 and 4 per cent over a three year horizon.

1 Introduction

Mortgage and housing markets are central to economic and financial stability. The experience over history, and in particular around the 2008 crisis globally, is that financial crises are more severe, and recoveries slower, when preceded by surges in mortgage lending (Jordá et al., 2016). Stronger lending to non-tradable sectors such as construction and real estate has also been shown to be particularly damaging to financial stability (Muller and Verner, 2021), while economic growth is weaker after housing-led credit booms (Mian et al., 2017). These insights on the "negative externalities" from unsustainable housing-related lending are at the core of the growth of macroprudential regulation in the mortgage market in the last decade.

Macroprudential regulations aim to promote system-wide resilience to shocks and guard against the emergence of an unsustainable relationship between credit markets and asset markets, such as housing. Given that, by their nature, macroprudential mortgage limits are designed to curtail high risk lending, any change in the calibration of these measures is likely to have implications for the volume and distribution of lending in the mortgage market, as well as house prices. For this reason, macroprudential authorities require a detailed understanding of the likely effects of changes in their policies on credit and housing outcomes.

In this *Note* we outline two empirical strategies available at the Central Bank of Ireland that can estimate the effect of a change in mortgage credit availability, modelled as being due to a change in macroprudential mortgage limits, on the economy-wide house price to income ratio. In both cases, the relationship between credit and house prices is nested within a broader model of macro-financial linkages, incorporating the relationship of these factors with unemployment and underlying structural drivers such as demographics and interest rates. Both modelling approaches

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have informed the 2021-22 mortgage measures framework review carried out by the Central Bank of Ireland.

One of the key benefits of macroprudential mortgage measures is the role they play in taming the self-reinforcing loop between mortgage lending and house prices (Aikman et al., 2021). The mortgage measures are estimated to have played an important role in Ireland since 2015 in preventing an unsustainable relationship between credit and house prices, relative to that which would have arisen without such regulation in place.[2] The models both suggest that the targeted recalibration of the measures under the revised framework for the mortgage measures, which involves an LTI increase for First Time Buyers (FTB), and LTV increase for Second and Subsequent Buyers (SSB), and an offsetting reduction in proportionate allowances, may lead – other things equal – to moderate increases in aggregate house prices relative to incomes that persist over the scenario horizon out to 2025.

The effect operates in two steps. Firstly, the policy change is estimated to increase credit *available* to mortgage borrowers by 8 per cent, using a micro-simulation approach. Secondly, this change in lending amounts is estimated to increase the aggregate house price to income ratio (HPI) in policy counterfactual exercises where all other macro-financial inputs are held consistent. The increase in HPI attributable to increased lending, all other things equal, is estimated to be between 2.8 and 4 per cent (for example, a value of 4.9 for the index relative to 4.7 without policy action). Like all modelling results, of course, there is significant uncertainty around these estimates, but they provide one input to inform policymaker judgement.

The Central Bank's revised framework for the mortgage measures outlines the cost-benefit assessment that it has undertaken to evaluate the targeted recalibration of the measures towards a higher LTI for FTBs, in which the modelling exercises outlined in this *Note* have played an important role.

2 Credit and house prices – a global perspective

Mortgage credit will cause house price growth when greater leverage available to borrowers increases the amount of liquidity available in the housing market. When household finances and housing supply are fixed in the short run, an increase in borrowing amounts will result in house price growth that outstrips income growth. Over time, looser lending conditions and strong house prices may have "general equilibrium" effects that increase incomes, wealth and stimulate further housing output, through a shift along the housing supply curve. From a financial stability perspective, the degree to which increased borrowing is due to accurate assessments of an improved economic outlook, as opposed to being speculative in nature, must be distinguished.

At the same time, higher house prices can also cause greater mortgage lending. This arises due to increases in the collateral values of borrowers and lenders, both of whom rely on real estate for a substantial portion of their aggregate balance sheets.[3] When real estate values rise, the net worth of borrowers and lenders rises, which increases their capacity to engage in further mortgage financing. These net worth effects are long-established in economics, and pre-date the GFC, with a prominent example being Bernanke, Gertler and Gilchrist (1999) introducing the concept of the

[2] See for example the Central Bank's *Financial Stability Review*, 2019:II, in which the annual review of the mortgage measures included estimates of the role of the measures in mitigating the risk of unsustainable house price growth.

