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A Revised Financial Satellite Model for COSMO

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Abstract

This working paper provides an updated overview of the financial block satellite model in COSMO. This block allows for an analysis of macro-financial relationships and links these back into the main COSMO specification. The critical importance of appropriately assessing macro-financial linkages in any assessment of macroeconomic stability and financial resilience has been clearly demonstrated by the global financial crisis in 2007. In light of this, considerable work has been done since the crisis to update macroeconomic models to take account of financial channels and assess financial stability risks. This update to the suite of macro-financial linkages in COSMO revisits equations for financial distress (mortgage arrears and firm insolvencies), mortgage, consumer and non-financial credit, house prices and housing supply. A new exogenous policy variable related to regulatory bank capital is also incorporated. The paper provides updated equations and estimations of long and short run relationships. It also provides an overview of the linkages with COSMO and provides an illustration of how a shock to the banking sector capital ratio propagates through the satellite model and the broader macroeconomic model.

Keywords: COSMO; Mortgage Credit; Macro-prudential Regulation; Financial Distress

1 Introduction

The importance of accounting for financial channels in macroeconomic models has been demonstrated by the fallout from the global financial crisis of 2007-2009. Standard macroeconomic frameworks without financial frictions have been shown to miss vital financial stability risks (Caballero, 2010; Blanchard, Dell'ariccia, & Mauro, 2010). In light of this, considerable work has been done on the macroeconomic modelling front to adapt and develop integrated macro financial models which can properly account for linkages between the real and financial economies. From a policy perspective, a considerable amount of work has been undertaken to adapt these macro-financial models to account for macro-prudential regulatory instruments which have gained in prominence as financial stability levers. This includes the modelling of bank capital regulations such as the counter-cyclical capital buffer or borrower based measures such which limit borrower leverage as well as using macro-financial models to undertake bank stress tests (Acharya, Engle, & Pierret, 2014; Buncic & Melecki, 2013; Claessens, 2014).

For the Irish economy, considerable work was previously completed on the original COSMO model to account for macrofinancial linkages (see for example Bergin et al. (2017); McInerney (2016, 2019, 2020)). This framework has been used to analyse various macro-prudential shocks such as developments in the counter-cyclical capital buffer as well as changes to borrower-based measures such as the loan-to-value and loan-to-income ratio (Duffy, McInerney, & McQuinn, 2016). Having models which can appropriately assess these linkages is critically important to understand the macro-financial feed-backs in Ireland and to test the parameterisation and calibration of policy instruments.

In this working paper, we revisit the financial block satellite within the COSMO model with the following aims: first, we aim to update the estimation of the model to take into account more recent data as the previous version had used data to the end of 2015. Therefore, we now expand the estimation sample to cover the period to the first quarter of 2020. Where appropriate, we stop the estimation at the onset of the Covid-19 pandemic due to the particular impact of that crisis on the trend in key variables (such as the unemployment rate); second, we adapt some of the empirical equations to align these with more recent developments in the literature. For example, in the financial distress models, we include the introduction of a double trigger component in the mortgage arrears equation and a replacement liquidity measure in the insolvencies equation. We also make some simplifying assumptions around model specifications which allow a more user friendly integration with the overall COSMO model. This step is in part motivated by changes that occurred to coefficients when re-estimating on the larger sample. This required changes to the specification to ensure findings remained in line with existing literature. Finally, we have changed the relationship for the banking sector capital ratio from a deterministic equation to an exogenous variable which impacts the financial block across the residential, corporate and consumer lending markets. This is motivated by the requirement for this variable to capture regulatory changes to capital levels. We also use new data on CET1 capital levels to input for this variable.

This paper also aims to provide a broad overview of the model, how the various financial factors interact across equations and how they link back at present to the broader COSMO model, matching real economy and financial channels. The model is composed of 10 equations across the housing and banking sectors. It models three specific credit markets (mortgage market, consumer credit, and non-financial corporate loans) with separate demand and interest rate supply equations. It provides macro-financial equations to measure mortgage arrears and corporate insolvencies which allows for a monitoring and analysis toolkit for financial distress. It also provides a deterministic model of both house prices and housing supply.

To demonstrate the long and short run linkages within the satellite model, the paper also deploys a specific credit supply shock by increasing the banking sector capital ratio by 1 percentage point and a subsequent analysis of how this propagates through both the real and financial economy is carried out. This shock could be seen as a demonstration of how a change to policy levers such as the counter-cyclical capital buffer, systemic risk buffer, or general macro prudential tools around bank capital link through to lending and housing market channels. Theoretically speaking, this shock should propagate through the model by impacting the cost of lending which lowers credit demand and increases the cost of capital thus lowering investment and consumption (through the housing wealth channel).

The rest of the paper is structured as follows: Section 2 presents our equations to measure mortgage arrears and corporate liquidations. Section 3 discuss the inclusion of the exogenous policy variable related to regulatory bank capital. Section 4 presents the equations for the mortgage and housing markets, Section 5 presents the equations for consumer and non-financial corporate credit and interest rates while Section 6 discusses the models inter-linkages as well as its linkages with the wider COSMO model while also presenting an illustrative shock to the banking sector capital ratio. Finally, Section 7 concludes.

2 Financial Distress

A defining feature of the recent financial crisis in Ireland was a considerable rise in impairments of household and corporate loans. The extension of credit on imprudent lending terms led to the build up of considerable asset quality problems which were exposed when the economy deteriorated (McCarthy & McQuinn, 2017). This inter-linkage between financial distress (as measured by loan arrears or insolvencies) and the lending channels is an important aspect to consider in any macro-financial model. In this section, we present our equations to model household mortgage arrears and corporate insolvencies.

2.1 Modelling Mortgage Arrears

The drivers of mortgage arrears have been the subject of very considerable research over the past number of years both in an international context (Elul, Souleles, Chomsisengphet, Glennon, & Hunt, 2010; Foote, Gerardi, & Willen, 2008; Haughwout, Peach, & Tracy, 2008; Mayer, Pence, & Sherlund, 2009) and more specifically for Ireland (Kelly & O'Malley, 2016; Lydon & McCarthy, 2013). This research outlines the main triggers of mortgage default coming through both affordability (changes in labour market outcomes as well as interest rates) and changes in housing equity. These factors also interact in what is known as the *double trigger* effect whereby labour market shocks or changes to affordability through higher interest rates compound the impact of negative equity and vice-versa. OToole and Slaymaker (2021) show that double trigger effects are notable in an Irish context.

