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(Evidence From Ireland)

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Assessing the Macroeconomic Costs and Benefits of Borrower Based Measures

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Abstract

We examine the costs and benefits of LTV and LTI borrower based measures (BBM) changes on future consumption growth rates. Costs are established using a semi-structural model of the Irish economy, which quantifies how macroprudential policy changes affect forecasts for expected consumption growth. Benefits appear in the form of changes to the tail risk to consumption growth, at the 5th percentile, over a forecast horizon of up to 4 years, given the same macroprudential policy change within a novel consumption at risk framework. We find that policy tightening actions involving LTV and LTI are associated with dampened central, or expected, consumption growth rates but appear broadly correlated with less adverse consumption growth tail risk. The timing of BBM adjustments is shown to be highly important, taking the phase of the financial cycle into account.

JEL classification: E5, G01, G17, G28, R39.

Keywords: Macroprudential Policy, Borrower Based Measures, Consumption Growth, Costs and Benefits Study, LTV, LTI, Financial Cycle, Policymaker Preferences.

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Non-Technical Summary

Borrower-based mortgage measures (BBMs) — such as limits on loan-to-income (LTI) and loan-to-value (LTV) ratios — are an essential part of the macroprudential policy toolkit. These tools are widely used by central banks and financial regulators, and have a significant influence on both housing markets and the broader economy.

The benefits of BBMs are increasingly well understood. They help reduce systemic financial risks by promoting more sustainable borrowing and lending practices. BBMs also enhance the resilience of households, making them less vulnerable to economic downturns or financial shocks.

As these benefits have become clearer, policy attention is shifting towards a deeper understanding of the macroeconomic costs and benefits associated with BBMs — particularly when these measures are tightened. Tighter BBMs can reduce access to credit and suppress economic activity in the short term, even while contributing to financial stability in the longer run.

This paper presents a framework to assess both the costs and benefits of BBMs in a unified and measurable way. We identify several key channels through which tighter BBMs affect the economy, particularly through their impact on aggregate household consumption. Importantly, we show that the economic costs of tightening are more immediate, while the financial stability benefits — such as reducing the likelihood of extreme economic tail risks (in this paper these are represented as negative consumption growth forecasts which have a low occurrence probability but which might entail a large negative impact effect upon overall economic activity) — materialize over a longer horizon.

Our approach allows policymakers to evaluate the "marginal" or "additional" impact of changing BBM calibrations. Specifically, we provide estimates of how much extra economic cost results from stricter LTI or LTV limits, and compare this to the extra benefit in terms of reduced systemic risk.

Finally, we highlight how different policymaker preferences — particularly how they weigh short-term economic costs against longer-term financial stability gains — can be incorporated into the analysis. Our framework offers, for the first time, a quantitative way to judge whether changes to LTI or LTV policies are likely to result in a net benefit or a net cost to the economy.

Introduction

The interplay between mortgage markets and macroeconomic outcomes has been a focal point for economists and policymakers, particularly since the 2008 global financial crisis, which highlighted vulnerabilities arising from elevated household leverage. Borrower-based mortgage measures (BBM), such as loan-to-value (LTV) and loan-to-income (LTI) limits, are critical macroprudential tools designed to enhance financial stability by curbing excessive borrowing and mitigating systemic risks in housing markets. These measures, however, extend their influence beyond financial stability, affecting macroeconomic variables over time. One such variable is household consumption, the core focus of this analysis. More specifically, we identify and quantify the macroeconomic costs and benefits associated with (assumed pre-existing) BBM calibration changes, thereby addressing an important gap in understanding the macroeconomic trade-offs involved.

BBM limits impact consumption through both direct and indirect channels. Directly, LTV and LTI limits may restrict households' access to credit, potentially reducing spending on housing-related goods, such as home furnishings, or other large purchases financed through borrowing. Indirectly, these measures influence consumption via house prices, wealth effects, and labour market dynamics. For example, tighter LTV limits may dampen housing demand, reducing house price growth and household wealth, thereby suppressing consumption. Conversely, by preventing excessive borrower leverage, BBM policies may enhance long-term consumption stability, reduce financial distress, and foster sustainable economic growth.

Aikman (2021) examines the objectives of BBM limits and explores in depth the consumption-related channels affected by these policies. He outlines a conceptual analytical framework that allows the costs and benefits of BBM adjustments to be empirically tested within a consumption growth setting. Our empirical approach aligns closely with that framework. More broadly, related literature investigates the widespread adoption of BBM limits post-2008 in countries such as Ireland, Canada, and New Zealand. Often, the focus of this research has been their effectiveness in curbing housing market exuberance. While studies such as Lim et al. (2011), Claessens et al. (2013), Cerutti et al. (2016), and Gaffney (2022) have explored the effectiveness of these measures in promoting financial stability, the cost–benefit trade-offs involving other macroeconomic variables, such as consumption, have, to the best of our knowledge, been largely overlooked. This gap is significant, as consumption fluctuations can amplify economic cycles, thereby affecting recovery and long-term growth.

Our analysis integrates two separate models to assess costs and benefits.[1] To estimate costs, we employ a semi-structural model of the Irish economy, building on McInerney (2020*a*), who captures the impact of BBM limit changes on median consumption growth rates. More specifically, we simulate the effects of exogenously imposed one-standard-deviation policy tightening actions involving LTI, LTV, and joint LTI–LTV changes. We then estimate the percentage point deviations of consumption growth rates, house prices, debt service ratios, unemployment rates, and the credit-to-GDP gap from the projected paths they would otherwise have followed in the absence of a policy change. Any reduction in the consumption growth rate stemming from the policy change represents the ***cost*** of a tighter calibration of the BBM.

To estimate benefits, we introduce a consumption growth-at-risk (CaR) model, a novel contribution to the growth-at-risk literature. This model quantifies the reduction in tail risk, i.e., low-probability yet high-impact consumption downturns, resulting from the same simulation exercise. As the post-BBM limit change paths for consumption, house prices, debt service ratios, unemployment, and credit growth unfold, the tail risk to consumption growth adjusts accordingly, given the explanatory role these variables play in the CaR model. We believe this is the first application of a CaR framework to evaluate macroprudential policies.[2] Our model is tractable and extensible, allowing its principles to be applied to other macroprudential instruments.

Our results are not intended to calibrate optimal levels of BBM policies. Such calibration would likely depend on the prevailing level of systemic risk in the economy, along with the current phase of the financial cycle. It would also reflect policymakers' preferences regarding the balance between reducing tail risk and tolerating expected consumption growth costs. These preferences vary across macroprudential authorities and would in turn reflect prevailing financial cycle and risk conditions. Furthermore, our results presuppose that BBM provisions are already in place. We do not attempt to quantify the costs and benefits associated with transitioning from a regime without BBMs to one in which they are mandated. Instead, our framework provides a robust tool for evaluating trade-offs arising from adjustments within an existing BBM framework, thereby informing policy calibration.

This study makes several significant contributions. First, it is the first to empirically examine and quantify the costs and benefits of BBM policies on consumption growth. Second, our dual-model approach combines a semi-structural model with

[1] Please refer to Figure 6 in the Appendices for a schematic overview of how the models overlap and interact to generate our cost–benefit results.

[2] While our simulations involve policy tightening actions, we note that policy loosening actions would produce symmetrical outcomes, as the semi-structural model is linear in nature. In other words, costs and benefits are equal in magnitude but opposite in sign.

a CaR framework, offering a comprehensive assessment of both expected (median) consumption outcomes and tail risks. Third, we account for intertemporal trade-offs, analysing when and to what extent costs and benefits materialise. Furthermore, our framework highlights how policymakers may weigh their preferences for mitigating low-probability, high-impact consumption downturns against higher-probability, less severe costs at the median of the consumption growth distribution.

Our findings suggest that tighter LTV and LTI limits are associated with lower expected or median consumption growth rates. It is reasonable to consider this reduction as one of the macroeconomic costs of tighter BBM limits. At the same time, tighter BBM limits appear to indirectly reduce adverse consumption growth tail risk. This relationship is more pronounced when the financial cycle approaches its peak, typically characterised by elevated household leverage following a period of relatively loose financial conditions. In contrast, tail risk gains appear less significant when the financial cycle is at a lower point. Taken together, our results underscore the importance of timing in BBM calibration, particularly regarding the broader macroeconomic repercussions of such adjustments (see Richter et al. (2019) and Richter et al. (2021)).[3]

The results we present are based on Irish data exclusively in the case of the semi-structural model and using a panel of OECD countries in the case of the CaR model. As such, they may not necessarily apply to other economies.[4] Our empirical approach represents a pragmatic response to several data limitation issues. Ideally, a single model approach would be adopted at some future point, one that embeds risk-sensitive preferences of the policy maker. Our framework generates conditional consumption growth forecasts and allows for scenario analysis to occur where forecast variation is contrasted, given the different scenarios. Risk preferences of the policy maker are accounted for in a post-forecast setting using a simplified weighting scheme or welfare function. Future work is recommended in this area, but for our purposes such a treatment remains outside the scope of this study.

Despite these limitations, our findings provide insights for policymakers seeking to balance financial stability with economic growth, particularly in economies with

[3] It is important to re-emphasise that our results pertain to ***existing*** LTV and LTI regimes, wherein exogenously adjusted BBM limits occur under various scenarios that we have artificially constructed. We make no claim that our results hold when national authorities are ***introducing*** BBM limits for the first time.

[4] We adopt a similar two-model approach in our paper examining the costs and benefits of marginal Tier 1 bank capital. This approach also uses the semi-structural model of the Irish economy to estimate the cost of additional Tier 1 bank capital and uses the same OECD panel as is used in this paper to estimate systemic banking crisis likelihood conditional upon Tier 1 bank capital. We present evidence from a broad literature of similar studies and show that our results remain consistent with those of others, (see McInerney et al. (2022)).

significant housing market exposure. The tractability of our model ensures its applicability to other macroprudential tools, making it a versatile instrument for future policy analysis.

The rest of the paper is organised as follows. We begin with a review of relevant literature relating to housing markets, consumption, and macroprudential policy. We then describe the data and models used in the analysis. Next, we present our main cost–benefit findings before considering the role of timing in BBM limit changes. Following this, we outline a simple framework for policymakers that illustrates how economic and financial stability trade-offs can be weighted depending on their objectives and preferences. We conclude by summarising our overall findings.

Relevant Literature

Borrower-based measures were introduced in Ireland in 2015 (see Cassidy & Hallissey (2016)) and have since become embedded within the regulatory frameworks of multiple jurisdictions following the global financial crisis of 2008. In Ireland, the stated objectives of these measures—targeting high ratios or multiples of loan-to-value (LTV) and loan-to-income (LTI) ratios—are to *“enhance the resilience of households and banks to financial shocks and to curb cyclical tendencies in the mortgage market”*. Over time, BBM limits increasingly influence the quality of retail banks' mortgage portfolios. Borrower resilience also improves, as a greater proportion of retail banks' mortgage books consists of borrowers better able to withstand income and asset price shocks, compared with jurisdictions where BBM limits are not mandated.

Given the direct link between BBM policies and homeownership levels (see Cassidy & Hallissey (2016)), the choice of consumption as the primary variable for assessing BBM-related costs and benefits is well justified. Indeed, Aikman (2021) comprehensively explores this rationale, noting that consumption *“aligns with the typical objectives of central banks, which we argue necessarily entails a central bank's macroprudential policy stance, allows us to express the costs and benefits of these (macroprudential) policies in the same units and is justified on the grounds that a Pareto improvement in welfare is possible if willingness-to-pay among beneficiaries of a policy exceeds willingness-to-accept among those made worse off”*.

This rationale builds upon prior foundational analyses. Modigliani (1966) and Friedman (1957) outline the life-cycle hypothesis of saving, which posits that households aim to smooth consumption over their lifetimes based on expected lifetime income. They suggest that households consume according to their expected permanent income rather than their current income. Given the importance of income for a household's propensity to consume, understanding the relationship among income, housing demand, and credit supply is highly relevant to our analysis. These factors are considered in studies examining income elasticity of housing demand (see Carliner (1973), Hansen et al. (1996), Belsky et al. (2006), and Chen & Jin (2014)).