[3] In Ireland, 62.7 per cent of household net wealth relates to housing, with this number being higher outside of the highest-income households, for whom financial assets are an important source of wealth, according to survey data from the Household Finance and Consumption Survey. For the three banks that will remain serving the Irish domestic market, 40 per cent of total assets related to mortgage lending in 2019, with that number falling since then due to the unprecedented growth in savings which has translated in growth in liquid assets on bank balance sheets.

"financial accelerator" through which endogenous developments in credit markets can amplify economic fluctuations.

These channels can lead to unsustainable dynamics, due to which mortgage credit and house price growth may become self-reinforcing. On top of these collateral effects, expectations formation means that, when agents observe strong house price growth, driven by unsustainable lending, they are likely to expect further growth.[4] Where these dynamics move credit formation beyond levels consistent with true underlying economic potential, financial stability risks are likely to emerge.

Macroprudential policy in the mortgage market operates most directly through the first of the above channels: by restricting the amount of mortgage financing available in the housing market. In doing so, such policies are likely to both improve borrower and lender resilience to adverse shocks, but also to restrict the impact that unsustainable mortgage lending can have in driving house price growth. While having a direct effect on the causal link from credit to house prices, macroprudential policy also acts indirectly to reduce the "accelerator" type effects: by slowing the credit-driven element of house price growth, these policies also act to tame the feedback loop that can arise from strong house price growth back to mortgage lending. The existence of such limits can also tame expectations: as a concrete example, evidence from Central Bank of Ireland surveys of real estate professionals shows that house price growth expectations slowed sharply after the introduction of macroprudential mortgage measures in 2015. Macroprudential policies are more likely to impose economic costs in cases where they curb not only unsustainable borrowing, but also borrowing that may have contributed to improvements in underlying productive capacity in the economy.

The role of mortgage financing in the housing market is the subject of a vast research literature in economics, which has grown enormously since the Global Financial Crisis (GFC). Early contributions such as Kiyotaki and Moore (1997) provide a framework in which both sides of the causal link outlined above are in operation: "*Borrowers' credit limits are affected by the prices of the collateralized assets. And at the same time, these prices are affected by the size of the credit limits. The dynamic interaction between credit limits and asset prices turns out to be a powerful transmission mechanism by which the effects of shocks persist, amplify, and spread out*". A wide range of theoretical contributions since then have been developed to provide insights on the interaction between credit and house prices, with much debate on the relative role of supply and demand factors.

Some papers, such as Favilukis, et al. (2017) argue that changes in credit supply conditions can explain the majority of the movement in house prices in the 2000s. In contrast, papers such as Kaplan, et al. (2020) argue that credit supply conditions explain virtually none of the boom and bust in house prices, once the changes in house price expectations are taken into account. Furthermore, Landvoigt, et al. (2015), Garriga and Hedlund (2018, 2020), Justiniano, et al. (2019), and Liu, et al. (2019) analyse models that imply credit conditions played a key role in the boom and bust, while Kiyotaki, et al. (2011) study a model in which credit conditions played only a limited role. Greenwald and Guren (2021) consolidate these divergent findings by highlighting the role of the segregation of owned and rented parts of the housing market: they show that, if all properties are equally likely to be demanded by either landlords of mortgaged owners, then a credit loosening will allow mortgaged owners to out-bid landlords, increasing the homeownership rate. On the other hand, if

[4] For example, Case et al. (2012) show that homebuyers during the US housing boom were more likely than the general population to expect house prices to continue to grow at the historical trend. Piazzesi and Schneider (2009) show that the group of households who believed that "now is a good time to buy because house prices will get higher" had doubled from 10 to 20 per cent over the course of the boom phase. It follows logically that, when recent mortgage-fuelled house price growth leads to such over-optimistic expectations about future house price growth, both lending and borrowing behaviour are likely to adjust upward, completing the "credit to house price to credit" feedback loop. Bordalo et al. (2018) study the relationship between expectations and credit cycles in a macroeconomic model of investment that relies on a belief formation mechanism. They show that in such a framework, in which agents have "diagnostic expectations", many key features of recent financial cycles can be explained.

owned properties are segregated from rented ones, a credit loosening for mortgaged owners will pass through to rising house prices in the short run as potential owners bid against each other.[5]

Following the housing and mortgage collapse in the USA from 2008 onward, a vigorous empirical debate has taken place on the relative roles of supply (lenders relaxing credit constraints) and demand (borrowers shifting their own attitudes to borrowing) in the US boom and bust. This strand of the literature has benefited from an explosion in the availability of granular data on mortgage borrowers and housing transactions over the last two decades.