To capture these channels, we model arrears as a function of aggregate housing equity, the unemployment rate (to capture the labour market channels) and the interaction between these two variables to capture the double trigger. To allow for the interest rate impact on affordability, we also include the mortgage lending rate. Interest rate triggers are more important in markets like Ireland where variable or floating rate mortgages predominate. The standard long run specification of the arrears equation is therefore expressed as;

$$\begin{aligned} arrears_t &= \alpha + \beta_1 hhequity_t + \beta_2 urx_t \\ &+ \beta_3 \left(hhequity_t \times urx_t \right) + \beta_4 rmt_t + t + \epsilon_t \end{aligned} \tag{1}$$

where *arrears* is mortgage arrears of 90 plus days on a principle dwelling house, *hhequity* is household equity as defined in Table 1, *urx* is the unemployment rate and *rmt* is the residential mortgage lending rate.[1]

We would expect arrears to be increasing in the unemployment rate, decreasing in housing equity, increasing in the interest rate and the double trigger should be negative (as the unemployment rate rises this should reduce the benefit of more housing equity). We also expect that higher interest rates should increase mortgage arrears as payments rise for floating rate customers (including the whole tracker mortgage book in Ireland) as demonstrated in Slaymaker, OToole, McQuinn, and Fahy (2018). The estimated coefficients on the error correction are presented in Equation 2 below;

$$\begin{aligned} \Delta arrears_t = & \underset{(0.05)}{-0.23}[(arrears_{t-1}) - (\underset{(0.14)}{1.40}\, urx_{t-1} - \underset{(0.26)}{0.78}\, hhequity_{t-1} - \underset{(0.14)}{0.07}\, (hhequity_{t-1} * urx_{t-1}) + \underset{(0.06)}{0.25}\, rmt_{t-1})] \\ & + \underset{(0.12)}{0.63}\, \Delta arrears_{t-1} - \underset{(0.12)}{0.27}\, \Delta arrears_{t-2} + \underset{(0.08)}{0.20}\, \Delta arrears_{t-3} + \underset{(0.11)}{0.28}\, \Delta urx_t + \underset{(0.17)}{0.17}\, \Delta urx_{t-1} + \underset{(1.7)}{1.6} \end{aligned} \tag{2}$$

As with all error-correction equations presented in this paper, the first term on the right hand side of Equation 2 is an equilibrium correction coefficient,

[1] A complete list of all variables used, their model mnemonic as well as the variable source can be found in Appendix A.

Table 1: Variable Measurement and Expected Signs

Variable	Measurement	Effect
	Equity Channel	
Household Equity	$AveHp_t \times Hstock_t - TotMort_t$	Coeff < 0
	Affordability Channel	
Unemployment	urx_t	Coeff > 0
Mortgage Rate	rmt_t	Coeff > 0
	Double Trigger	
HH Equity $\times$ Unemp.	$AveHp_t \times Hstock_t - TotMort_t \times urx_t$	Coeff < 0

multiplied by the associated lagged deviation from steady-state (inside brackets) and standard errors are provided in parenthesis under the coefficient values. Individually the coefficients in the arrears equation are strongly significant and carry the expected signs. Also, the model fit for the arrears variable appears to track the actual series well as seen in Appendix C.

2.2 Corporate Insolvencies

The second aspect of financial distress that is modelled in the framework is corporate insolvencies. A considerable increase in insolvencies occurred following the financial crisis as many high leverage enterprises became unsustainable due to their gearing rates while other firms suffered in particular from the prolonged drop in aggregate demand. To model corporate insolvencies, we adopt a simple model which pairs back some of the financial crisis specific elements in previous specifications. The model allows the impact on firm survival of the general economic environment and aggregate demand to be captured through the unemployment rate. We also include a measure of firm liquidity which is defined as corporate deposits, *cordep* divided by corporate loans, nfc. This will capture the possible internal funding that firms have at their disposal to cover external finance. The standard long run specification of the corporate insolvencies is taken as:

$$insol_t \quad = \quad \alpha + \beta_1 urx_t + \beta_2 (corpdep_t / nfc_t) + \epsilon_t \tag{3}$$

where *insol* is corporate insolvencies, *urx* is the unemployment rate, *corpdep* is deposits from Irish resident private-sector enterprises and nfc is total credit advanced to Irish resident private-sector enterprises excluding financial intermediation and property related sectors. We expect that the unemployment rate will have a positive effect on insolvencies: higher unemployment signals a poorer economic context for the firms operating activities and thus a higher risk of insolvency. We expect that liquidity ($corpdep/nfc$) will have a negative effect on insolvencies: the larger the share of internal funds relative to external debt the lower the risk of insolvency for the enterprise (see Table 2).

Table 2: Variable Options for Channels

Variable	Measurement	Effect
Unemployment	urx	Coeff > 0
Liquidity	$\left(\frac{corpdep}{nfc}\right)$	Coeff < 0

The estimated error-correction coefficient are presented in Equation 4

$$\Delta insol_t = \underset{(0.19)}{-0.70}[(insol_{t-1}) - (\underset{(0.11)}{0.95}\, urx_{t-1} - \underset{(0.20)}{0.29}\,(corpdep_{t-1}/corpcred_{t-1})]$$

$$+ \underset{(0.18)}{0.03}\, \Delta insol_{t-1} + \underset{(0.13)}{0.33}\, \Delta insol_{t-2} + \underset{(0.69)}{1.21}\,(\Delta corpdep_{t-1}/\Delta corpcred_{t-1}) - \underset{(0.71)}{1.54}\,(\Delta corpdep_{t-2}/\Delta corpcred_{t-2})$$
$$- \underset{(0.72)}{1.09}\,(\Delta corpdep_{t-3}/\Delta corpcred_{t-3}) - \underset{(0.63)}{1.98} \quad (4)$$

As expected, we find a strongly significant impact of the unemployment rate on insolvencies with a positive coefficient i.e. as unemployment rises, so do corporate insolvencies. This is a critical macroeconomic channel feeding back through into financial distress. We find a negative relationship between our liquidity variable and insolvencies: as deposits rise relative to loans, firms have more internal funds to cover external liabilities, and financial distress falls.

3 Bank Capital

A critical factor in any macro-financial model is to adequately capture the impact and determinants of bank regulatory capital. Since the onset of the financial crisis, the use of prudential regulatory capital tools has become widespread and a range of new instruments have been designed to build bank resilience.