Several studies examine the effectiveness of macroprudential policies. Richter et al. (2018) investigate the costs of LTV limits in terms of output loss and inflation dynamics. Cerutti et al. (2016) analyse various macroprudential policies and find that their activation is generally associated with reduced credit growth, with the extent of the effect influenced by the financial cycle (see also Lim et al. (2011) and Richter et al. (2021)). Alam et al. (2019) examine macroprudential policies across 134 countries from 1990 to 2016. They identify strong effects of LTV limit changes on household credit but note that these effects diminish if the initial LTV level is already restrictive. Jurča et al. (2020) evaluate the costs and benefits of BBM policies in Slovakia, developing a semi-structural framework that combines micro and macroeconomic data to assess household resilience implications.[5] Our approach differs in that we assess BBM costs and benefits primarily through a consumption growth lens, without attempting to incorporate societal welfare-related benefits arising from enhanced household resilience as estimated by Jurča et al. (2020).

Other relevant studies include Carroll et al. (2011), which finds that consumption changes as households transition from renting to homeownership. Similarly, Gruber et al. (2021) investigate the impact of mortgage interest payments on homeownership decisions and their subsequent effects on household consumption expenditures. Acolin et al. (2016) demonstrates how borrowing constraints influence the timing of homeownership, affecting consumption behaviour (see also Karlan & Zinman (2009), Clancy et al. (2014), and Linneman & Wachter (1989)). Cerutti et al. (2016) is also relevant, as they find that the effectiveness of macroprudential policies depends on the state of the financial cycle—a finding echoed in our analysis (see also Richter et al. (2021)).

Finally, Galán (2020) show that various macroprudential policy actions are associated with less adverse left-tail GDP growth outcomes, with benefits outweighing negative consequences at median GDP growth outcomes for EU countries.[6]

[5] A variety of resilience indicators are evaluated, including default probability, expected losses, and expected losses given default.

[6] Galán (2020) uses a growth-at-risk framework to estimate both costs and benefits to GDP growth stemming from macroprudential policy stance.

Data and Methodology

Data

To evaluate the consumption growth-related cost of BBM adjustments, we utilise the Central Bank's semi-structural model of the Irish economy. The model incorporates a wide range of linkages between the Central Bank, commercial banks, households and firms.[7] A key feature of the model is that it includes transmission mechanisms for several lender- and borrower-based macroprudential instruments, including limits on the LTI and LTV ratios covering household mortgages. The equations in the 'real' block model are estimated using quarterly data from the *National Accounts*, *Government Finance Statistics*, and the *Labour Force Survey* compiled by the CSO, while the behavioural equations and balance sheet identities in the model's banking sector primarily use data from the Central Bank's *Retail interest Rates and Credit and Banking Statistics*. Summary statistics for the key variables driving the costs of borrower-based instruments in the semi-structural model are shown in Table 1.

Table 1. Selected Variables from Semi-Structural Model - Summary Statistics

Variable	Source	Freq.	Coverage	Obs.	Min.	Max.	S. Dev.	Mean
New Mortgages (€mn)	CBI	Q	1997Q1 - 2019Q4	92	400.65	7158.85	1877.38	2335.79
House Prices (€'000s)	CSO, ESRI	Q	1997Q1 - 2019Q4	92	85.049	333.778	63.804	218.391
Household Consumption (€mn)	CSO	Q	1997Q1 - 2019Q4	92	10140.68	34534.91	6897.73	24350.73

Notes: New Mortgages refers to new mortgages extended for household purchase for the CBI's Credit and Banking Statistics. House Prices refer to average national prices on new houses from the CSO's Residential Price Index, with pre-2005 series backcasted using the ESRI's series on new house prices. Household consumption is the final consumption expenditure of households including NPISH from the CSO's Quarterly National Accounts.

To assess consumption growth-related tail risk benefits of BBM, we extend the dataset described in O'Brien & Wosser (2018). This dataset encompasses a panel of 27 OECD countries spanning a variety of macro-financial indicators, measured at quarterly frequency from 1980Q1 up to 2021Q4. We augment this dataset with observations measuring consumption (in levels at constant prices, sourced via the OECD).

Table 2 presents summary statistics for the variables in the consumption GaR model, sourced from the OECD, the Bank for International Settlement (BIS), and the European Central Bank's statistical data warehouse. Data are quarterly and, in most cases, span

[7] See McInerney (2020*b*) for a comprehensive discussion of many more macro-financial linkages in the semi-structural model than are relevant to the more narrow consumption-related analysis examined here.

Table 2. Consumption At Risk Model - Summary Statistics

Variable	Source	Freq.	Coverage	Obs.	Min.	Max.	S. Dev.	Mean
Consumption growth	OECD	Q	1980Q1 - 2021Q4	3,713	-27.80%	33.28%	3.21%	2.02%
CLIFS	ECB-SDW	Q	1990Q1 - 2021Q4	2,712	0.007	0.844	0.099	0.13
House prices	BIS	Q	1980Q1 - 2021Q4	3,531	26.63	216.28	36.63	82.57
Unemployment rate	OECD	Q	1980Q1 - 2021Q4	3,328	2.03%	22.50%	4.1%	7.67%
Household debt service ratio	BIS	Q	1980Q1 - 2021Q4	1,541	2.9	24	4.12	10.21
Credit to GDP gap	BIS	Q	1980Q1 - 2021Q4	3,936	-70.6	69.81	14.19	0.39

Notes: 1. Consumption data is private final consumption expediture, in local currency, volume estimates seasonally adjusted and with constant prices. 2. CLIFS stands for country level index of financial stress. 3. House price indices are indexed against the year 2000. 4. Household debt service ratio measures a weighted average of multiple borrowing repayments to total household income 5. Credit to GDP gap measures deviation of total credit extended to households and non-financial corporations to GDP from long its run country average.

1980Q1–2021Q4.[8] Table 2 summarises the data underpinning the CaR specification outlined below.[9]

The dependent variable is the average annualised consumption growth over t to $t + h$ $(1 \leq h \leq 16$ quarters), sourced from OECD public-domain data. Current consumption growth significantly predicts future growth, so the first covariate is the autoregressive annual growth rate from $t - 4$ to t. Financial conditions capture the impact of interest rates, exchange rates, and market liquidity shocks on consumption.[10] House prices influence the binding thresholds for LTV and LTI borrower limits, the time needed to save deposits, and thus consumption patterns. Interest rates affect disposable income after debt repayments. As households often hold multiple debts (e.g., credit card, overdraft, car loans), the debt service ratio shapes consumption from residual income. Employment status, as our results show, also strongly affects disposable income and debt repayment capacity. Finally, the credit gap variable captures the financial cycle, given evidence that excessive credit growth often precedes crises Jordà et al. (2011) and Richter et al. (2021).

Consumption tail risk appears linked to financial crises. Our cross-country panel shows that consumption growth narrows in dispersion in the quarters before crises, then drops sharply as crises unfold. Figure 1 shows that the inter-quartile range contracts before crises. The average 5th, 10th and 25th percentile growth rates fall alongside, suggesting

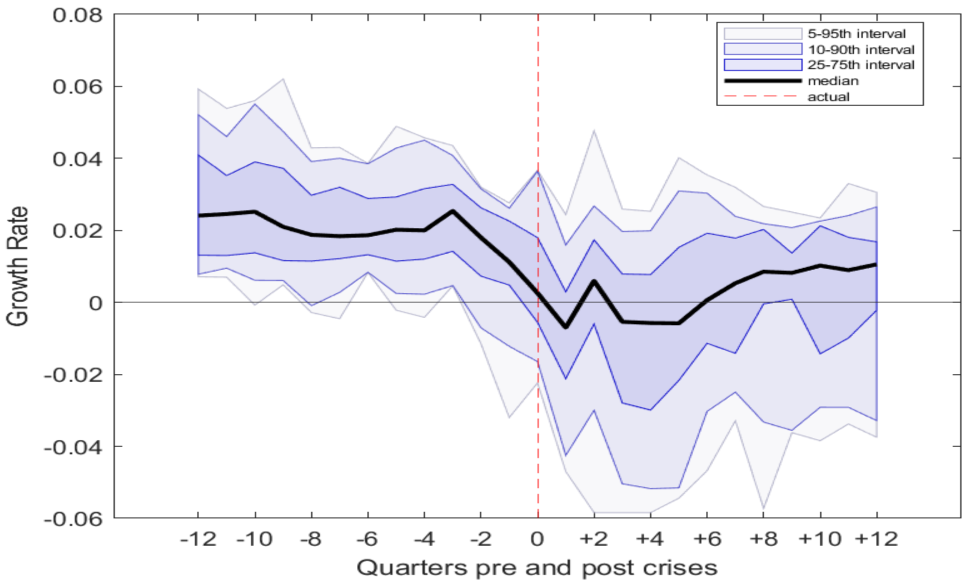
[8] We end our sample at 2021 due to high levels of post-pandemic consumption volatility, which could confound our results. For CaR quantile regressions, we use data only up to 2019Q4.

[9] The steps to arrive at the CaR specification are in the Appendices, including identification of key variables for consumption tail risk and selection of the best-performing model in in-sample and out-of-sample forecasting.

[10] We use the Country Level Index of Financial Stress (CLIFS) as a proxy for financial conditions. For Ireland, CLIFS is replaced with the Irish Composite Stress Index (ICSI). See Parla (2021) for details.

tail risk offers early-warning signals up to eight quarters in advance. Upon crisis onset, the left tail turns negative and remains so for at least five years.

Figure 1. Consumption Growth Pre and Post Financial Crises



Note: Shaded areas show unconditional percentile ranges of consumption growth across OECD panel countries for four years before and after a financial crisis, as defined by the Laeven & Valencia (2013) dataset.

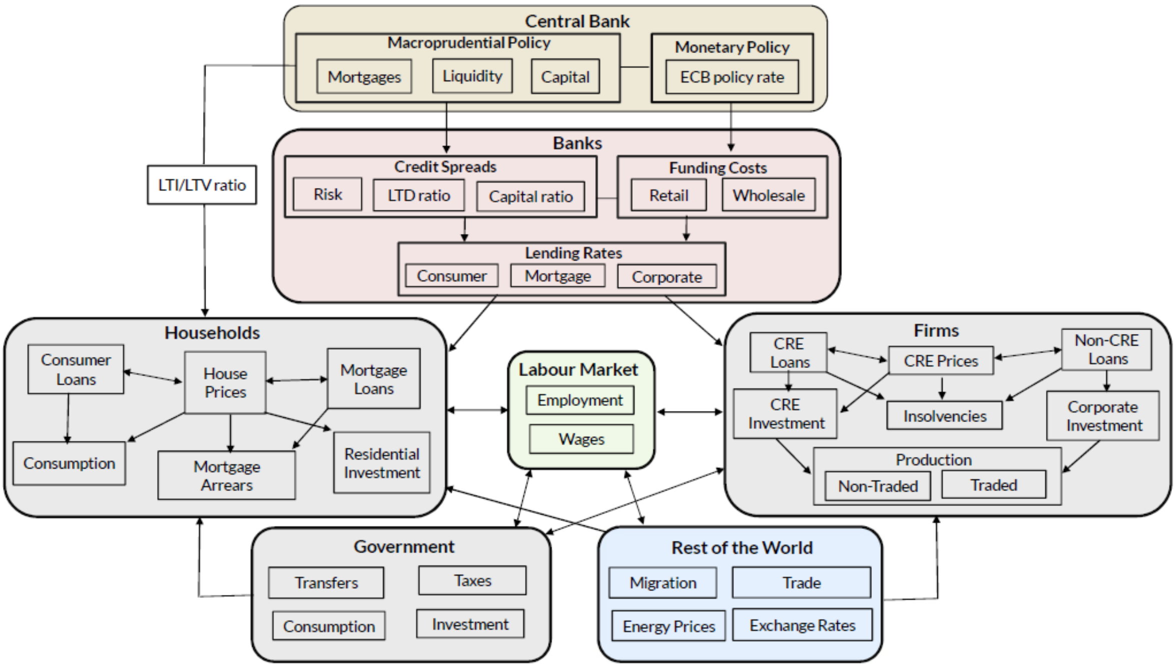
In contrast, the median growth rate returns to positive within 6–8 quarters. The 75th percentile rarely recovers to pre-crisis levels even after 20 quarters. The inter-quartile range widens substantially post-crisis, reflecting greater cross-country volatility in consumption growth.

Methodology

As suggested by Aikman (2021)'s two part analytical framework, we make use of two separate but interlinked econometric models to complete our analysis. The data channels through which they interact is depicted in Fig. 6 in the Appendices. The first model used is a semi-structural model of the Irish economy, which facilitates scenario developments critical to our study. Details of the LTV and LTI scenarios driving our results are outlined below. A schematic of the semi-structural model is shown in Fig. 2 below.