The seminal early contribution from Mian and Sufi (2009) emphasised the role of the relaxation of credit standards, with ZIP codes dominated by subprime borrowers being shown to experience the greatest increase in lending, and greatest subsequent increase in defaults. Keys et al. (2010) expand on this view by providing evidence that lax screening was *caused* by the increasing availability of securitization: as it become more feasible for US lenders to move risk off-balance-sheet during the 2000s, their screening became weaker, leading to the proliferation of lending to borrowers who proved ex-post not to be credit-worthy. Such studies would suggest that the technological innovations in financial markets in the early 2000s caused a shock to credit supply, which led lenders to reduce their own standards, causing an unsustainable credit boom.

Complementing this is the role of bank de-regulation, which is used to establish the role that credit supply played in the USA by Favara and Imbs (2015). Using de-regulation in the 1990s and 2000s as a quasi-natural experiment, they estimate that it can explain between one half and two thirds of the increase in mortgage lending, and between one third and one half of the increase in house prices observed in the run-up to the GFC.

On the other side of this debate in the US are papers that use household-level data to show that *across the income distribution* there was substantial and similar growth in mortgage borrowing (Adelino et al., 2016). The authors also show that higher-income households accounted for the majority of the growth in defaults from 2007 onward, suggesting that the subprime lending boom cannot alone explain the difficulties faced in the US mortgage market. Foote et al. (2021) complement both strands of this debate by showing that during the boom, the allocation of mortgage debt and real estate assets across the income distribution remained steady, in line with the "demand side" view that households of all types contributed to the boom-bust cycle in real estate. However, they also explain that this phenomenon required a relatively greater relaxation in credit standards during the boom for lower-income households to maintain borrowing growth at similar rates to higher-income households. Their model suggests a plausible role for both demand and supply side forces in the boom-bust cycle in the USA that led to the GFC.

3 Mortgage credit and housing market – research in Ireland

The experience in Ireland during and after the GFC has meant that the link between the mortgage and housing markets has received much attention by researchers domestically.

Empirically, the extreme relaxation in credit standards to the unsustainable level experienced in Ireland before the GFC is established by McCarthy and McQuinn (2013) and Kelly et al. (2018). In the former paper, average *drawn down* LTV is shown to have risen from 58 to 78 per cent from 2000 to 2008, while the share of income devoted to mortgage payments rose on average from 16 to 25 per cent. In the latter paper, the authors show that the credit volumes *available to borrowers*, i.e. an estimate of the supply side of the market, increased significantly, by analysing the tails of the LTI, LTV and DSR distribution. Available LTI ratios, for example, increased from under 5 to 6.5 between 2003 and 2007. The authors estimate that each 1 per cent increase in this credit availability during the Irish boom led to a 0.15 per cent increase in house prices, and simulate that macroprudential

[5] See Piazzesi and Schneider (2016) for an extensive review on the theoretical literature on housing and macroeconomics.

policy restricting LTV and LTI would have had substantial effects on credit volumes and house prices relative to those observed before 2007 in Ireland.

At the introduction of macroprudential regulation in the mortgage market in 2015, the Central Bank of Ireland used a range of tools to assess the likely impact. One example is Cussen et al. (2015), who used a combination of micro-simulation and a Bayesian VAR similar to that described in section 4.1 of this paper to estimate that the introduction of an 80 LTV would lead to a decrease relative to the baseline of 9 per cent in mortgage lending, with knock-on negative effects for mortgage interest rates, house prices and housing completions.

Irish researchers have also assessed the role of mortgage credit conditions in house price formation at the aggregate level. Using a time series (error correction) framework, Lyons (2018) estimates a sizable effect of credit conditions on the housing market: a 10 percentage point increase in the FTB LTV ratio in Ireland increases house prices by 9 per cent, holding rents constant. Cronin and McQuinn (2016) use a similar approach and estimate that tightening of macroprudential policy, through lowering the aggregate LTV ratio, reduces the house price to rent ratio.

The Central Bank of Ireland's models of the Irish economy contain detailed treatment of the role of banks, LTV and LTI conditions, and the housing market. The links between the mortgage and housing market, as well as their spillover effects to the wider economy, can be captured in these models. For example, in the Central Bank's semi-structural model of the Irish economy, a 5 point reduction in the LTV ratio is shown by McInerney (2020) to lead to a fall in mortgage lending and house prices of 20 per cent and 6-8 per cent, respectively. A decrease of 0.25 in the LTI ratio is shown to have similar but slightly smaller effects, capturing the important role that macroprudential policy can play in taming the house price cycle, as well as in reducing the credit-housing amplification mechanism. There are more modest effects on the rest of the economy in these models. The 5-point LTV reduction, for example, reduces long-run GDP and raises long-run unemployment by 0.25 per cent and 0.15 per cent, respectively.