Earlier iterations of the financial block within COSMO included a deterministic equation for bank capital, expressing the level of capital held by banks as a function of variables such as risk weighted assets (RWA) and the level of economic activity (see for example Bergin et al. (2017); McInerney (2016, 2019, 2020). However, as the level of bank capital, and by extension the bank capital ratio, may change for various reasons, ranging from regulatory (Peek & Rosengren, 1997; De Jonghe, Dewachter, & Ongena, 2020); to economic and managerial, (Houston, James, & Marcus, 1997; Berrospide & Edge, 2010; Gambacorta & Marques-Ibanez, 2011) fitting a deterministic equation is difficult, particularly as relationships may have changed over time reflecting the post-crisis period of increasingly demanding bank capital regulation and subdued profitability. This aspect affects the practical importance of studies which are concerned with both the determinants and effects of changes in bank capital levels. As pointed out in a recent paper by Malovana, Hodula, Bajzik, and Gric (2021), very few studies capture the "pure" effects of changes in bank capital due to a newly endorsed capital regulation. Those few rely mostly on (semi)natural experiments, while the vast majority of studies rely on more or less precise identification strategies.

Melis and Weissenberg (2019) also find that EU banks' choice of the actual level of capital ratios to hold depends on a number of aspects. While regulatory requirements are clearly a key driver, there are additional idiosyncratic factors that influence banks' choice of internal capital 'targets'. A number of elements such as a firm's strategy, business model, macroeconomic environment and aversion to risk are only some of the firm-specific factors taken into account when setting the internally desired or 'target' capital ratio.

Accordingly, the updated financial block now includes a measure of the bank capital ratio as an exogenous policy variable which enters the three interest rate equations for the residential interest rate (rmt), the corporate lending rate ($nfcrat$) and the consumer lending rate ($rcons$). The impact of changing capital requirements introduced under Basel III and changing levels of capital help by banks on bank lending rates and loan growth has been assessed by a umber of different authors in recent years. For example, in the US Firestone, Lorenc, and Ranish (2017) found that an increase of 1 percentage point in capital ratios would lead to changes in lending rates of somewhere between 3.5 to 7 basis points (bps) depending on whether or not banks pass along 100 percent of any increased capital cost to borrowers. A Bank of England Financial Stability Paper by Brooke et al. (2015) find that lending spreads could rise by between 5 and 10 bps for a 1 percentage point increase in capital requirements. Finally, using bank data from a selection of European economies Gavalas (2015) finds that a 1% increase in the bank capital ratio denotes a 5 and 2 bps average increase in the loan rate for banks in countries which have experienced and not experienced a banking crisis respectively.

One potential issue that arises is which measure of bank capital ratio to apply as the regulatory policy lever in COSMO's updated financial block. In the original framework, the variable bank capital, bc_t was applied which represented total bank capital over risk-weighted exposures. A 'purer' measure of the regulatory capital ratio, Common Equity Tier (CET1) over risk-weighted exposures, shows the relation of core equity capital to total risk-weighted assets. The Central Bank of Ireland produce a quarterly time series entitled the Banking Sector Capital Ratio (BSCR) as part of their monthly Countercyclical Capital Buffer (CCyB) rate setting decision announcement. This series is described as the aggregate CET1 ratio of the group of Irish retail banks. It is calculated as CET1 capital expressed as a percentage of risk weighted assets and is calculated on a fully loaded Basel II basis. This series is only available since 2014Q2 however. As all estimations in COSMO's banking and housing block are since 2003 or earlier, this presents a problem, particularly as the ratio will be inserted into three key equations. With this in mind, we back-cast the series using determinants of capital rati, such as total assets and ratio of total loans to total bank assets, as as outlined in Jokipii Milne (2011) and Fonseca González (2010). The resulting series can be seen in Appendix B[2].

[2]Various specifications were applied until best fit for the actual data between 2014Q2 and 2022Q1 was achieved

4 The Irish mortgage market

4.1 A model of house prices

In terms of specifying a house price model, the approach here is to draw from a number of specifications in the literature. A standard approach frequently taken is to invert the housing demand function and rearrange it such that the dependent variable is the house price, as opposed to the quantity of houses. Similar applications are found in Peek and Wilcox (1991), Muellbauer and Murphy (1997), Meen (1996), Meen (2000), Cameron, Muellbauer, and Murphy (2006), Kelly and McQuinn (2014) and Cronin and Quinn (2021). The model, which assumes that the demand for housing services is proportional to the housing stock, is usually derived in log-linear fashion. According to this equation, house prices are positively related to real income per capita and are negatively related to the per capita housing stock and the user cost of capital.

However, one issue with this specification, as noted in McQuinn and O'Reilly (2008) is the relatively small effect which is found for either the nominal or real interest rate or the user cost of capital. This is particularly important if the model is to be used for assessing monetary policy simulations. Therefore, the present approach draws from McQuinn and O'Reilly (2008), who used the concept of an affordability variable. This approach assumes that the demand for housing is mainly a function of the amount that prospective house purchasers can borrow from financial institutions and this, in turn, is dependent on current disposable income and the existing mortgage interest rate. The relationship between income levels, interest rates and the typical amount of a mortgage offered by a financial institution is generally based on the present value of an annuity. The annuity is the fraction of current disposable income $\kappa(pdr_t)$ that goes toward mortgage repayments and is discounted at the current mortgage interest rate, rmt for a horizon equal to the term of the mortgage τ. Thus, the amount that can be borrowed $afford_t$ is given by

$$afford_t = \kappa(pdr_t)\left(\frac{1-(1+rmt_t)^{-\tau}}{rmt_t}\right). \tag{5}$$

This mimics the reality that people seek to maximise the amount they can borrow subject to the lending criteria of mortgage lending institutions.

4.2 Credit and Irish house prices

One issue, which arises, particularly, in the case of Irish house prices over the period in question, is the potential role played by the easing of credit standards. The liberalisation of the domestic credit market has been documented in studies such as Kelly, McQuinn, and Stuart (2011), McCarthy and McQuinn (2017) and Cronin and Quinn (2021). The significant increase in mortgage credit which was provided in the run-up to 2007 is often cited as one of the main reasons for the particularly harsh impacts of the financial crisis on the Irish financial sector (see Honohan, Donovan, Gorecki, and Mottiar (2010) for example).