The model comprises three sectors: a traded sector driven primarily by world demand and Ireland's export prices relative to competitors; a non-traded sector dependent on domestic economic conditions; and a government sector that grows in line with the economy in the absence of changes to fiscal policy. The Central Bank acts as the

Figure 2. Central Bank's Semi-Structural Model of the Irish Economy



macroprudential authority in the model. It has four instruments that it can use to mitigate different dimensions of systemic risk. On the borrower side, it can manage mortgage credit conditions by imposing limits on household leverage and income gearing through restrictions on LTI and LTV ratios. On the lender side, it can adjust liquidity requirements for banks by imposing a ceiling on LTD ratios and it can raise minimum capital requirements. The Central Bank as part of the ESCB is also the monetary authority in the model, although the latter is assumed to be exogenous to Irish economic conditions.

Borrower-based macroprudential instruments affect mortgage credit demand directly, while lender-based instruments affect banks' lending spreads. Credit demand is assumed to depend on the cost of credit, income and the value of collateral, as approximated by house prices and CRE prices. As mentioned, household mortgage demand will also depend on the prevailing LTI and LTV ratios. In addition to mortgages, households also demand consumer loans. On the corporate side, the model distinguishes between CRE loans and other corporate credit due to the differential elasticity of demand of each loan type with respect to economic growth and CRE prices.

The response of house prices to shocks affects household consumption and the demand for consumer loans through the housing wealth channel. It also affects residential investment by changing the profitability of house building. As both consumption and investment are components of non-traded output, employment and wages in that sector will rise or fall depending on the shock. The impact on household mortgage arrears depends on the relative strength of the response of housing equity, the mortgage rate and the stock of mortgage debt.

The channels through which shocks in the banking system are transmitted to the corporate sector are similar to those in the household sector. The corporate lending rate is particularly important as it is the key component of the user cost of capital, which in turn affects the demand for CRE and non-CRE credit as well as commercial property prices. Both CRE and non-CRE corporate investment drive the long-run productive capacity of the economy by increasing the capital stock. Finally, Figure 2 shows how macro-financial and macroprudential shocks can spillover to the government and international sectors. The impact on the government sector is indirect and occurs through automatic stabilisers. The response of consumption and investment to these shocks also affects the economy's external position through changes in important demand and external competitiveness.

The second model is a newly constructed Consumption at Risk (CaR) model, primarily used to estimate the tail risk benefits to consumption growth resulting from tighter LTV and LTI ratios. The CaR extends the GDP Growth at Risk (GaR) framework (see Adrian et al. (2019) and O'Brien & Wosser (2021)). It allows an in-depth, forward-looking examination of the relationship between future consumption growth at all percentiles of the conditional forecast distribution and the explanatory variables that determine these outcomes. Our focus is on the forecast fifth percentile growth rates stemming from scenarios that incorporate a one standard deviation reduction in regulatory minimum LTV or LTI ratios over a term structure h of up to 16 quarters.

The CaR model is estimated in two stages, following Canay (2011). In the first stage, country-specific fixed effects are treated to avoid bias in the second-stage quantile regression coefficients. Canay (2011) assumes country fixed effects are locational shifts of the entire growth distribution and constant across quantiles. This allows for their elimination before estimating coefficients of the tail risk determinants of interest.

To begin, we estimate a pooled panel model (within estimator) per the following:

$$y_{i,t+h} = \alpha_i^h + \gamma^h X_{i,t} + \epsilon_{i,t} \tag{1}$$

Here, the dependent variable is the average annualised consumption growth rate for country *i* over the interval *t* to *t+h* where *h* is a forward looking horizon, at quarterly frequencies with values ranging from 1-16. Thus;

$$y_{i,t+h} = \frac{Y_{i,t+h} - Y_{i,t}}{h/4} \tag{2}$$

where $Y_{i,t+h}$ is the log of real consumption in country *i* at time *t+h* quarters ahead. The country fixed effects are denoted by α_i^h and the determinant vector $X_{i,t}$ (see also Table 2) comprises the following: i) current consumption growth rate, ii) a country level index of financial stress (CLIFS), iii) a house price index (base year = 2000Q1), iv) the unemployment rate, v), the household debt service ratio, vi) the credit-to-GDP gap and vii) an interaction term involving CLIFS and the credit-to-GDP gap. All dependent variables are standardised using the country level mean and standard deviation and are estimated contemporaneously, with the exception of the unemployment rate which is lagged by one quarter.[11]

According to Calvo (1998), the fixed effects can be estimated as;

$$\hat{\alpha}_i^h = \frac{1}{N}\sum_{i,t}(y_{i,t+h} - \hat{\gamma}^h X_{i,t}) \tag{3}$$

We then treat the dependent variable according to the following;

$$y_{i,t+h}^* = y_{i,t+h} - \hat{\alpha}_i^h \tag{4}$$

The second stage of the Canay (2011) estimation then proceeds where quantile regressions are used to estimate the quantile τ coefficients of interest β_τ^h according to the following;

$$\hat{\beta}_\tau^h = argmin_{\hat{\beta}}\sum_{i,t}\rho_\tau(y_{i,t+h}^* - X_{i,t}\beta_\tau^h) \tag{5}$$

Here ρ_τ is the standard asymmetric absolute loss function. We estimate the model from quarters *h* = 1-16 ahead, paying particular attention to the coefficients corresponding to the fifth percentile regressions (i.e. $\tau = 5$).[12]

The *two-model in combination* approach is effective because the variables common to each model are linked. As Fig. 6 shows, both models estimate Irish household personal consumption expenditure after a simulated BBM limit adjustment. For example, we model a 5% tightening of the LTV ratio, a 0.35 reduction in the LTI multiplier, and a third case where both are jointly tightened. In each scenario, the consumption growth costs and benefits are estimated. When LTV or LTI limits are tightened, the covariates in the CaR model diverge from the paths they would have followed without the change.

[11] The dependent variable y is not standardised, implying the coefficients can be interpreted as percentage point changes in real consumption growth rates.

[12] It is worth nothing that the framework allows the relationship between the explanatory and control variables to be explored for each percentile of the forecast consumption growth distribution and not just those dealing with the fifth percentile.

One such covariate is the expected consumption growth rate, which trends lower under more restrictive BBM limits. The deviation from its baseline path is designated as the consumption-related ***cost*** of the adjustment. Several CaR model covariates shift in this way, each contributing to a revised tail risk forecast for consumption growth. The magnitude of these deviations, and their tail risk implications, are outlined below.

The macro-financial implications of the simulation allow us to measure the consumption-related tail risk impact of the policy change. If tail risk improves, the gain is the ***benefit*** of the simulated change. Thus, both ***costs*** and ***benefits*** of BBM adjustments can be quantified and compared.

Depending on the modeller's risk preferences, costs and benefits may be considered directly comparable and netted to assess the overall effect. Later, we introduce a framework allowing policy makers to assign weights to the probability of the baseline forecast consumption growth rate (from the macroeconomic model) versus the less likely 5th percentile rate (from the CaR model). We also apply a welfare function, per Cecchetti & Suarez (2021), to jointly evaluate costs and benefits. On this basis, our results suggest a net additional benefit from tighter BBM limits in years two, three, and four after a policy change is possible.

Results

Macroeconomic costs of BBM limit adjustments

To quantify the macro-financial impact of BBM limit changes using Irish data, we simulate separate and combined one standard deviation reductions in the limits on LTV ratios and LTI multiples.[13] A one standard deviation shock corresponds to a 5-percentage-point lowering of the LTV limit and a 0.35 reduction in the income multiple under the LTI limit.[14] Figure 3 illustrates the macro-financial impact of these shocks on the Irish economy over a five-year period, relative to a baseline in which the mortgage measures remain constant.

The impact on consumption is considerable. A one standard deviation tightening in both LTI and LTV limits reduces household spending by nearly 1 percentage point on average relative to baseline, with roughly equal contributions from each instrument. This effect arises through both direct and indirect channels. Directly, lower housing

[13] The semi-structural model is essentially linear, so the sum of the macro-financial impacts of the separate LTV and LTI shocks should approximately equal the impact of the joint shock. This property also implies that loosening and tightening of these measures is broadly symmetric.

[14] We simulate a one standard deviation change because the consumption GaR model uses standardised variables, allowing easier cross-comparison of results and ranking of policy effects.

demand reduces average house prices, which in turn depresses consumption via the wealth effect. Indirectly, lower economic activity leads to reduced wages and household income, further dampening consumption.

In the model, LTI and LTV ratios function as collateral and affordability constraints on new mortgage lending. A one standard deviation reduction in the LTI ratio reduces new mortgage volumes by nearly 18 percent relative to baseline after five years, while a similar reduction in the LTV ratio has a comparable impact. Combined, both measures lower new mortgage lending by approximately 35 percent after five years. These findings are broadly consistent with Bekkum et al. (2024), who find that a five-percentage-point reduction in LTV limits in the Netherlands reduced borrowing by close to 10 percent in the year of purchase.

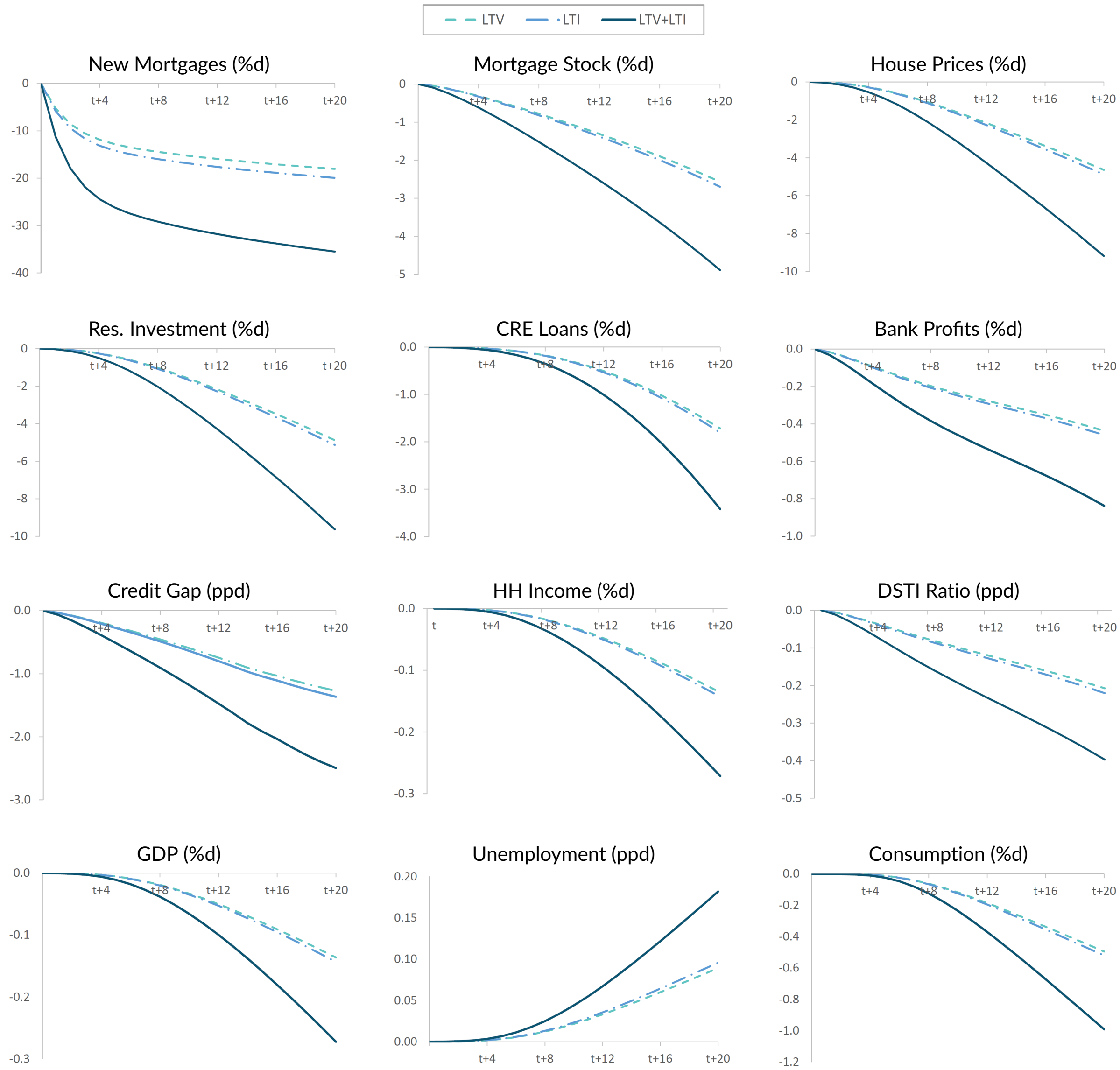
The decline in mortgage borrowing leads to a fall in the outstanding stock of mortgages over time, with the combined scenario reducing mortgage stock by nearly five percent relative to baseline over the five-year horizon.