DSGE models of the Irish economy have also been used to study the importance of macroprudential regulation in the credit and housing cycle. Research by Clancy and Merola (2017) highlights the importance of counter-cyclical macroprudential regulation in attenuating boom-bust cycles, in particular its importance in dampening the kind of unsustainable expectations formation highlighted in Section 2. Lozej et al. (2022) utilise a similar DSGE modelling framework to highlight the importance of the house price cycle as a potential target for macroprudential regulation.

4 Model summary

We now discuss two models available at the Central Bank of Ireland to assess the impact of changes in mortgage lending on the aggregate house price to income ratio (HPI). In both cases, mortgage lending enters as an explanatory variable in a macro-econometric system. For the purposes of policy assessment, that new mortgage lending input can be altered or shocked to mimic the effect of an exogenous change to macroprudential mortgage measures. The two approaches are outlined in turn below.

4.1 Bayesian VAR

The Bayesian Vector Autoregressive (BVAR) model simultaneously estimates a number of selected variables as function of their lagged values. In particular, the reduced-form of the model reads as follows:

$$X_t = c + \sum_{i=1}^{p} \beta_i X_{t-i} + \varepsilon_t$$

where X_t represents a $(NX1)$ vector of N endogenous variables, c is a $(NX1)$ vector of constants, β_i are (NXN) parameter matrices, where $i = 1, \dots, p$ represents the number of lags (we set $p = 4$ in

order to eliminate residual serial correlation). The vector ε_t contains $(NX1)$ uncorrelated and normally-distributed error terms with zero-mean and variance-covariance matrix Σ. The BVAR model in the present work includes six variables: the real mortgage rate, employment, lending supply, supply of housing, real house price, and real income. The estimation of the model is performed via a Bayesian approach that also controls for time-variation of the variance-covariance matrix Σ (heteroscedasticity). The data enter the model at quarterly frequency and cover the period 1984Q1-2022Q1.

4.2 State-Space model

State-space (SS) modelling estimates the trend and cycles of the HPI at the same time using both cyclical indicators and trend drivers in a multivariate state-space model. The estimated trend is not identified as a random walk process, instead, it is explicitly modelled as being driven by long-run fundamental factors (Yao, 2022). This approach makes the estimated trend economically interpretable and therefore increases the usefulness for policy purposes. Cyclical indicators are also introduced into the model, which helps the estimated cyclical component to be consistent with historical experiences of financial cycles. More specifically, under this approach, the HPI trend is explicitly modelled as being driven by slow-moving housing demand, housing supply and estimates of the natural interest rate, while the cyclical component is identified by using variables such as the mortgage growth rate and the unemployment rate, in an unrestricted Vector Autoregression (VAR) model. These modelling specifications are then fit into the state-space and estimated by the maximum likelihood estimator with quarterly time series data from Ireland between 1984 Q1 and 2021 Q4.

The indicator variables used in the multivariate State-Space model are chosen to reflect both slow-moving structural factors and fast-moving cyclical factors. The HPI trend in the model is driven by long-run factors: the number of households in Ireland, which proxies for housing demand. Housing stock is chosen to reflect housing supply. In addition, we also use an estimate of the natural interest rate to summarize changes in financing conditions for the Irish housing market. Those trend drivers are commonly used in the housing literature (see e.g. Muellbauer and Murphy, 1997; Geng, 2018).

For informing cyclical movements in the HPI ratio, we consider a range of time series that capture both business and financial cycles. In particular, we select the unemployment rate as the business cycle indicator and credit growth as the financial cycle indicator.[6]

5 Results from simulations of mortgage lending shocks on HPI

Shocks to credit availability that result from changes in macroprudential policy calibration are mapped into mortgage lending outcomes that are fed into the models to produce forecasts of the aggregate house price to disposable income (HPI) ratio. For example, if the microsimulation exercise indicates that credit availability has grown by 8 per cent relative to the baseline calibration, we then impose an 8 per cent growth rate on the mortgage lending variable that enters the macro-econometric exercise.