To allow for the impact of changing credit conditions in the model, we employ the approach in Duca, Muellbauer, and Murphy (2011) who address the issue in the US housing market. Namely, we, first, construct an *adjusted* loan-to-income, lti, series for the Irish housing market over the period. As noted in McCarthy and McQuinn (2017), changes in the loan-to-income ratio were one of the most important changes which occurred in the Irish credit market in the period preceding 2007. This is achieved in the same way as Duca et al. (2011) by estimating the following regression:

$$lti_t = \beta_0 + \beta_1\ (afford_t/pcd_t) + \epsilon_t lti. \tag{6}$$

The residuals from the regression, $(\epsilon_t lti)$, can be considered as the exogenous shift in credit conditions in the Irish market i.e. those changes in credit conditions which are not captured by the endogenous factors contained in $afford_t$. These residuals are then included in the house price equation to allow for the presence of changing credit conditions. The house price model also includes the stock of housing, (cap_t), which evolves according to the standard perpetual inventory method:

$$cap_t = cap_{t-1} \times (1 - \psi) + hs_{t-1} \tag{7}$$

where ψ is the rate of obsolescence in the Irish housing market and hs_t is the level of new dwelling completions. The stock of housing is included to allow for supply-side effects in the house price model and provides a link with the housing supply equation. The house price equation also includes a demographic variable. The standard long run specification can therfore be written as:

$$hp_t = \beta_0 + \beta_1\ afford_t + \beta_2\ \epsilon_t lti + \beta_3\ (pop_{2544t}/tpop_t) + \beta_4\ cap_t + \epsilon_t. \tag{8}$$

where $afford$ is the affordability measure estimated in Equation 4.1, $pop2544/tpop$ is the proportion of the population between the ages of 25 to 44, capturing the main house purchasing cohort and cap is the measure of supply. We would expect all variables to exhibit a positive sign with the exception of the supply of housing variable. The results of the estimated error-correction equation are presented in Equation 9;

$$\Delta hp_t = \underset{(0.02)}{-0.11}[(hp_{t-1}) - (\underset{(0.15)}{1.05}\, afford_{t-1} + \underset{(0.22)}{1.46}\, \epsilon_t lti_{t-1} - \underset{(0.89)}{4.82}\, cap_{t-1} + \underset{(0.70)}{0.27}\, (pop2544_{t-1}/totpop_{t-1}))] +$$
$$\underset{(0.07)}{0.35}\, \Delta hp_{t-1} + \underset{(0.09)}{0.33}\, \Delta\theta_t - \underset{(0.08)}{0.20}\, \Delta\theta_{t-1} + \underset{(0.06)}{0.25}\, \Delta lti_t + \underset{(0.63)}{7.85}\ (9)$$

All coefficients have the expected signs and are significant with the exception of the population variable.

4.3 Housing supply

As noted in AddisonSmyth, McQuinn, and OReilly (2009) models of the supply side of the housing market are much less common than that of the demand-side. Mayer and Somerville (1996) distinguish between two different types of supply approaches. In the first, housing supply and demand functions are combined into a single reduced form equation. The response of supply to price changes is derived from the coefficients in such models. Examples of this approach include Follain (1979), Stover (1986) and Malpezzi and Maclennan (2001). The second approach involves direct estimation of the aggregate supply function where supply is typically hypothesised as a function of house prices and cost shifters. Studies by Poterba (1991), Topel and Rosen (1988) and DiPasquale and Wheaton (1994) all estimate supply functions of the housing market directly. Using Irish data, Kenny (1999) and Kenny (2003), looks at the relationship between the housing stock, aggregate income and interest rates and on the dynamics of supply response. Stevenson and Young (2007) compare the performance of three different forecasting models of Irish supply while AddisonSmyth et al. (2009) specify and estimate a supply function to quantify the level of structural demand in the Irish housing market. Our specification of housing supply is very much in the spirit of the second strand of approaches with the supply of new dwellings expressed as:

$$hs_t = \beta_0 + \beta_1\ hp_t + \beta_2\ nfcrat + \beta_3\ bcost_t + \beta_3\ iprct_t + \epsilon_t \tag{10}$$

where hs_t is new dwelling completions, hp is house prices, $nfcrat$ is the interest rate for non-financial cooperates, $bcost_t$ is builder's costs and $iprct_t$ is the level of investment in the construction sector. The latter represents one of the key links between the real economy's production sector and the housing market (see Bergin and Egan (2022) for further details). We expect all variables to have a positive sign, with the exception of building costs, an increase of which will depress the supply of new homes. Ideally, the supply response function should also include land costs, which are an integral element of housing costs, however, the absence of an official series of such costs prevents this. The estimated error-correction equation is provided in Equation 11;

$$\Delta hs_t = \underset{(0.09)}{-0.32}[(hs_{t-1}) - (\underset{(0.31)}{3.19}\, hp_{t-1} + \underset{(0.05)}{0.03}\, nfcrat_{t-1} - \underset{(0.61)}{2.23}\, bcost_{t-1} + \underset{(0.04)}{0.06}\, (iprct_{t-1}))] + \underset{(0.10)}{0.16}\, \Delta hs_{t-2} + \underset{(0.50)}{1.86}\, \Delta hp_t - \underset{(2.24)}{4.95}\ (11)$$

All variables have the expected sign; while the interest rate is not significant, we retain it in the model for scenario purposes. The plots the actual and fitted value for the model can be seen in Appendix C. It is clear that the model does appear to underestimate the scale of collapse in the supply-side of the market between 2009 and 2014. This was a period of intense contraction in the Irish construction sector. The sheer collapse of residential activity in the Irish market post 2009 would be particularly difficult to capture.

4.4 Mortgage demand and supply

In modelling the stock of mortgage credit, we separate out the supply and demand side of the market. The demand for mortgage credit is modelled as a function of house prices and housing supply. Thus, both price and quantity effects are captured in the approach. The standard long-run specification for mortgage demand is therefore represented by:

$$md_t = \beta_0 + \beta_1\ hp_t + \beta_2\ hs_t + \epsilon_t \tag{12}$$

where md is the total value of mortgages approved and hp and hs are house prices and supply respectively. Intuitively, both variables are expected to exhibit a positive sign. The error-correction estimation is described in Equation 13 below;

$$\Delta md_t = \underset{(0.05}{-0.11}[(md_{t-1}) - (\underset{(0.45)}{0.88}\, hp_{t-1} + \underset{(0.23)}{0.70}\, hs_{t-1})]$$
$$+ \underset{(0.09)}{0.41}\ \Delta hs_t - \underset{(0.09)}{0.21}\, \Delta hs_{t-1} + \underset{(0.09)}{0.22}\, \Delta hs_{t-2} + \underset{(0.09)}{0.32}\, \Delta hs_{t-3} - \underset{(0.89)}{0.81} \tag{13}$$

In modelling residential mortgage supply in the Irish market we follow McInerney (2020) in assuming that Irish banks are monopolistically competitive; banks set interest rates as a markup over funding costs which implies that financial institutions can supply any quantity of credit at the going interest rate.