The increase in credit constraints facing households reduces the demand for housing. This leads to a fall in house prices, which ultimately drop by over 4.5 percentage points in each of the LTI and LTV scenarios and by over 9 percentage points if both are tightened simultaneously, on average. The impact of the LTV shock on house prices is consistent the results in van Bekkum et al. (2024) who find that a five percentage point reduction in LTV limits is associated with a close to six percent fall in housing values. It is approximately half of the effect found in Lyons (2018), although his results are estimated in a single equation framework that only incorporates the LTV ratio as an indicator of Irish credit conditions and thus may also capture changes in the LTI ratio which were highly correlated with changes in LTV ratios over his sample period. Finally, the impact of a joint tightening of mortgage measures is consistent also with the average one-year effect estimated using Irish loan-level data in Kelly et al. (2018).

The resulting fall in the profitability of housing construction reduces residential investment in line with the decline in house prices. Over time, lower construction, along with the depreciation of existing units, lowers the housing stock. The decline in residential investment also means that construction firms require less credit for housing development, so that the outstanding stock of commercial real estate (CRE) lending falls by close to 3.5 percent relative to baseline in the scenario in which both macroprudential instruments are reduced by one standard deviation.

On the banking side, lower asset values and lending volumes reduce profits, prompting banks to raise lending rates to maintain their target capital levels (capital is primarily raised through retained earnings).

Figure 3. Impact of a One Standard Deviation increase in Mortgage Measures



Note: Fig. 3 shows the impact of a separate and combined one standard deviation tightening of macroprudential mortgage measures using the Central Bank's semi-structural model of the Irish economy. The results are presented in terms of percent (%d) or percentage point (ppd) deviation from baseline.

Aggregate credit-to-GDP gaps fall by around 2.5 percentage points in the combined tightening scenario. Household income declines in all scenarios, but the DSTI ratio also falls because the numerator (credit demand) declines more than the denominator (income).[15] Overall, tightening either LTV or LTI limits reduces household debt servicing obligations similarly.

Finally, the combined tightening of LTV and LTI limits has broader macroeconomic effects: GDP is roughly 0.35 percent lower, and the unemployment rate is about 20 basis points higher than baseline after five years. The impact of the LTV shock on GDP is approximately half of that found in Richter et al (2019). However, the impact is similar if we consider only measures of domestic activity that thus exclude the distortionary impact of multinational enterprises (MNEs) on aggregate measures of Irish output such as GDP.[16]

Benefits of tighter BBM calibration

The costs of more restrictive BBM limits, as outlined above, result in variation in the dynamics of several key macroeconomic variables relative to a baseline scenario in which no BBM adjustment occurs. As Eq. 1 to Eq. 5 show, several of these macroeconomic variables represent important explanatory variables in the preferred CaR specification (see the Appendices for an outline as to how this specification was determined). In particular, Fig. 3 highlights the impact of tighter BBM on consumption growth, house prices, the credit-to-GDP gap, the household debt service ratio and the unemployment rate. Furthermore, the CaR specification includes a financial conditions indicator (Country Level Index of Financial Stress (CLIFS index)) which we assume is not impacted by the semi-structural model policy simulations we perform, but which our analysis shows is an important determinant of consumption growth tail risk.

We estimate the fifth percentile quantile regressions, per Eq. 5 and report the coefficients in Table 7, spanning a term structure of h from 1 to 16 quarters ahead. The reported coefficients are informative from the perspective of an agent concerned about consumption growth tail risk changes that might accrue from adjusting the minimum LTV or LTI regulatory ratios.

It is important to note that the semi-structural model of the Irish economy is linear. As such, looser BBM limits will have the *equal but opposite* effects upon consumption growth tail risk as BBM limits tightened by the same extent. Because of this, we can

[15] Mortgage interest payments also fall slightly due to reduced riskiness of household lending and looser capital constraints.

[16]The results for domestic demand and the output of the 'non-traded' sectors of the Irish economy are available on request.

examine simulated BBM limit changes in a variety of ways including, i) a comparison of the effects of BBM limit relaxation versus BBM limit tightening, ii) the inter-temporal trade offs corresponding to a policy change (i.e. the extent of near-term costs for medium-term benefits), iii) which BBM instrument yields the largest consumption growth costs and/or benefits and over which period of time, iv) whether or not tail risk benefits measured across the full term structure we consider, i.e. 4 years, amount to a net tail risk benefit overall, and so on.

Turning to the results reported in Table 7, several important findings emerge. First, the consumption growth coefficient is significantly positive in quarters 1-5 but is invariably negative from quarter 6 onward. As such, more restrictive BBM limits are associated with a drop in the credit gap (Fig 3 panel 8), and will initially result in increased tail risk for a period of 5 quarters, via this channel. However, the effect reverses commencing in quarter 6 and tail risk to consumption growth via the direct consumption channel eases thereafter.

Second, and perhaps more significantly, as house prices fall relative to the baseline (see Fig. 3 panel 3), there is an immediate easing of the fitted / forecast tail risk to consumption growth via the housing channel (capturing household wealth effects, see also Labhard et al. (2005), Wolff et al. (2005) and Iacoviello (2011)). In a more general sense, this result tends to align with prior literature that finds financial crises to be invariably accompanied by a large fall in consumption levels (see Fig 1), and which are often also preceded by housing booms (see also Case & Shiller (1988), Case & Shiller (2003), Reinhart & Rogoff (2008) and Kindleberger et al. (2005)). Our model suggests that if house prices increase significantly for a sustained period, any tail event involving weakened consumption growth rates is likely to be considerably more adverse.

Third, we find that consumption tail risk is impacted by the uptick in unemployment depicted in Fig 3 panel 11. Our CaR model suggests that in quarters 1-8 following tighter simulated BBM limits, the corresponding increase in unemployment, reported via the semi-structural model, appears to mitigate consumption growth tail risk. However, similar to the direct consumption channel, we find that from quarter 10 onward the opposite effect is observed. Eventually, unemployment-related consumption growth tail risk can be expected to increase in years 3 and 4 post-tightening, as one might intuitively expect.

Fourth, the semi-structural model demonstrates that the household debt service ratio will reduce in the years following BBM tightening (see Fig.3 panel 9). As the debt service to income share lowers, tail risk to consumption growth eases. Evidence supporting this can be see in the historical decomposition of tail risk charts where post-GFC household debt deleveraging appears to alleviate tail risk forecasts. Finally, the significantly negative interaction term involving the financial conditions and credit gap variables suggests that financial conditions shocks occurring in circumstances where household leverage is high appear to amplify consumption growth tail risk.

Fifth, our findings show that the coefficient on the credit gap is positive and statistically significant when we control for house prices. As controls for the business cycle (with unemployment as a proxy variable) and for debt servicing costs (mechanical repayment burdens) are also included, the positive coefficient on the credit gap may be interpreted as the banking system's balance-sheet capacity or collateral effect. When credit-to-GDP is above trend, banks are less constrained in their lending and households can smooth consumption against elevated collateral values (Drehmann & Juselius (2012), Mian & Sufi (2011) and Bernanke et al. (1999)).[17]

Taking these results on aggregate, whereas the direct effect on projected consumption envisages lower expected consumption (Fig.3 panel 12), any expected consumption reduction may eventually be partially or fully offset by the associated reduction in consumption growth tail risk as consumption, along with the macro-financial variables we consider, dynamically adusts according to the semi-structural model's projections. In the section below, we net off the sometimes competing dynamics suggested by the CaR coefficients in order to quantify the net easing, if any, to consumption growth tail risk stemming from the simulated policy changes.

Other findings of interest emerge from the estimated CaR results. Prior research has shown that financial conditions affect near-term GDP at risk forecasts much more significantly than is the case at longer horizons (see O'Brien & Wosser (2021) and Lang et al. (2023)). This effect is also apparent with respect to consumption growth tail risk, wherein we find that the impact of tighter financial conditions appears to have only modest consumption growth tail risk implications beyond the ensuing three quarters.

Macroeconomic response to BBM adjustments

At this point, we have established that a simulated tightening policy action involving the LTV ratio, or the LTI multiplier or both jointly, necessarily implies a consumption-related

[17] In the appendices we describe how the CaR specification was determined. As part of that analysis we found that 3 year credit growth has a negative fifth percentile regression coefficient in the CaR at horizon h=12, when we control for house price growth rather than house prices per se, although both the house price growth and credit growth coefficients are statistically insignificant. This suggests that the collateral effect is largely absorbed in this specification, with the remaining signal to consumption tail risk from credit growth appearing to capture the more fragile, late cycle aspect of leverage expansion. This interpretation is more consistent with literature that finds rapid credit growth to be associated with rising downside risks to economic activity (see Schularick & Taylor (2012) and Jordà et al. (2011).

cost. There is evidence that consumption growth tail risk will ease via the household debt-service ratio effect and, initially, via the unemployment effect. However, there appear to be offsetting effects on tail risk depending on which variable is being examined, the extent to which the simulation exercise impacts these variables over time, and the forecasting horizon involved.

In order to shed light on these various effects, we quantify the costs and benefits, in consumption growth terms, on average. This involves setting the key covariates in the CaR model (Eq. 1) to their sample average values and simulating tighter (by one standard deviation) BBM limits to LTV and LTI measures. To give effect to these simulations the LTV ratio is reduced by one standard deviation (5%), or the LTI multiplier is reduced by one standard deviation (0.35) and a final scenario in which both the LTV and LTI are jointly tightened by one standard deviation. By setting the relative variables values to their sample average in this manner, an implicit assumption of ours is that the credit cycle is at a mid-cycle or neutral point, with credit levels neither elevated nor muted.

Table 3. Average costs versus benefits of tighter BBM

Consumption Impact	1yr	2yr	3yr	4yr
LTV tightening - 5% reduction in ratio				
- Cost	-0.025	-0.102	-0.152	-0.167
- Benefit at fifth percentile	0.015	0.033	0.056	0.093
LTI tightening - 0.35 multiplier reduction				
- Cost	-0.025	-0.103	-0.154	-0.169
- Benefit at fifth percentile	0.015	0.034	0.057	0.094
Joint LTV and LTI tightening				
- Cost	-0.048	-0.194	-0.290	-0.323
- Benefit at fifth percentile	0.034	0.057	0.098	0.168

Notes:
This table shows the outputs from two models. Costs are derived from a semi-structural model of the Irish economy and benefits from CaR. Costs and benefits are shown as percentage point changes in consumption growth rate. So an LTV tightening action after 3 years would see the consumption growth rate reduce from its otherwise growth rate by 15.2 basis points. At the same time, the tail risk to consumption growth is less adverse by 5.6 basis points as a result of the same policy action. These results apply to when CAR covariates are at their sample average values. Positive values imply an easing of tail risk.

The consumption-related costs and benefits for each scenario are presented in Table 3: the top panel for LTV tightening only, the middle for LTI tightening, and the bottom for a joint change to both.

Where BBM limits are tightened, costs (negative values) indicate consumption falling relative to a no-change baseline. The semi-structural model shows these costs increasing over four years (Fig. 3 panel 12), as the policy remains in effect and consumption reverts only gradually, absent further intervention.[18] Benefits are measured at the 5th percentile forecast growth rate—representing a severe downturn with extremely weak consumption growth. Positive values reflect a less adverse tail risk than in the baseline.

Several key findings emerge. First, separate LTV and LTI changes have broadly similar effects on consumption growth over four years. Joint tightening nearly doubles the costs relative to either measure alone. Forecast tail risk benefits from joint tightening are also close to double those from a single limit, with maximum benefits four years post-policy change. These results reflect the altered paths of CaR covariates following the simulated policy change. While our tail risk horizon is limited to four years due to forecast uncertainty, the cost–benefit gap narrows over years 2–4, and in some cases benefits may exceed costs in "raw" terms (ignoring risk preferences or likelihoods), depending on economic conditions.

On average, however, costs exceed benefits in raw terms, highlighting the importance of incorporating policymakers' preferences when weighing expected costs against tail risk benefits. This also implies that loosening BBM limits can, on average, yield greater raw benefits than costs, especially at a neutral point in the cycle when systemic vulnerabilities (e.g., credit-to-GDP ratio) are not elevated.

In a later section, we assess how risk preferences might net off these outcomes. This is complicated by differences in i) likelihood of occurrence, ii) timing of impacts, iii) nature of the change (loosening vs tightening), and iv) the policy instrument used.