The scenario chosen for analysis is the updated recalibration of the Central Bank of Ireland's mortgage measures: LTI levels of 4 and 3.5 for FTB and SSB borrowers, respectively, an LTV of 90 for both borrower types, and 15 per cent of lending allowed above the limits for each borrower type. Buy to Let mortgages are excluded from the analysis.

The modelled scenario results in an increase in credit availability, following an approach based on that introduced by Kelly et al. (2018), of 8 per cent relative to the baseline of a continuation of the

[6] In addition, as a robustness test, we also consider alternative cyclical indicators, such as inflation and new home completions. Our decomposition results are robust to cyclical indicators used in the model.

previous mortgage measures framework. This modelling framework takes information on borrowers' incomes and estimates of their wealth available for housing deposits, based on recent mortgage origination data. It then calculates two hypothetical loans for each potential borrower: (i) a loan based on the borrower income and the prevailing LTI limit; (ii) a loan based on borrower wealth for deposits and the prevailing LTV limit. The *credit available* to an individual borrower is then the minimum of these two hypothetical loans.

A number of caveats to this approach are worth highlighting. Firstly, it measures the amounts available to borrowers, but cannot shed light on the likely amounts drawn down. Kelly et al. (2018) show that the distribution of the share of credit available that was actually drawn down during the pre-2008 credit boom is bell-shaped, with a mean at around 60 per cent, i.e. many borrowers are likely to draw down substantially less than that made available by lenders. Secondly, assessment of the likely allocation of allowances in such a simulation is challenging. The modelling approach taken involves the random allocation of lending above the level of allowances specified. Thirdly, the model does not treat the *extensive margin*, i.e. the addition of new mortgage borrowers into the market who may previously have been constrained before policy change. Rather, it is an analysis of the credit volumes available to a fixed group of borrowers, assessed before and after policy reform. Using alternate techniques, Gaffney (2022) addresses certain of these methodological challenges.

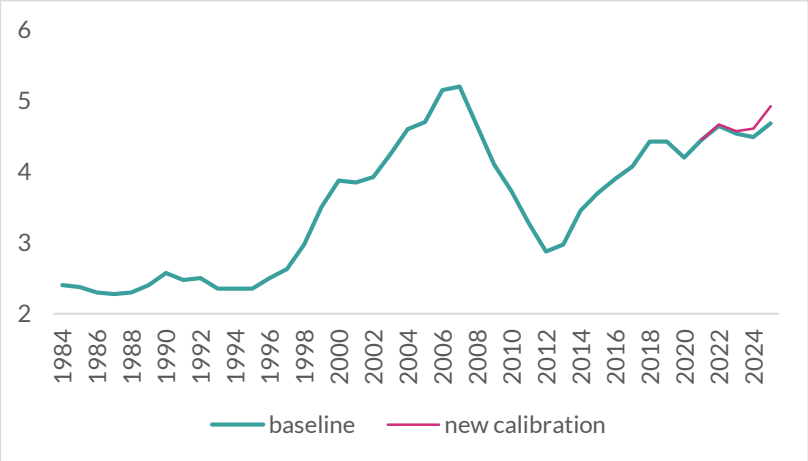
We turn firstly to the results from the BVAR. The BVAR is estimated with quarterly data from 1984Q1 to 2022Q1. The exercise consists of two steps. In the first step we estimate the unconditional forecast for the variables for a three year horizon. The second step entails the estimation of conditional forecasts, given the change in mortgage lending that arises from our macroprudential policy scenario. The calibration of the shock assumes that credit deviates from baseline by the same amount in each quarter of the scenario window.

Figure 1 shows the results. At the end of the three year period, the unconditional forecast projections, i.e. those projected by the model based on information available in the model up to 2022Q1, are for a HPI of 4.8, growing from 4.4 at the start of the forecast horizon. By contrast, the scenario in which an 8 per cent shock to mortgage lending is incorporated to proxy the change in macroprudential policy calibration, HPI grows to (above) 4.9. This represents an increase in HPI relative to baseline of 4 per cent.[7]

We also calculate the cumulative deviation between the house price index (one of the components of HPI) in the baseline and policy scenario. Importantly these are not forecasts for house price growth rates themselves but rather deviations due to a policy counterfactual where all elements of the baseline scenario apart from credit flows are entered into the model on a consistent basis. The results show that the deviation grows to 8 per cent in total over three years of the projection horizon. The reason for weaker growth in HPI, compared to the house price index, is that household incomes also grow in a scenario with more buoyant credit flows.