The relationship between the European Central Bank (ECB) policy rate and the standard mortgage variable rate (SVR) charged by Irish credit institutions has received some attention in the Irish literature recently McQuinn and Morely (2015) and Goggin, Holton, Kelly, Lydon and McQuinn (2012), owing to the continued observed difference between the SVR and the rate of interest charged on other variable rate mortgages in the Irish market. The Irish mortgage market consists of loans issued at both fixed and variable rates of interest. However, the latter form of finance dominates with over 85 per cent of loans issued at variable rates. There are two types of variable rates: Tracker mortgages, which were particularly popular during the boom period, are linked contractually to the ECB policy rate. Therefore, when the ECB rate changes, the tracker rate changes automatically. SVRs (which are variable rates other than trackers) are not specifically linked to an underlying market or wholesale rate. The lender may change this rate at their discretion. Consequently, with so many mortgages financed with either tracker or standard variable rates, particularly when compared with other European countries, the Irish mortgage book is more vulnerable to changes in the policy rate.

Our empirical application follows the marginal cost pricing model outlined by Rousseas (1985) and specifies retail lending rates as a function of the cost of funds and a mark-up, which is typically referred to as the interest rate spread. A similar approach is adopted in Goggin et al. (2012), McQuinn and Morely (2015) and McInerney (2020). The Euribor rate is taken to be representative of the European Central Bank (ECB) policy rate. We also include a variable which measures the ratio of capital amongst Irish financial institutions to their holdings of risk weighted assets, measured by the Central Bank's Banking Sector Capital Ratio (BSCR) described in Section 3. This assumes that if Irish credit institutions have to increase their holdings of capital for a given level of weighted assets, this will cause an increase in the spread between the ECB policy rate and domestic mortgage rates. *Ceterus paribus,* this would result in a decline in mortgage lending in the sector.

Therefore the mortgage supply function is specified as follows:

$$rmt_t = \beta_0 + \beta_1\ euribor_t + \beta_2\ bscr_t + \epsilon_t \tag{14}$$

where rmt_t is the domestic residential mortgage interest, $euribor_t$ is the Euribor rate and $bscr_t$ is the banking sector capital ratio. Both exogenous policy variables are expetced to have a positive impact on the residential mortgage rate The results of the estimated error-correction model is summarised in Equation 15.

$$\Delta rmt_t = \underset{(0.07)}{-0.26}[(rmt_{t-1}) - (\underset{(1.2)}{1.1}\, bscr_{t-1} + \underset{(0.05)}{0.48}\, euribor_{t-1})]$$
$$+ \underset{(0.12)}{0.42}\ \Delta rmt_{t-2} + \underset{(0.04)}{0.56}\ \Delta euribor_t - \underset{(0.04)}{0.24}\ \Delta euribor_{t-2} + \underset{(0.19)}{0.66} \quad (15)$$

5 Non-Mortgage Credit Markets

5.1 Non-Financial Corporate Credit

Non-financial corporate credit (NFC) demand is modelled as a function of the NFC interest rate, corporate profits to measure internal funds, and GDP to capture economic activity. This is in line with the original model in McInerney (2019). We expect that credit demand will be decreasing in the interest rate. In terms of the demand shifters, we expect that demand is decreasing in corporate profits which are a proxy for internal funds i.e. we expect that internal funds are preferred to external funds due to the cost of external financing. Therefore more profitable firms should have a lower demand for external financing as they have more internal resources. This is in line with the pecking order theory of financial hierarchy (Myers & Majluf, 1984). We expect credit demand to be increasing in general economic activity. Therefore, it should have a positive correlation with GDP.

$$nfc_t = \beta_0 + \beta_1\ nfcrat_t + \beta_2\ profits_t + \beta_3\ yer_t + \epsilon_t \tag{16}$$

where nfc is total credit advanced to Irish resident private-sector enterprises excluding financial inter-mediation and property related sectors, $nfcrat$ is the lending rate offered to NFC, $profits$ is gross operating surplus and mixed income of non-financial corporations and yer is GDP at market prices. As discussed, we expect negative signs on both the interest rate and profit variable and a positive sign on the measure of economic activity, GDP. The estimated error correction model is represented by Equation 17 below:

$$\Delta nfc_t = \underset{(0.02)}{-0.51}[(nfc_{t-1}) - (-\underset{(0.05)}{0.03}\, nfcrat_{t-1} - \underset{(0.47)}{1.22}\, profits_{t-1} + \underset{(1.09)}{2.11}\, gdp_{t-1})]$$
$$+ \underset{(0.11)}{0.34}\ \Delta nfc_{t-2} + \underset{(0.11)}{0.38}\ \Delta nfc_{t-3} - \underset{(0.39)}{0.03} \quad (17)$$

On the supply side, we expect the interest rate to be increasing in the cost of funds, *euribor* and we expect that the interest rate will be positively related to the bank capital ratio, *bscr* i.e. higher capital should increase the opportunity cost of funds and this will be passed on to borrowers.

$$nfcrat_t = \beta_0 + \beta_1\ euribor_t + \beta_2\ bscr_t + \epsilon_t \tag{18}$$

where $nfcrat$ is the lending rate advanced to non-financial corporations, The estimated error-correction equation is given by Equation 19:

$$\Delta nfcrat_t = \underset{(0.21)}{-0.51}[(nfcrat_{t-1}) - (\underset{(0.05)}{0.66}\ euribor_{t-1} + \underset{(1.25}{5.28} bscr_{t-1})]$$
$$+ \underset{(0.10)}{0.56}\ \Delta euribor_{t-1} - \underset{(0.09)}{0.13}\ \Delta euribor_{t-2} + \underset{(0.56)}{1.40}\ (19)$$

The significant and positive relationship with both *euribor* (increases in monetary policy interest rates increase lending rate in Ireland) and the *bscr* is important in terms policy channels through which monetary and macro-prudential policy can impact the Irish financial sector. The model predictions versus the actual data are presented in Appendix C. It is clear the model provides an good representation of the actual data.

5.2 Consumer Credit

Consumer loans in this model relate to loans for auto or other vehicle purchases, personal loans and other consumer funding. As with the non-financial corporate credit model, we estimate a level demand equation with an endogenous interest rate modelled to determine the supply side. The demand for consumer credit is specified as a function of the interest rate, household income, housing wealth and financial assets. The demand for consumer credit is therefore

$$cons_t = \beta_0 + \beta_1\ pdr_t + \beta_2\ hhequity_t + \beta_3\ fassets_t + \epsilon_t \tag{20}$$

where *cons* is credit advanced to Irish private households, other than for house purchases; *pdr* is disposable income; *hhequity* is the level of household equity as described in Section 2 and $fassest$ is financial assets proxied by household net worth. The demand side has the following expected interpretations: consumer credit demand should be increasing in disposbale income and housing wealth but decreasing in financial assets. The financial assets finding relates to the substitution between internal funds and external financing: if households have sufficient financial assets, then they will not have a demand for consumer loans. The estimated error-correction equation is given as Equation 21 below;

$$\Delta cons_t = \underset{(0.06)}{-0.20}[(cons_{t-1}) - (-\underset{(0.06)}{0.09}\ rcons_{t-1} + \underset{(0.95)}{1.62}\ pdr_{t-1} + \underset{(0.24)}{0.64}\ hhequity_{t-1} - \underset{(0.46)}{0.71}\ fassets_{t-1})]$$
$$- \underset{(0.02)}{0.09}\ \Delta rcons_{t-2} - \underset{(1.60)}{3.05}\ (21)$$

As expected, we find that consumer credit is decreasing in the interest rate, increasing in disposal income, increasing in housing wealth and decreasing in financial assets.