Accounting for the credit cycle

It is clear from prior literature that the credit cycle plays an important role in shaping the likelihood and extent of financial crises (see Jordà et al. (2011), McCarthy & McQuinn (2017) and Reinhart & Rogoff (2008)). Indeed, macroprudential policy instruments such as BBM (LTV and LTI limits), as well as the countercyclical capital buffer (CCyB), are designed to dampen the financial cycle and to constrain the excessive credit growth that has often characterised previous crises, including the global financial crises of 2008.

[18]The model suggests it can take up to 10 years for macro-financial variables to return to pre-policy levels.

In addition to highlighting the inter-temporal implications of tighter BBM above, it is important from a policymaking perspective whether the impact of a policy change in state-dependent, in particular, whether it interacts differently with each phase of the financial cycle. Accordingly, we now assess the costs and benefits of tighter policy at two distinct points of the cycle capturing different levels of household leverage. The first period coincides with a point in the cycle where Irish household leverage was at a historically high level(in 2007Q4). This may also be considered as representative of a point in time when LTV and LTI would have been relatively high. The second period, 2019Q4 (and thus pre-pandemic), reflects a time when more constrained financial conditions prevailed and Irish household leverage was relatively low. Comparing the results from high- and low-leverage periods, can provide some insight into whether policymakers may need to incorporate nonlinearities when calibrating the macroprudential policy stance.

In terms of the semi-structural model of the Irish economy, testing for state-dependence in the impact of BBM required the partitioning of the data sample into a period during which lending standards were, in retrospect, relatively relaxed (1997Q1 – 2008Q4) culminating in high household leverage by 2007Q4, and a period (2009Q1-2019Q4) corresponding to a period during which lending standards were more stringent, particularly following to introduction of BBM in 2015. We thus re-estimate the semi-structural model's equations for mortgage credit, house prices and household consumption, which are the key equations for the transmission of LTV and LTI shocks, over each of the sub-samples.

The equation of new morgage lending in the semi-structural model has the following form:

$$\begin{aligned} NewMortgages_t = \alpha + \beta_1 NewMortgages_{t-1} + \beta_2 MorRate_t + \beta_3 LTV_t \\ + \beta_4 LTI_t + \beta_5 \Delta HP_{t-1} + \beta_6 \Delta Income_{t-1} + \beta_7 HCompl_{t-1} + \varepsilon_t \end{aligned} \tag{6}$$

where $NewMortgages$ is the volume of real new mortgage lending, $MorRate$ is the real mortgage interest rate, $Income$ is real personal disposable income, HP is the real house price, $HCompl$ is the volume of housing completions, and LTV and LTI are the respective ratios net of demand-side factors. The lagged dependent variable is included to capture persistence in new mortgage lending, while ε is the error term.[19] All variables, except for the mortgage interest rate, are in logs. We first difference income and house prices so that there is a common order of integration among the regressors. Nominal variables are deflated by the consumer expenditure deflator to obtain real values.

[19] As ε denotes the error term in each of the equations below, we define it here for all equations.

The results for the estimation of this model for the full sample, and for both the high- and low-leverage subsamples, are shown in Table 8. The high leverage regime coincided with a period when changes in affordability constraints, as represented by the LTI ratio, appear to have been more important than changes in leverage constraints (as captured by the LTV ratio). Since the financial crisis and the subsequent introduction of the borrower-based macroprudential measures, constraints on the LTV ratio have had a much larger effect on mortgage borrowing. These differences in the relative importance of each instrument in each period are also reflected in the coefficients on income and house price growth. In this period when credit conditions were more relaxed, the latter dominates while the opposite holds in the later period when credit conditions were tighter and household leverage was lower.

The equation for house prices in the semi-structural model follows the inverted demand approach with house prices error-correcting to the following long-run equilibrium:

$$\begin{aligned} HP_t = \alpha + \beta_1 User_t^h + \beta_2 Income_t + \beta_3 (NewMortgages_t/Income_t) \\ + \beta_4 (HStock_t/Pop2539_t) + \beta_5 URX_t + \varepsilon_t \end{aligned} \tag{7}$$

where $User^h$ is the real user cost of housing, $HStock$ is the stock of housing units, $Pop2539$ is the population of 25 to 39 year olds, URX is the unemployment rate, and other variables are as previously defined. The short-run model also includes lagged and contemporaneous changes in these variables.

The parameter estimates for the housing equation for the full sample and each sub-sample are shown in Table 9. The coefficients from the long-run model are reported in the top panel of the table. Intuitively, we find that income is less important as a driver of house prices in *high-leverage* periods, as credit conditions (as reflected in the ratio of new mortgages to income) become more influential. In the *low leverage* 'regime', the coefficient on credit conditions almost halves, while that on income rises to close to unity. The coefficients of the error-correction model are reported in the lower panel of Table 9. We find that error-correction is also faster in the *low leverage* period, likely due to the dampening of credit shocks following the introduction of both borrower- and lender-based macroprudential instruments. There is also some evidence that the determinants of short-run house price dynamics differ across both periods, with changes in credit conditions more important in a *high-leverage* macro-financial environment and changes in household income more important when leverage is relatively low.

The third variable for which we consider state dependence is household consumption. The semi-structural model specifies that household consumption is driven in the long run by disposable income, housing wealth and households' net financial assets:

$$Cons_t = \alpha + \beta_1 Income_t + \beta_2 HWealth_t + \beta_3 NFA_t + \varepsilon_t \tag{8}$$

where $Cons$ is log final consumption expenditure of households, $HWealth$ is log housing wealth and NFA is the log of households' net financial wealth. The coefficients on these variables is constrained to sum to unity in the long-run model. The short-run model also includes lagged and contemporaneous changes in these variables along with the unemployment rate.

The results from estimating this model over each sample period are presented in Table 10. The key differences in the behaviour of consumption across sub-samples relate to the impact of income and financial wealth. In *high leverage* periods, the impact of consumption falls while that of financial wealth increases as households finance more of their spending through credit. In *low leverage* periods, the opposite occurs as the propensity to consume out of income rises and that out of financial wealth falls. In the short run, housing wealth also plays a relatively stronger role in driving consumption dynamics during periods coinciding with high household leverage.

The policy scenarios in the previous section assumed that the impact of macroprudential policy changes were linear and abstracted from potential interactions with the financial cycle. We now consider potential state-dependence in the impact of the BBM rules by simulating a model in which the parameters of the equations estimated above are allowed to 'switch' depending on the degree of household leverage.

To conduct a complete costs-benefit analysis for a *high leverage* period, we proceed as follows. We construct a counterfactual scenario in which the LTV and LTI macroprudential rules were introduced at some notional point in time prior to 2007 (in reality they were not introduced in Ireland until 2015). We further assume that, despite the notional implementation of LTV and LTI policies at some point prior to 2007, the values of the key consumption tail risk determinants match their recorded levels for 2007Q4. We then induce a tightening of the said-imagined LTV and LTI policies to the same extent as in our prior analysis, namely we force a one standard deviation exogenous tightening shock to LTV and LTI limits through the semi-structural model and allow the CaR covariates to adjust according to the new parameters, per Fig. 3 and Tables 8 - 10. As the CaR covariates adjust, we trace the change in consumption growth tail risk by fitting the fifth percentile CaR coefficients to the policy-affected covariates.

This allows us to quantify the intertemporal consumption-related cost and benefit effects of the simulated policy changes from 2007Q4 onwards for the subsequent four years, assuming no other external shock to underlying variables occur over this period (thus, we abstract from the GFC).

Table 4. Cost vs benefits of tighter BBM - high household leverage

Consumption Impact	1yr	2yr	3yr	4yr
LTV tightening - 5% reduction in ratio				
- Cost	-0.0286	-0.061	-0.080	-0.085
- Benefit at fifth percentile	-0.016	0.054	0.088	0.114
LTI tightening - 0.35 multiplier reduction				
- Cost	-0.127	-0.285	-0.375	-0.402
- Benefit at fifth percentile	0.063	0.176	0.331	0.459
Joint LTV and LTI tightening				
- Cost	-0.160	-0.360	-0.474	-0.510
- Benefit at fifth percentile	0.011	0.234	0.477	0.638

Notes:
This table shows the outputs from two models. Costs are derived from a semi-structural model of the Irish economy and benefits from CaR. Costs and benefits are shown as percentage point changes in consumption growth rate. So an LTV tightening action after 3 years would see the consumption growth rate reduce from its otherwise growth rate by 8 basis points. At the same time, the tail risk to consumption growth is less adverse by 8.8 basis points as a result of the same policy action. These results apply to to a point in time when households were highly levered. LTV and LTI values were also high, with 0.95 LTVs and LTI multipliers in excess of 4 not uncommon.

The costs and benefits of LTV and LTI tightening at a highly leveraged (household) point in time are presented in Table 4. There are some similarities between Tables 3 and 4 but there are also several notable differences, some of which may be significant from the policymaker's perspective.

Consistent with the results from Table 3, Table 4 shows that costs and benefits increase over time. This reflects the underlying adjustments to the rate of consumption as well as the other CaR model covariates in response to the individual and joint exogenous shocks to the LTV and LTI ratios (see Fig. 3). The increasing benefits over time (implying lower consumption growth tail risk as a result of policy tightening) is a mechanical response to fitting the fifth percentile CaR coefficients to the covariates which, as above, have responded in a way that implies less adverse tail risk forecasts. In addition, similar to Table 3, the results in Table 4 show that joint LTV and LTI tightening scenarios exhibit larger costs and benefits compared with a tightening of LTV or LTI (but not both jointly).

However, in other cases the results from the state-dependent model are quite different to those from the linear model. In scenarios where only the LTV constraint is tightened, the consumption-related costs and benefits are considerably different in a *highly* *leveraged* scenario compared with costs and benefits of such policy tightening *on average*. For example, expected consumption growth after 2 years post LTV tightening will be 10.2 basis points lower on average, but when applied to a quarter where Irish household leverage was high, such as 2007Q4, the reduction in expected consumption growth is a more modest 6.1 basis points lower, given a tightening of the LTV limit by one standard deviation. Similarly, the average 2 year post-policy change tail risk benefit to the LTV tightening increases from 3.3 basis points on average to 5.4 basis points.

When an LTI tightening is simulated in a *highly leveraged* period, we observe considerably different results to those relating to a simulated LTV tightening. Both costs and benefits related to LTI tightening are considerably higher in Table 4 than those reported in Table 3. For example, after three years have elapsed following the simulated LTI tightening action in the *highly leveraged* sub-sample, we see that consumption is expected to be 37.5 basis points lower than it would have been had no policy change been imposed. The average cost, reported in Table 3 is considerably lower (15.3 basis points). Meanwhile, the benefits increase from an average tail risk improvement of 5.7 basis points to 33.1 basis points when households are highly leveraged. LTI tightening actions therefore appear to be associated with considerably larger tail risk benefits than those associated with an LTV tightening, when lending standards were loose and household leverage increased significantly.

Maximum tail risk gains, representing an improvement in tail risk by up to 63.8 basis points, take place 4 years after a joint tightening of the LTV and LTI limits, when households were highly leveraged. This benefit comes at the cost of a reduction in the expected consumption growth rate of 51 basis points over the same period. These findings suggest that if the policymaker's preference is to mitigate a tail event involving consumption growth, the most significant alleviation of tail risk occurs when household leverage is high and when the policymaker tightens both of the LTV and LTI limits by one standard deviation.

Finally, we examine costs and benefits of simulated policy changes when household leverage is at a low level, such as occurred in 2019Q4. We repeat the same exercise as before, simulating an exogenous shock to LTV and LTI limits, but in this case we apply the *low leverage* parameter estimates from Tables 8 - 10 to the same macro-financial covariates determining consumption growth tail risk in the CaR model. The results are presented in Table 5 and may be compared and contrasted with Tables 3 and 4 as before.