[7] It is important to note that the income variable used in this macroeconomic analysis to calculate HPI is net of taxes, and therefore it is not comparable to the income used in the implementation of the LTI in the mortgage measures. For this reason, comparisons of HPI in these data to the 3.5 LTI limit in place in the macroprudential framework since 2015 are not meaningful.

Figure 1: House price to income ratio, baseline and policy scenario



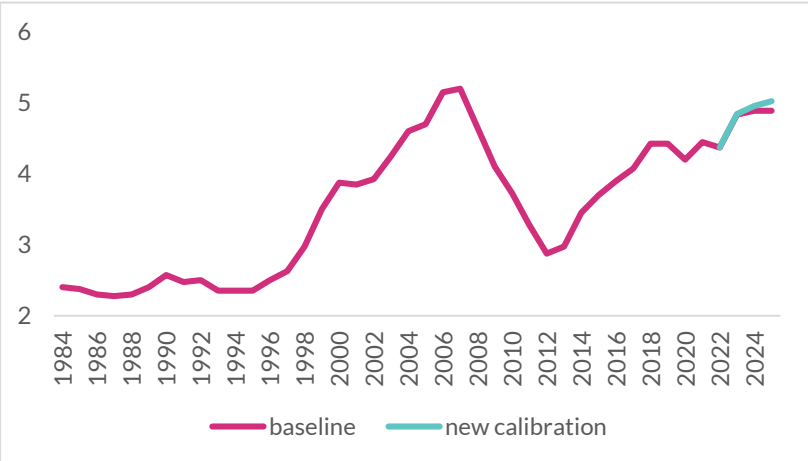
Note: model results from Bayesian VAR. Baseline involves a projection based on information available to the model during 2022, and does not represent a Central Bank of Ireland forecast.

We now turn to the State-Space model. For this conditional forecasting exercise, we feed the same credit availability shocks into the SS model and let them change one of the cyclical drivers – mortgage credit growth. The SS model is estimated using the same quarterly data of HPI, unemployment, credit growth, from 1984Q1 to 2021Q4, along with long-run trend drivers, such as housing demand, supply and the neutral interest rate changes.

In the forecasting horizon, we make the assumption that the trend of HPI stays constant, but the cyclical component is affected by new credit growth which will vary depending on the credit availability estimates that result from different calibrations of the macroprudential mortgage measures. The results show in Figure 2 that the level of HPI rises from 4.37 (end-2022 estimate) to 4.9 by 2025, and that the additional increase due to the recalibration of the mortgage measures is to move the 2025 number to 5.1, and increase of 2.75 per cent.

It is important to note that this projection, charted in the teal line of Figure 2, is based on the assumption that the interest rate stays at levels seen at the end of the modelling horizon. However, if interest rates rise and unemployment risks materialise during the same time, cyclical risks in housing markets related to macroprudential policy changes are likely to be mitigated. Across a number of scenarios, the SS model suggests that a range of plausible yet severe combinations of interest rate and unemployment increases, that are becoming more likely given global developments currently, would more than offset the increase in HPI that is modelled to result from the targeted LTI and LTV increases announced as part of the Central Bank's framework review.

Figure 2: House price to income ratios under the state-space model



Note: results from State-Space modelling, Yao (2022)

6 Conclusion

The relationship between mortgage lending and house price formation is central to the understanding of the role that macroprudential policy plays in the economy. As part of its toolkit for understanding the way in which changes to its mortgage measures may impact the housing market and house prices, the Central Bank of Ireland has used two aggregate empirical tools as part of its recent framework review of the mortgage measures. These tools allow changes in mortgage credit conditions (for example the LTI or LTV ratio) to impact the aggregate house-price-to-income ratio, as a way to gauge the potential cyclical effects of any recalibration of the mortgage measures.

The revised calibration of the mortgage measures is modelled to increase credit availability to borrowers by an estimated 8 per cent. Under the two modelling strategies, this is then projected to lead to increases in house prices relative to incomes over a three year horizon. In one modelling approach, HPI increases to 4.9 relative to the baseline of 4.7 under a no-change scenario. In a second approach, the estimates are more muted at 5 relative to 4.9.

The Central Bank's framework recalibration decision has taken into account a broad set of costs and benefits of the mortgage measures. An increase in the aggregate house price to income ratio is one input to this broad assessment. Future work will evaluate the role played by the changes to macroprudential limits announced in the framework review on outcomes in the housing and mortgage markets.

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