On the supply side, we determine credit supply (interest rate) as a function of the banking sector capital ratio, *bscr* the cost of funds, *euribor* and mortgage arrears, $arrears$ to capture household risk attached by the banks to the lending decision. In recent years, the higher than expected cost of lending rates in Ireland has been attributed to lower levels of competition following bank exits during the crisis period Goggin, Holton, Kelly, Lydon, and McQuinn (2012). The specification is presented below as:

$$rcons_t = \beta_0 + \beta_1\ euribor_t + \beta_2\ bscr_t + \beta_3\ arrears_t + \epsilon_t \tag{22}$$

where *rcons* is the lending rate provided to consumers for credit other than for house purchases. We expect that the interest rate will be increasing in bank capital i.e. if banks have to hold more capital, this increases the opportunity cost of lending and they pass this on to borrowers in higher rates. In essence this means more capital lowers credit supply. We include the Euribor to determine the cost of funds and enter mortgage arrears to measure the default risk attached to the uncollateralised lending activity which can be associated with consumer loans. The estimated error-correction model is given as;

$$\Delta rcons_t = \underset{(0.07)}{-0.16}[(rcons_{t-1}) - (-\underset{(0.05)}{0.11}\, euribor_{t-1} - \underset{(1.69}{4.13} bscr_{t-1} - \underset{(0.04}{0.09} arrears_{t-1})]$$

$$+ \underset{(0.12)}{0.27}\ \Delta euribor_t + \underset{(0.12)}{0.31}\ \Delta euribor_{t-1} + \underset{(0.31)}{0.89}\ (23)$$

Once again the model predictions versus the actual data are presented in Appendix C. It is clear the model provides an reasonable representation of the actual data. It must be noted that the correlation appears to break down in more recent periods where the rates have risen, despite some of the driving factors (such as Euribor and bank capital) trending downwards.

6 Model Linkages and Illustrative Shocks

The aim of this section is to present the financial block satellite model in a more general framework by: a) presenting an overview of the linkages between the blocks and the wider COSMO framework, illustrating how the real and financial channels operate; and b) by providing an illustrative long run shock to the banking model and tracing the impacts on the credit and housing markets. This later exercise is parameterised as an increase in bank regulatory capital.

6.1 Model Overview and Linkages

Appendix D illustrates the inter-linkages within the financial block as well as its interaction with the wider COSMO model. A useful exercise is to examine the linkages within the financial sector by talking through the impact of a shock to interest rates on the housing market. Suppose there is an increase in the ECB's policy interest rate, *euribor*. This increase will first cause an increase in the residential mortgage rate, *rmt* which will in turn depress house prices, *hp* through the affordability measure outlined in Section 4.1. The change in house prices subsequently impact the level of both mortgage demand, *md*, and mortgage arrears, *arrears*. In addition, both consumer, *rcons* and corporate lending rates, $nfcrat$ will also be influenced with the latter also feeding back into the housing market through its relationship level of housing supply hs .

The financial block is connected to a number endogenous variables within the wider COSMO model which provides crucial macro-financial feed-backs and linkages. For example, housing supply, hs, is determined by the level of investment in the construction sector, *iprct* and building costs, *bcost*. Both *iprct* and *bcost* are estimated in the construction sector production block of COSMO specifically designed to distinguish shocks or policy responses on the construction sector and how they feed through the rest of the economy. (see Bergin and Egan (2022) for more details). The level of disposable income, *pdr* which is endogenously determined in COSMO impacts the financial block through the affordability measure which is a determinant of *hp* and directly determines the level of consumer credit, $cons$. The rate of unemployment, urx which is determined in COSMO as the ratio of employed persons over the labour force is a dependent variable in the equations for both mortgage arrears, $arrears$, and corporate insolvencies, $insol$, highlighting the link between financial distress and the strength of the economy as described in Section 2. Finally, real GDP, yer, also a key macro variable determined endogenously in COSMO is a driver of non-financial credit, nfc to where it captures the response of corporate lending to economic activity.

6.2 Illustrative Shock - 1% Change in Banking Sector Capital Ratio

Apart from the standard policy lever of the ECB's Euribor rate as discussed in the previous section, the updated financial block also includes the exogenous policy variable *bscr*, representing the banking sector capital ratio. Since the onset of the financial crisis, the importance of bank capital levels has come to the fore both a resilience mechanism for bank stability and a tool for managing credit cycles. Major changes to regulatory structures have provided for higher levels, and greater quality of capital, to achieve both micro and macro-prudential policy aims. However, increasing capital levels are not cost-less and provide for lower levels of lending. This can have macroeconomic consequences and considerable research has been undertaken exploring the relationship between capital and economic growth (BSBS, 2010; Martynova, 2015; Ambrocio, Hasan, Jokivuolle, & Ristolainen, 2020). From a policy perspective, trade-offs therefore exist between promoting financial stability and banking resilience and the wider economic impacts. Having evidence to inform these policy decisions, for example around the impacts of raising capital buffers, is critically important to informing the calibration of the instruments.

In this sub-section, we document how the channels in COSMOs updated financial block work and their impact on the real economy using an illustrative shock to banking sector capital ratio, *bscr*. This variable allows us to examine the impact of a change to regulatory capital such as an increase in the countercyclical capital buffer or systemic risk buffer. In this illustrative shock, we raise the *bscr* by 1 percentage point, which could be for example through an increase in a macro-prudential instrument or a micro-prudential tool. Appendix D documents, in the form of a simple schematic, how the impact of the capital increase works through our model. The schematic shows that if bank capital is raised, this acts to lower credit supply by increasing the interest rate, across the residential mortgage, consumer and non-financial corporation markets.