There are several notable differences between Table 5 and each of Tables 3 and 4. Primarily we note that, nominally at least, the costs of policy tightening involving LTV and LTI limits invariably outweigh benefits when households are only modestly leveraged. This is particularly so in the two years post-policy change. An alternative way to look at

Table 5. Cost vs benefits of tighter BBM - low household leverage

Consumption Impact	1yr	2yr	3yr	4yr
LTV tightening - 5% reduction in ratio				
- Cost	-0.167	-0.276	-0.242	-0.106
- Benefit at fifth percentile	0.010	0.049	0.067	0.104
LTI tightening - 0.35 multiplier reduction				
- Cost	-0.124	-0.206	-0.180	-0.077
- Benefit at fifth percentile	0.007	0.040	0.053	0.081
Joint LTV and LTI tightening				
- Cost	-0.278	-0.462	-0.411	-0.193
- Benefit at fifth percentile	0.033	0.078	0.106	0.167

Notes:
This table shows the outputs from two models. Costs are derived from a semi-structural model of the Irish economy and benefits from CaR. Costs and benefits are shown as percentage point changes in consumption growth rate. So an LTV tightening action after 3 years would see the consumption growth rate reduce from its otherwise growth rate by 24.2 basis points. At the same time, the tail risk to consumption growth is less adverse by 6.7 basis points as a result of the same policy action. These results apply loosely to to a point in time when households were historically lowly levered. LTV and LTI values were also low, partially as a result of the introduction of the mortgage measures in 2015.

these results is that in the context of a policy *loosening* action, at a time when household leverage is low, entails gains in expected consumption growth *as well as* at the cost of only a small deterioration of consumption growth tail risk in the near term.

The central point here is that the distribution of consumption growth in the four years following a tighter calibration of BBM limits depends to some extent upon the prevailing level of household leverage at the time. Therefore, it is incumbent upon the policymaker to take the credit cycle and credit conditions into account prior to making any BBM adjustments.

BBM changes and policymaker's risk preferences

Having established the macroeconomic costs and benefits associated with tighter BBM, questions arise in terms of how these are to be evaluated. For instance, are costs and benefits directly comparable? Note, in several cases outlined in Tables 3 – 5, the costs associated with a tightening action outweigh the benefits, especially when households are not highly leveraged. Also, benefits and costs generally increase for up to four years following a policy tightening actions involving BBM limits. As such, the inter-temporal implications of the policy changes form a part of the evaluation process.

Whereas maximal benefits appear to accrue 3-4 years post-policy adjustment, this result is clouded by other considerations. For example, LTI-tightenings yield the largest benefits to tail risk in the medium term (years 3 and 4), especially when household leverage is relatively high, but tail risk benefits are only modest, and in some cases non-existent in years 1 and 2. Therefore, it would appear that the policymaker must weigh several factors in order to weigh up the consumption growth-related implications of tighter BBM limits.

One mechanism to facilitate these factors comes via the assignment of risk preferences to the outcomes detailed in Tables 3 – 5. For example, circumstances might arise in which a policymaker is considering a tightening of the LTV ratio. Knowing that there are consumption growth related trade-offs associated with this policy stance change, a more risk averse agent might prefer to trade a modestly lower "expected" consumption growth rate (see Table 3, upper panel year 2) in return for the tail risk mitigation that accrues at some future point, such as is reflected in year 4. As such, the utility one might ascribe to each outcome comes into focus.

One aspect of utility assessment involves outcome likelihood. The CaR model outputs a forward-looking distribution of consumption growth, at some future point *t+h* quarters ahead, conditional on the explanatory variables' values at time *t*. Each percentile of the forecast distribution is informed by two components, the percentile growth rate itself and the growth rate likelihood. In contrast, the semi-structural model of the Irish economy reveals the conditional growth rate for consumption given a policy change, but it does not report an accompanying growth likelihood. Therefore, within the confines of our cost versus benefit framework, we are unable to directly weight cost and benefit outcomes by their respective likelihoods.

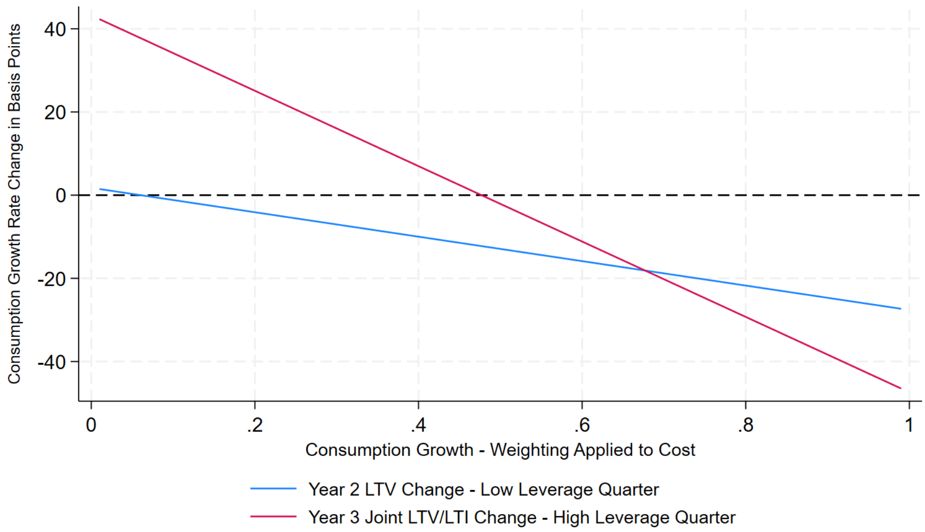
Even were this difficulty to be overcome by assuming the likelihood of occurrence of the CaR's median forecast is a proxy for that of the semi-structural model's forecast growth rate, the problem of the policymaker's omitted risk preferences remains unresolved. Because of these limitations, the Galán (2020) median-to-tail forecast gap policy-evaluation metric cannot be utilised. The metric also fails to take the actual costs and benefits directly into account – it simply measures the distance between the two.

A basic schema might involve attributing weights to the costs and benefits at different points in time. At the policymaker's discretion, these weights might account for risk preferences involving central outcomes versus tail outcomes. In addition, they might account for the phase of the financial cycle, and there may be different weights for LTV policy adjustments versus LTI policy adjustments. Again, weight assignment is simply an expression of the policymaker's preferences, taking a variety of relevant factors into account. In the simplest scheme, weight assignment might involve the following:

$$Netgain = (\alpha).Cost + (1 - \alpha).Benefit \tag{9}$$

Here, α (0<α<100) is the weight a policymaker attributes to the expected consumption growth cost. By taking policy-change induced outcomes and plotting all possible values for α, it is possible to determine the minimum weight applied to the costs and benefits that yield a net positive outcome for the policy change in consumption growth terms. Two examples are depicted in Fig. 4 below.

Figure 4. Simple Weighting Scheme to Appraise Net Cost/Benefit



Note: The figure depicts a simple weighting scheme applied to two of the outcomes described in Tables 3 to 5. Weight applied to the cost outcome is shown on the x-axis, the y-axis reflects annual consumption growth rate net cost (-) or benefit (+) in basis points. The lines reflect all weights from .01 to .99, applied to costs and trace the net cost/benefit of the relevant policy change. The red line shows the Year 3 cost vs benefits under different weightings of a joint LTV / LTI 1 s.d. tightening action in a quarter (2007Q4) when households were highly levered. The blue line traces the Year 2 costs/benefits, under weightings, of an LTV 1 s.d. tightening when household leverage was relatively low (2019Q4)

We examine two of the outcomes reported in Tables 3 to 5. In Fig. 4, the lines show the net cost or benefit of the policy change, applying all weights from 0.01 to 0.99 to the cost of the policy action. Where the line appears above 0 on the y-axis, this implies a net positive benefit for all weights applied to cost up to the point at which it crosses the x-axis. The further to the right this intersection happens to be, the higher the weight that would have to be applied to the policy change's cost outcome in order for a net negative consumption growth outcome to prevail. More risk averse policymakers may prefer to mitigate tail risk at the cost of a modest expected consumption growth cost and so might give a low weight to costs and a correspondingly higher weight to the benefits. A less risk averse person might assign higher weights to costs and lower weights to benefits.

For example, the blue line applies to a "low" leverage environment (2019Q4,) with tail risk benefits estimated at the 5th percentile and where the policy action involved a one standard deviation tightening of the LTV ratio only. Any weighting applied to costs above 0.07 will yield a net negative outcome. By contrast, the red line examines costs and benefits in a "highly leveraged" environment (2007Q4) and involves a one standard deviation tightening of both LTV and LTI simultaneously. In this scenario, a weighting above 0.47 would have to be attributed to the policy cost in order for a net negative outcome to prevail. Any cost weighting below this limit will see a positive consumption growth outcome, taking risk preferences into account.

Rather than the informal and somewhat arbitrarily subjective weighting scheme implied by Fig 4, a more objective multi-faceted schema can be designed to help inform the weightings. For example, higher weights might be applied to near term outcomes rather than ones beyond year 2 of the policy adjustment. Thus the inter-temporal cost and benefit benefit outcomes could be facilitated. For example, a risk averse policy maker might give higher weights to tail risk benefits in years 3 and 4 because there exists enough time for policy interventions to take effect in the interim. Going further, one might incorporate a utility function to take one's risk preferences into account and assign or adjust weights according to one's preference for tail risk gains relative to expected outcome costs. One might also adjust weights according to the likelihood of each outcome. There are myriad additional factors that might be incorporated within such a weighting scheme. However, this analysis likely represents a separate research topic and is beyond the scope of this paper, albeit that it represents an area we recommend for additional research and analysis.

A more rigorous treatment, one that accounts for intertemporal costs and benefits of policy changes, is possible by the adoption of the welfare function described in Cecchetti & Suarez (2021) and described in Eq. 10

$$W = \bar{y} - 1/2\omega(\bar{y} - y_c)^2 \tag{10}$$

Here, welfare W is a function of the expected consumption growth rate $\bar{y}$ the tail risk to consumption growth y_c, and the aversion to risk of a policy agent with constant average risk aversion (CARA) parameter ω. The choice for ω is subjective and may be increased or decreased as required to account for the tail risk tolerance of the agent.

Figure 5. Use of Welfare Function to Appraise Costs vs Benefits

Note: The figure depicts a weighting scheme (see Cecchetti & Suarez (2021)), applied to one of the outcomes described in Tables 3 to 5. The x-axis traces the welfare function over years 1 to 4 post-policy action, the y-axis reflects the value of the welfare function W. The red line reflects welfare had no policy change been applied, the blue line reflects welfare after the policy change is made. Here, the policy change involves a 1 s.d. tightening of both LTV and LTI when household leverage was high, IE 2007Q4 data.

In our example we set $\omega = 2$, following Cecchetti & Suarez (2021). Two traces of W over a four year period, the first involving a baseline where no policy action takes place (based off 2007Q4 data for IE) and a second counterfactual scenario wherein both LTV and LTI were tightened by one standard deviation jointly, is depicted in Fig. 5. As time progresses following the policy intervention, welfare has increased in the subsequent years, reflecting the consumption related overall benefits of the revised policy stance from, in this case, 2007Q4 onwards.

As such, societal welfare, as captured by a function such as Eq. 10, might also represent one of the factors used in the design of the weighting scheme referenced above.

Conclusion

In this paper, we employ a semi-structural model of the Irish economy to estimate the marginal macro-financial effects of changes to LTV and LTI borrower-based mortgage (BBM) limits on consumption growth, house prices, the credit-to-GDP gap, the unemployment rate, and the household debt-service ratio. Lower limits are interpreted as a tighter BBM policy stance, while higher limits imply a looser stance. When consumption growth declines following a one standard deviation reduction (tightening) in these limits, we quantify the extent of the reduction and interpret this as the ***cost*** of an exogenously generated tightening of the BBM framework.

Because each of the affected macro-financial variables also informs the tail risk to consumption growth in our novel consumption-growth-at-risk model, we are also able to evaluate how tail risk adjusts dynamically after a one standard deviation tightening of LTV and LTI limits. In circumstances where the tail risk appears less adverse under tighter limits, *ceteris paribus*, we interpret the improvement in tail risk as the ***benefit*** of BBM tightening in terms of consumption growth outcomes.

Our results indicate that tighter LTV and LTI limits are associated with lower expected consumption growth. For instance, a one standard deviation tightening of both the LTV ratio (equivalent to a five percentage point reduction, such as from 85% to 80%) and the LTI multiple (a reduction of 0.35, such as from 3.5 times income to 3.15 times income) lowers expected consumption growth by approximately 32 basis points after four years relative to the baseline without policy adjustment.

At the same time, our results show that tail risk to consumption growth improves following the same policy action. Specifically, the 12-quarter-ahead (T+12Q) tail risk to consumption growth is reduced by almost 17 basis points on average, four years after the introduction of tighter limits, reflecting the dynamic adjustment of covariates in the consumption-at-risk model.

We also examine the state dependence of the financial cycle in our analysis. By dividing the sample into two sub-periods and re-estimating the semi-structural model, we illustrate how the effects of BBM tightening vary depending on the prevailing financial conditions. The first sub-sample, covering 1997Q1–2008Q4, corresponds to a period of relatively loose financial conditions, culminating in historically high household leverage. The second sub-sample, covering 2009Q1–2019Q4, represents a period of relatively tight conditions, with household leverage at historically low levels by the end of the period.

The revised estimates shed light on how expected consumption growth and tail risk respond differently across the financial cycle. As shown in Tables 4 and 5, the costs and benefits of BBM tightening appear greater when household leverage is elevated following a period of loose financial conditions. For example, had both LTV and LTI limits been tightened by one standard deviation in 2007Q4, expected consumption growth by 2011Q4 would have been approximately 51 basis points lower, while the T+12Q tail risk would have improved by as much as 64 basis points.

We propose two complementary approaches by which policymakers may appraise these costs and benefits, each of which accounts for differing degrees of risk tolerance and preference. More broadly, we underscore the importance of financial cycle conditions for prospective policy adjustments, thereby enabling policymakers to better assess the timing of potential BBM recalibrations.[20]

As an illustration, we show how a welfare function—incorporating both expected consumption and tail risk to consumption growth, following Cecchetti & Suarez (2021) (see Fig. 5), can help weigh the relative value of costs and benefits in light of policymakers' risk aversion. This approach enables consistent appraisal of the costs and benefits of BBM adjustments over a horizon of up to four years after policy implementation.

Following the 2008 financial crisis, many central banks and national authorities adopted macroprudential policy instruments. As post-implementation data accumulates, particularly in panel data contexts, it is increasingly feasible to assess the ancillary macro-financial costs and benefits of these policies using approaches similar to the one advanced in this paper.

[20] In the sample period covered by our panel, the financial cycle may also proxy for the initial values of LTV and LTI ratios, which were relatively high at the peak of the credit cycle and low during its subsequent downturn.

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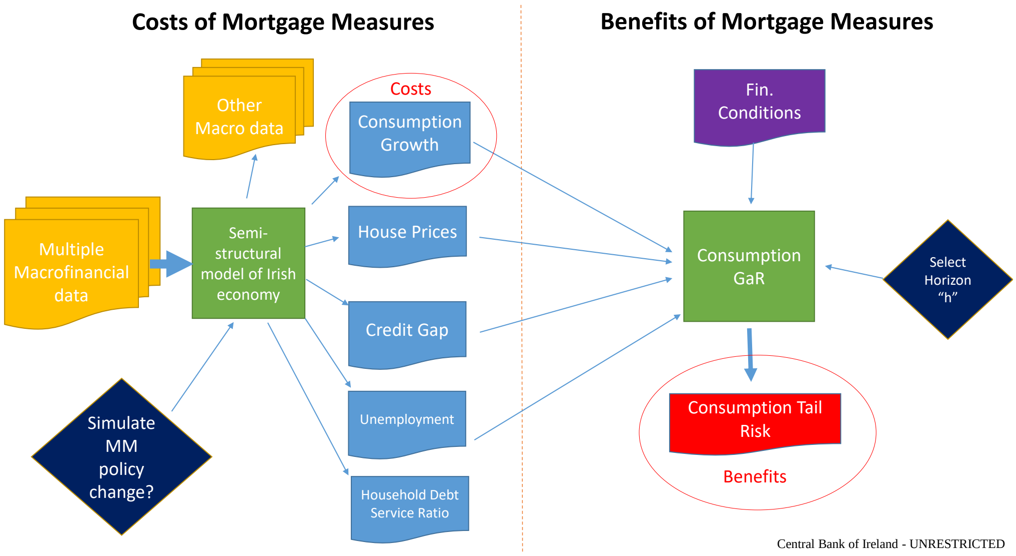
Appendices

Figure 6. Model Framework and Interaction



Note: The chart reflects a tightening action involving MM. In such circumstances the semi-structural model reflects a consumption growth cost and the CaR model reflects a benefit (tail risk reduction).

Derivation of the Consumption at Risk Specification

The steps taken to determine the novel CaR model specification involve the following. First, we apply the adapative Lasso method of Szendrei & Varga (2023), whereby a relatively large initial set of regressors, informed by the consumption literature described above, are reduced by a formalised process that penalises and eliminates covariates having little statistical significance or effect in the quantile regressions used to estimate consumption growth tail risk (5th percentile quantile regressions). We pay attention to the choice of forecast horizon "h" at this stage also, because our cost vs benefits scenarios involve policy changes and we wish to facilitate the intertemporal trade offs involved in the policy change over a medium term horizon. As such, we set quantile "q" to 5, and forecast horizon "h" to 8 quarters and then to 12 quarters while perform the adaptive Lasso method (see also Bondell et al. (2010) and Jiang et al. (2014)).

This process involves estimating the following set of equations:

$$\hat{\beta}(\tau) = min_{\beta,\alpha} \sum_{q=1}^{Q} \sum_{i=1}^{n} \rho_{\tau_q}(y_i - \alpha_{\tau_q} - x_i^T \beta_{\tau_q}) \tag{11}$$

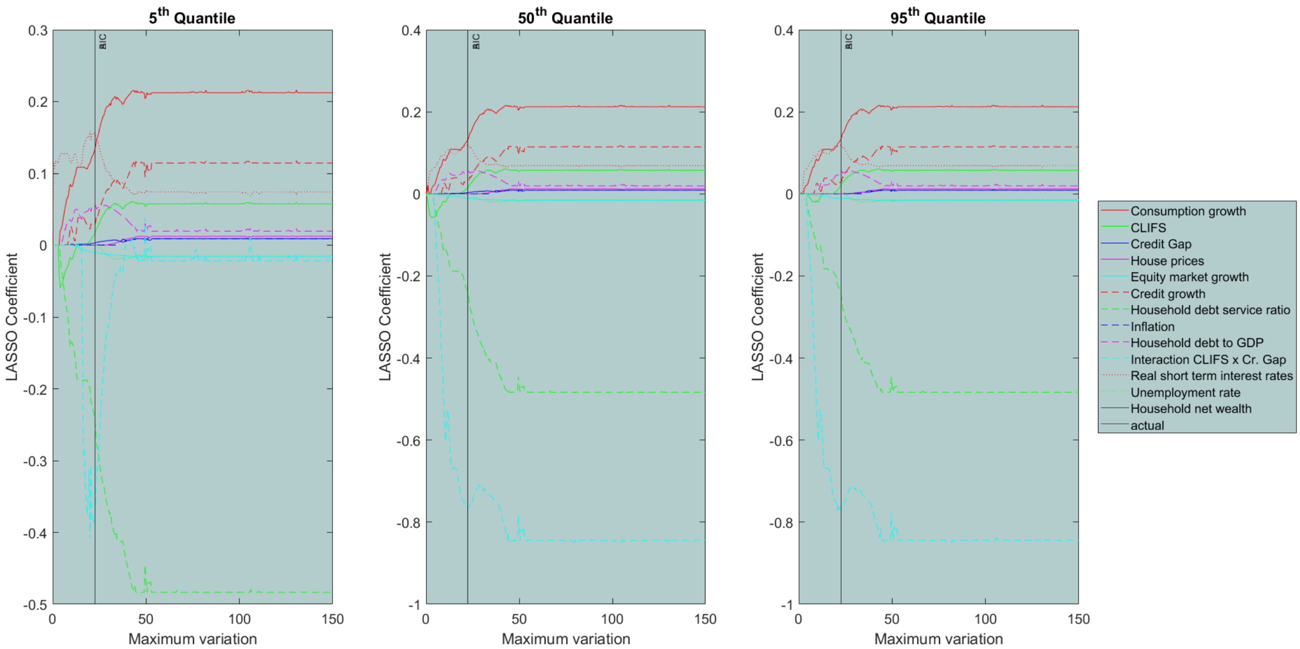
$$s.t.\ \alpha_{\tau_q} + X^T \beta_{\tau_q} \geq \alpha_{\tau_{q-1}} + X^T \beta_{\tau_{q-1}} \tag{12}$$

$$\sum_{q=1}^{Q} \sum_{k=1}^{K} w_{k,\tau_q} |\beta_{k,\tau_q}| \leq t^* \tag{13}$$

The equations describe an AdaLASSO (adaptive LASSO) shrinkage with weights $w_{(k,\tau_q)} = |\Theta_{k,\tau_q}|^{-1}$ being the estimated coefficients of a regular quantile regression (Q), with a full design matrix and $\rho_{\tau,q}$ is the tick loss function (see Koenker & Basset (1978)). The second constraint is the AdaLASSO constraint which imposes that the sum of the coefficients be at most t. To obtain the optimal global parameter, t^*, a grid search is employed. The model with the lowest information criteria (AIC or BIC) is considered optimal. Regressors with coefficient values furthest from zero are candidates for further consideration, given their significant consumption tail risk association (see 7)

This analysis is suggestive of the variables most strongly correlated with Irish consumption growth tail risk, but it is may be less so, given the single-country limitations of the methodology, in the context of the wider panel. The results of this analysis are presented in Fig. 7. As can be seen, current consumption growth and household debt service ratio appear to have strong predicitive power, however the technique shrinks the coefficients on inflation and the household debt-to-GDP variables close to zero, thereby rendering them less relevant in the context of consumption growth tail risk to the Irish economy.

Figure 7. Adaptive LASSO Variable Selection For IE



Note: 5th, 50th and 95th percentile coefficients following adaptive LASSO treatment, per Szendrei & Varga (2023). Forecast horizon "h" = t+12 ahead. Shrunk coefficients have values close to or equal to zero (e.g. inflation) and appear less informative than those furthest from zero (e.g. debt service ratio). All variables are standardised. AIC and BIC scores overlap.

Next, we examine the forecast properties of various model specifications encompassing covariates highlighted by the above analysis. For instance, one prospective specification implied by the above involves running the following quantile regression:

$$\Delta Cons_{i,t+h,\tau} = \alpha_{i,\tau} + \beta 1_j Consgrow_{i,t} + \beta 2_j CLIFS_{i,t} + \beta 3_j Gap_{i,t} + \beta 4_j CLIFS.Gap_{i,t} + \epsilon_{i,t} \quad (14)$$

Here, the dependent variable is the Canay (2011) treated average annualised growth rate from *t* to *t+h*, where *h* (range 1-16) is a future quarter, $Consgrow_{i,t}$ is the consumption growth rate from *t-4q* to *t*, $CLIFS_{i,t}$ is a country-level index of financial stress and the financial vulnerability indicator $Gap_{i,t}$ is the total credit-GDP gap. As before, countries are indexed by *i* and quantiles by τ. The forecast horizon *h* is an input parameter.

We examine the in-sample and out-of-sample fit of this model's residuals relative to the fit of a benchmark specification, the latter being an (AR(1) model where only current annual consumption growth from *t-4Q* to *t* is estimated. In practice, the approach is identical to that of Lang et al. (2023), where a *tick loss function* is used to measure model fit according to the following:

$$TL_{h,\tau} = (\tau - \mathbf{1}(\hat{\epsilon}_{h,\tau} < 0))\hat{\epsilon}_{h,\tau} \quad (15)$$

Here, $\mathbf{1}()$ denotes the indicator function. We selected $\tau = 0.05$ for this exercise, given our primary focus on the tail risk of consumption growth.

A subset of the specifications examined tick loss' results are outlined in Table 6. The specification outlined in row 1 shows that the 1 year ahead (T+4Q) in-sample model fit (per the tick loss function) is improved by 9.55% over a baseline AR(1) specification. However, out-of-sample forecast residuals show that specification 1 underperforms an AR(1) model by 2.42% with respect to year 2 forecasts. In fact, the AR(1) baseline outperforms several multivariate specifications in terms of out-of-sample tick loss.

As a prospective operational risk management tool, our view is that a CaR model should yield improved out-of-sample forecasts to justify its selection ahead of an AR() model. Ideally, it should also reliably improve the model fit across all forecast horizons. As such, specification 6 appears to be best suited for our purposes. Note, model 6 would also be the preferred specification according to Lang et al. (2023), who rank the various specifications they consider according to the optimal in-sample tick loss improvement over a 2 year ahead forecast horizon.