Appendix E presents the impact of the shock on both key financial block variables and in the wider real economy through the financial blocks linkages with COSMO as discussed in Section 6.1. The impact of the increase in the capital ratio is first felt across the three estimated interest rates in the financial block - residential mortgage rates,rmt, non-financial corporation rates, $nfcrat$ and consumer rates, $rcons$. The shock to $bscr$ causes an increase of approximately 0.02% (2bps) and 0.06% (6bps) increase in the residential mortgage and corporate rates respectively. The reaction of the consumer lending rate, $rcons$ is much stronger however with a 1% shock to the capital ratio resulting in almost a 0.25% change in the rate by $t + 8$ after the initial shock. In the residential property market, the increase in rmt has knock on effects by reducing the prices of houses by 0.2% from its baseline $t + 5$ after the initial shock. There are also decreases in the level of mortgage demand, md, reflecting a decline in affordability and in housing supply - the latter also being impacted by the increase in the cost of borrowing in the non-financial sector. The number of mortgage arrears also rises. In the corporate sector itself, the increase in $nfcrat$ sees corporate credit, nfc, fall persistently in response and this is coupled with an increase in corporate insolvencies for the first 5 years after the initial shock. Finally, consumer credit has a strong negative reaction to the shock owing to the strong reaction of the lending rate $rcons$ to the increase in the bank regulatory capital variable, $bscr$.

Outside the financial block, Appendix E also gives a brief snapshot of the impact of the increase in the capital ratio on the wider macro-economy with employment and GDP both falling from the baseline across the estimation period. Unemployment also rises above the baseline initially before recovering, although this is due to a decrease in the workforce in the wider model rather than stronger economic activity.

While the shocks we have presented are mild in terms of magnitude, we think they provide a useful benchmark of the reaction of the key financial and macro variables in the context of changes to macro-prudential policy and tools aimed at bolstering financial stability.

7 Summary and Further Research

This working paper has provided a detailed update to the financial satellite model in COSMO. This update to the suite of macro-financial linkages in COSMO revisits equations for financial distress (mortgage arrears and firm insolvencies), mortgage, consumer and non-financial credit and house prices and housing supply. It also includes a new exogenous policy measure relating to regulatory bank capital. These relationships are modelled in error-correction format to fit in with the broader COSMO model. The aims were: a) were to update the data and estimations to present; b) to update where appropriate selected equations with new factors; and c) to ensure that previous relationships held given updated data.

A new satellite has been developed with 10 estimated equations across the banking and housing markets. This allows for the modelling of financial distress, credit conditions, and bank capital changes. Some of the specifications have been altered relative to the previous version of the model where the estimates or specifications did not follow previous findings or where new data may have change the underlying relationships. However, we have endeavoured to follow previous iterations in spirit.

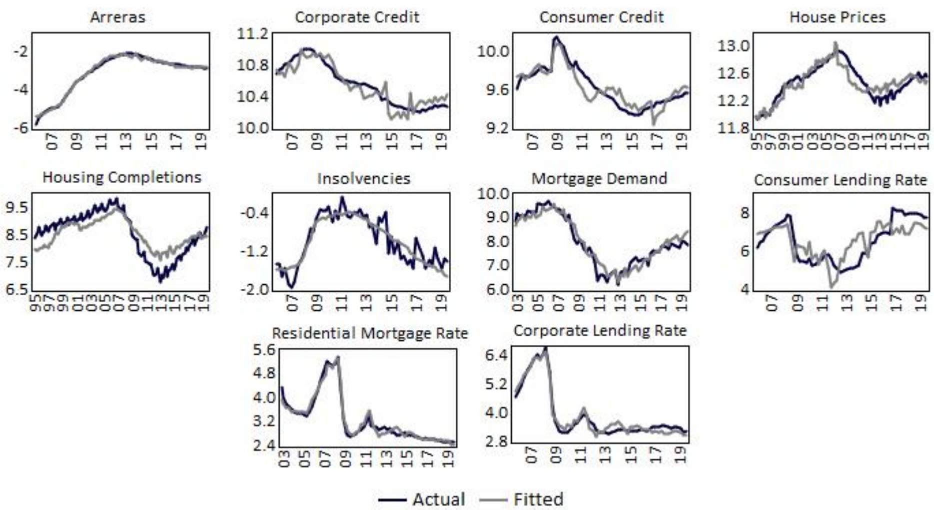
In terms of future research, further development of some of the macro-financial channels in COSMO are under consideration including the development of consumption and investment as a function of consumer and corporate credit levels, as well as allowing leverage to drag corporate investment. We are also attempting to explicitly introduce a bank competition channel which links competition through market concentration to the supply of credit. There is considerable literature which demonstrates that competition impacts credit supply (Ryan et al., 2014; Carbo-Valverde et al., 2009). We hope to take advantage of recent data published by the Central Bank of Ireland to measure market concentration in Ireland using the Herndahl-Hershmann Index of the Irish banking system. This would allow us to explore the relationship between interest rates and market competition in line with the market power hypothesis of credit market competition i.e. banks with more market power (higher concentration) will raise interest rates.

Appendix A Financial Block Variables

In the below table CBI represents Central Bank of Ireland, CSO is the Central Statistics Office, DoH is the Department of Housing and BPFI is the Banking Payments Federation of Ireland

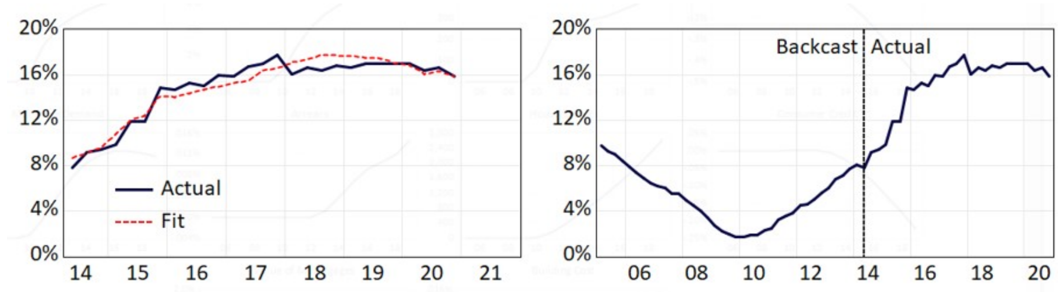
Variable	Description	Source
arrears	Mortgage Arrears, 90+ principal dwelling house (PDH)	CBI
bcost	Building Cost Index	DoH CSO
bscr	Banking Sector Capital Ratio, Aggregate Common Equity Tier 1 ratio of the group of Irish retail banks.	CBI Authors
cap	Total Housing Stock	CSO
cons	Credit Advanced to Irish Private HouseholdS, other than house purchases	CBI
corpdep	Deposits from Irish Resident Private-Sector Enterprises	CBI
nfc	Total Credit Advanced to Irish Resident Private-Sector Enterprises excluding Financial Intermediation and Property Related Sectors	CBI
pdr	Personal disposable income	CSO
euribor	3 Month Euribor, Average of Monthly Data	CBI
fassets	Financial Assests, Household Net Worth	CBI
yer	GDP at market prices	CSO
hp	Residential Property Price Index	CSO Authors
insol	Corporate Insolvencies	CBI
iprct	Productive Gross Fixed Capital Formation, Construction Sector	CSO
lti	Loan-to-Income Residual (Section XXX)	CBI and Authors
morstock	Credit Advanced to Irish Resident Private Households for House Purchase	CBI
nfcrat	Non-Financial Corporation Lenng Rate	CBI
pcd	Personal Consumption Deflator	CSO Authors
*pop*2544	Population, Share of age 25-44	CSO
profits	Gross Operating Surplus and Mixed Income of Non-financial Corporations	Eurostat
rcons	Consumer Lending Rate	CBI
rmt	Residential Mortgage Interest Rate	CBI
hs	New Dwelling Completions	CSO, DoH Authors
tpop	Population, total	CSO
tvalloan	Total Value of Mortgages Approved	BPFI, DOH Authors
urx	Unemployment Rate	CSO
vloan	Average Mortgage Loan (Based on BPFI total value of mortgages approved and BPFI total volume of mortgages approved)	BPFI, DOH Authors