Table 6. Improvement in Tick Loss function (5th percentile)

Spec No.	Model Specification	In Sample				Out of Sample			
		Yr 1.	Yr. 2	Yr. 3	Yr. 4	Yr. 1	Yr. 2	Yr. 3	Yr. 4
1	Curr. Cons. Growth, CLIFS	9.55	4.66	5.31	3.67	-0.73	-2.42	2.31	8.55
2	Curr. Cons. Growth, CLIFS, Credit-to-GDP Gap	8.83	13.36	17.53	19.13	-12.48	-26.72	-43.79	-68.17
3	Curr. Cons. Growth, CLIFS, Credit-to-GDP Gap, H/hold Debt. Svc. Ratio	37.36	44.84	51.03	54.74	-6.86	-21.17	-21.03	-13.78
4	Curr. Cons. Growth, CLIFS, Credit-to-GDP Gap, H/hold Debt. Svc. Ratio, House Prices	39.29	48.56	51.39	54.87	-2.44	-6.50	2.85	9.14
5	Curr. Cons. Growth, CLIFS, Credit-to-GDP Gap, H/hold Debt. Svc. Ratio, House Prices, Unemployment Rate	44.57	50.42	54.94	57.34	5.51	-2.44	3.28	15.39
6	Curr. Cons. Growth, CLIFS, Credit-to-GDP Gap, H/hold Debt. Svc. Ratio, House Prices, Unemployment Rate, CLIFS x Credit-to-GDP Gap	47.37	52.42	55.40	57.61	5.25	1.19	4.49	15.96

Notes: Shows Tick Loss percentage point improvements (+) and inferior fit (-) of the model relative to the reported tick loss of an AR(1) specification where only current growth is estimated. The best model is model 6 as it improves upon an AR(1) specification at all horizons for both in and out of sample forecasts. Model 6 would also be the preferred specification according to Lang et al. (2023) whose approach to model selection we have adopted. The model is estimated over the period 1980Q - 2010Q4 for in-sample forecasts, and fitted to data from 2011Q1-2021Q4 for out-of-sample results.

Table 7. Term Structure of Tail Risk Determinants

Variables	(1) y1	(2) y2	(3) y3	(4) y4	(5) y5	(6) y6	(7) y7	(8) y8	(9) y9	(10) y10	y11	y12	y13	y14	y15	y16
Current Consumption Growth Rate	0.00143	0.00835	0.0111***	0.0116***	0.0133***	-0.000531	0.00243	-0.00119	-0.00458	-0.00183	-0.00272	-0.00250	-0.00148	-0.000829	-0.00302	-0.00420*
	(0.00705)	(0.00613)	(0.00369)	(0.00436)	(0.00286)	(0.00566)	(0.00448)	(0.00372)	(0.00448)	(0.00475)	(0.00336)	(0.00368)	(0.00265)	(0.00245)	(0.00235)	(0.00235)
Country Level Index of Financial Stress (CLIFS)	-0.0150***	-0.00938	-0.0184**	-0.00189	-0.00791	-0.0146**	-0.00111	-0.00791	-0.00734*	0.000495	-0.000293	-0.000216	-0.000198	-0.000795	-0.00113	-0.00273
	(0.00374)	(0.00776)	(0.00809)	(0.00633)	(0.00545)	(0.00718)	(0.00512)	(0.00519)	(0.00420)	(0.00266)	(0.00275)	(0.00196)	(0.00162)	(0.00166)	(0.00155)	(0.00246)
House Prices	0.00107	-0.000324	0.00102	0.00272	0.00206	0.000649	-0.00502	-0.00401	-0.00355	-0.00418	-0.00608**	-0.00594**	-0.00460***	-0.00490***	-0.00392***	-0.00347**
	(0.00493)	(0.00591)	(0.00575)	(0.00487)	(0.00454)	(0.00461)	(0.00455)	(0.00401)	(0.00300)	(0.00317)	(0.00247)	(0.00234)	(0.00159)	(0.00138)	(0.00136)	(0.00167)
Unemployment Rate	0.00788	0.0164***	0.0205***	0.0169***	0.0168***	0.0109**	0.00391	0.00351	0.00173	-0.000365	-0.00263	-0.00285	-0.00221	-0.00156	-0.00211	-0.00228
	(0.00506)	(0.00624)	(0.00505)	(0.00524)	(0.00461)	(0.00442)	(0.00456)	(0.00393)	(0.00339)	(0.00359)	(0.00315)	(0.00246)	(0.00245)	(0.00200)	(0.00206)	(0.00191)
Household Debt Service Ratio	-0.0142***	-0.0137***	-0.0128***	-0.0133***	-0.0102***	-0.0117***	-0.00945***	-0.00870***	-0.00804***	-0.00769***	-0.00536***	-0.00500***	-0.00610***	-0.00570***	-0.00625***	-0.00673***
	(0.00355)	(0.00393)	(0.00284)	(0.00297)	(0.00277)	(0.00266)	(0.00240)	(0.00240)	(0.00212)	(0.00259)	(0.00173)	(0.00146)	(0.00121)	(0.000909)	(0.00102)	(0.00106)
Credit to GDP Gap	0.00390	0.0115	0.0205***	0.0196***	0.0233***	0.0208***	0.0132***	0.0130***	0.0114***	0.00835***	0.00678***	0.00512***	0.00375**	0.00337**	0.00211	0.00200
	(0.00461)	(0.0116)	(0.00765)	(0.00588)	(0.00383)	(0.00402)	(0.00273)	(0.00285)	(0.00252)	(0.00247)	(0.00206)	(0.00152)	(0.00175)	(0.00171)	(0.00160)	(0.00214)
Credit to GDP Gap x CLIFS	-0.00167	-0.00207	0.00323	-0.00456	0.00164	0.00258	-0.00285	0.00110	0.000876	-0.00305**	-0.00256	-0.00348**	-0.00352***	-0.00346***	-0.00341**	-0.00110
	(0.00360)	(0.00758)	(0.00548)	(0.00526)	(0.00361)	(0.00341)	(0.00336)	(0.00270)	(0.00263)	(0.00155)	(0.00188)	(0.00141)	(0.000973)	(0.00118)	(0.00146)	(0.00163)
Constant	-0.0367***	-0.0349**	-0.0422***	-0.0398***	-0.0436***	-0.0369***	-0.0257***	-0.0243***	-0.0224***	-0.0176***	-0.0143***	-0.0114***	-0.0105***	-0.00863***	-0.00790***	-0.00775***
	(0.00471)	(0.0141)	(0.0102)	(0.00776)	(0.00691)	(0.00643)	(0.00452)	(0.00451)	(0.00341)	(0.00360)	(0.00311)	(0.00279)	(0.00232)	(0.00201)	(0.00220)	(0.00206)
Observations	1,011	1,011	1,011	1,011	1,011	1,011	1,011	1,011	1,011	1,011	1,011	1,011	1,011	1,011	1,011	998

Notes:
This table shows the fifth percentile quantile regression results of the CaR specification at forecast horizons ***h*** from 1-16 quarters ahead. Negative coefficients imply that marginal increases in the covariate are associated with more adverse tail risk. In all regressions the dependent variable is the average annualised consumption growth rate. It has been adjusted according to the method described in the paper (see also Canay (2011)). The model is pooled across the panel, i.e. there are no country fixed effects included.
The data sample is drawn from the cross country panel of OECD countries described in the data section above (see 2

Table 8. Equation for New Mortgages in the Semi-Structural Macroeconomic Model

	Full Sample	High Leverage	Low Leverage
Constant	-0.512*	-0.911*	-0.152
	(1.6)	(1.7)	(0.3)
$NewMortgages_{t-1}$	0.698***	0.692***	0.372
	(4.4)	(9.6)	(1.5)
$MorRate_t$	-0.033***	-0.026***	-0.019***
	(4.5)	(4.1)	(5.1)
LTV_t	0.812**	0.329*	1.352**
	(2.2)	(1.8)	(2.4)
LTI_t	0.332**	0.591***	0.381**
	(2.0)	(5.2)	(2.0)
$\triangle$ HP $_{t-1}$	0.652***	1.163***	0.788***
	(2.7)	(4.9)	(3.0)
$\triangle$ $Income_{t-2}$	1.112**	0.459*	1.351**
	(2.4)	(1.8)	(2.0)
$HCompl_{t-1}$	0.165*	0.185***	0.261*
	(1.9)	(3.1)	(1.8)
Adj. R^2	0.981	0.987	0.918
Sample	1997Q1-2019Q4	1997Q1-2008Q4	2009Q1-2019Q4

Notes:
Table 8 shows the estimation results of equation (6) for real new mortgage borrowing (*NewMortgages*) over the full sample, and separately over a high and low leverage sub-sample. *MorRate* is the real mortgage rate. *LTV* and *LTI* are the loan--to-value and loan-to-income rations for first-time buyers, respectively. *HP*, *Income*, and *HCompl* are real house prices, real personal disposable income and housing completions, respectively. All variables are in logs except for the mortgage rate. *t*-statistics are in parenthesis. Statistical significance of the coefficients shown as ***, ** and * at the 1%, 5% and 10% levels respectively. Data sample drawn from the semi-structural model of the Irish economy.

Table 9. Equation for House Prices in the Semi-Structural Macroeconomic Model

	Full Sample	High Leverage	Low Leverage
Dependent Var.:	HP_t	HP_t	HP_t
Constant	-3.377***	-2.151***	-1.888
	(3.7)	(2.6)	(0.65)
$User_t$	-0.006***	-0.005***	-0.007***
	(4.2)	(5.4)	(8.4)
$Income_t$	1.093***	0.755***	0.962***
	(9.8)	(6.9)	(4.0)
$NewMort_t/Income_t$	0.253***	0.351***	0.185***
	(4.5)	(7.9)	(9.9)
$HStock_t/Pop2539_t$	-0.891**	-0.722**	-0.967*
	(2.1)	(2.2)	(1.9)
URX_t	-0.141***	-0.181***	-0.072*
	(5.5)	(8.7)	(1.9)
Dependent Var.:	ΔHP_t	ΔHP_t	ΔHP_t
ECT_{t-1}	-0.171**	-0.132***	-0.291***
	(2.0)	(2.6)	(3.1)
$\Delta Income_t$	0.237***	0.180***	0.263**
	(2.6)	(4.9)	(2.0)
ΔURX_t	-0.075**	-0.091***	-0.083**
	(2.3)	(2.6)	(2.2)
$\Delta(NewMort_{t-1}/Income_{t-1}$	0.085*	0.229**	0.050
	(1.8)	(2.0)	(0.8)
ΔHP_{t-1}	0.634***	0.549***	0.739***
	(2.7)	(5.3)	(4.7)
Adj. R^2	0.659	0.721	0.834
Sample	1997Q1-2019Q4	1997Q1-2008Q4	2009Q1-2019Q4

Notes:

Table 9 shows the estimation results of equation (7) for real house prices (*HP*) over the full sample, and separately over high and how leverage subsamples. *User* is the user cost of housing. *HStock* is the housing stock. *Pop2539* is the number of 25 to 39 year olds in the population. *URX* is the unemployment rate. *ECT* is the error correction term. All variables except for the user cost are in logs. *t*-statistics are in parentheses. Statistical significance of the coefficients shown as ***, ** and * at the 1%, 5% and 10% levels respectively. Data sample drawn from the semi-structural model of the Irish economy.

Table 10. Equation for Consumption in the Semi-Structural Macroeconomic Model

	Full Sample	High Leverage	Low Leverage
Dependent Var.:	$Cons_t$	$Cons_t$	$Cons_t$
Constant	0.484***	0.632***	0.427***
	(5.6)	(8.4)	(7.9)
$Income_t$	0.815***	0.756***	0.829***
	(8.4)	(5.4)	(9.4)
$HWealth_t$	0.088**	0.093**	0.083**
	(2.3)	(2.1)	(2.3)
NFA_t	0.097	0.151	0.088
	(na)	(na)	(na)
Dependent Var.:	$\Delta Cons_t$	$\Delta Cons_t$	$\Delta Cons_t$
ECT_{t-1}	-0.230***	0.242***	0.317***
	(6.8)	(3.4)	(3.2)
$\Delta Income_t$	0.193***	0.145***	0.154***
	(4.4)	(2.6)	(2.7)
$\Delta HWealth_{t-1}$	0.085*	0.197	0.321***
	(1.8)	(1.5)	(2.6)
ΔURX_t	-0.048***	-0.036*	-0.089***
	(3.4)	(1.9)	(3.7)
Adj. R^2	0.591	0.654	0.689
Sample	1997Q1-2019Q4	1997Q1-2008Q4	2009Q1-2019Q4

Notes:
Table 10 shows the estimation results of equation (8) for real personal consumption (*Cons*) over the full sample, and separately over high and how leverage subsamples. *HWealth* is real housing wealth. *NFA* are households' net financial assets. *ECT* is the error correction term. The coefficients on income, housing wealth and net financial wealth are constrained to sum to one in the long-run model. All variables are in logs. *t*- statistics are in parentheses. Statistical significance of the coefficients shown as ***, ** and * at the 1%, 5% and 10% levels respectively. Data sample drawn from the semi-structural model of the Irish economy.

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