Appendix B Variable Fit - Predicted vs Actual



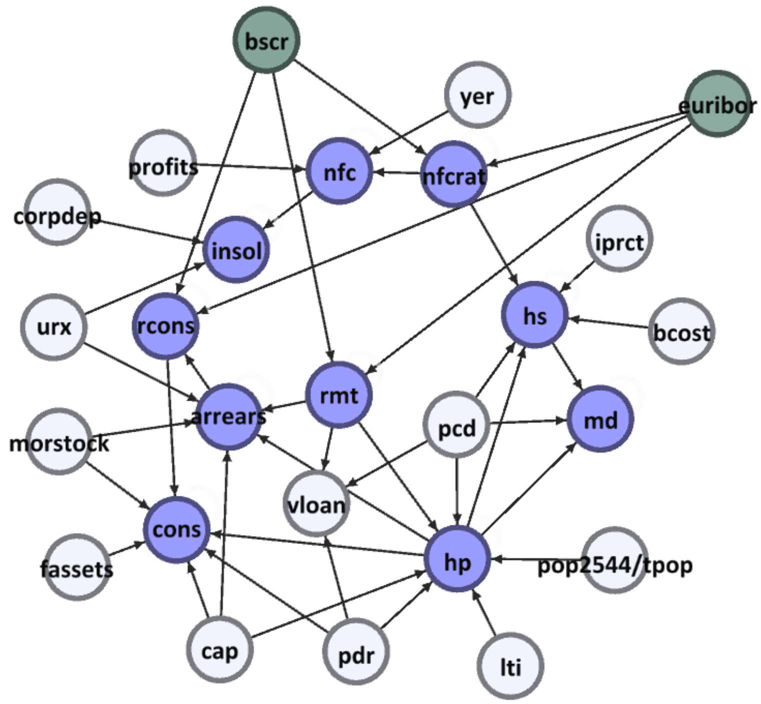
Appendix C Backcasting of Banking Sector Capital Ratio, $bscr_t$

The panel on the left-hand side plots the actual BSCR data along with the model fit. The right-hand side plots the actual data from 2014Q2-2020Q4 as well as the backcast data from 2005Q1-2014Q1

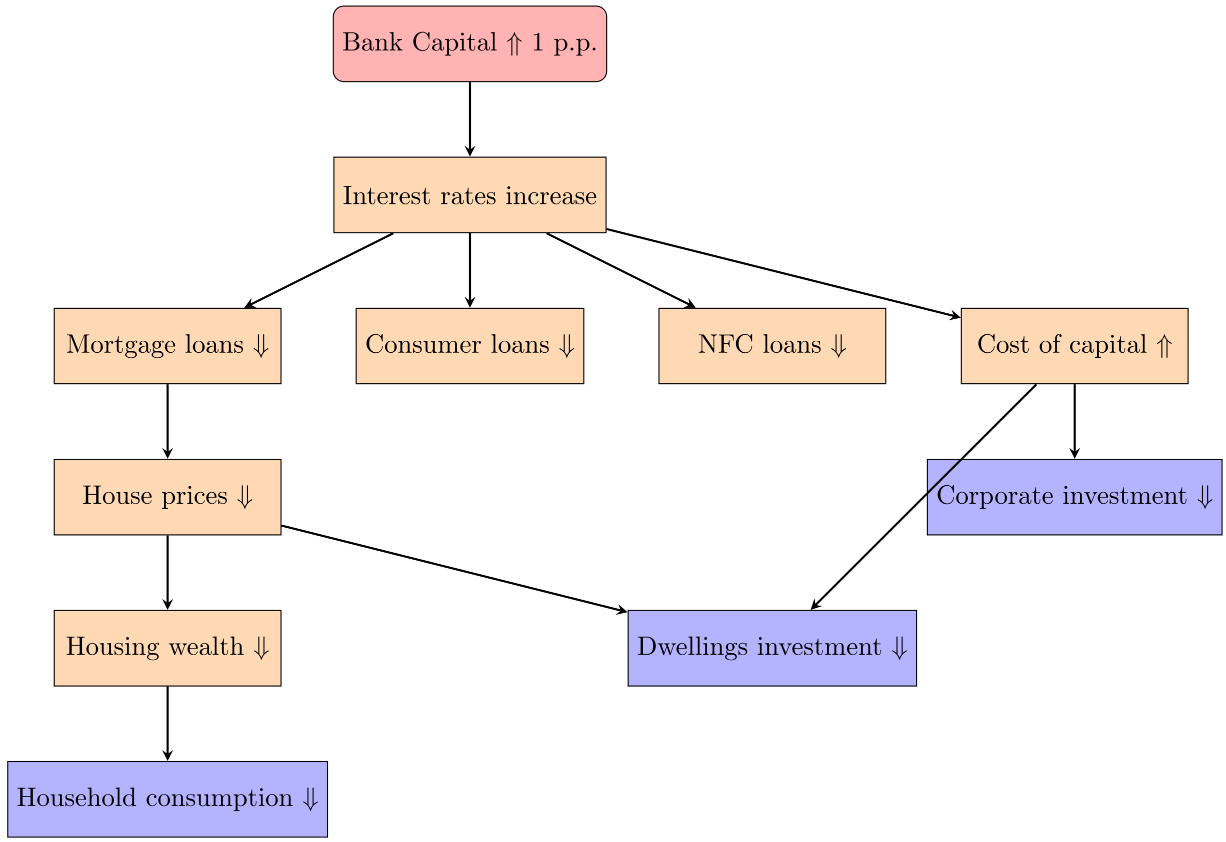


Appendix D Financial Block Inter-linkages

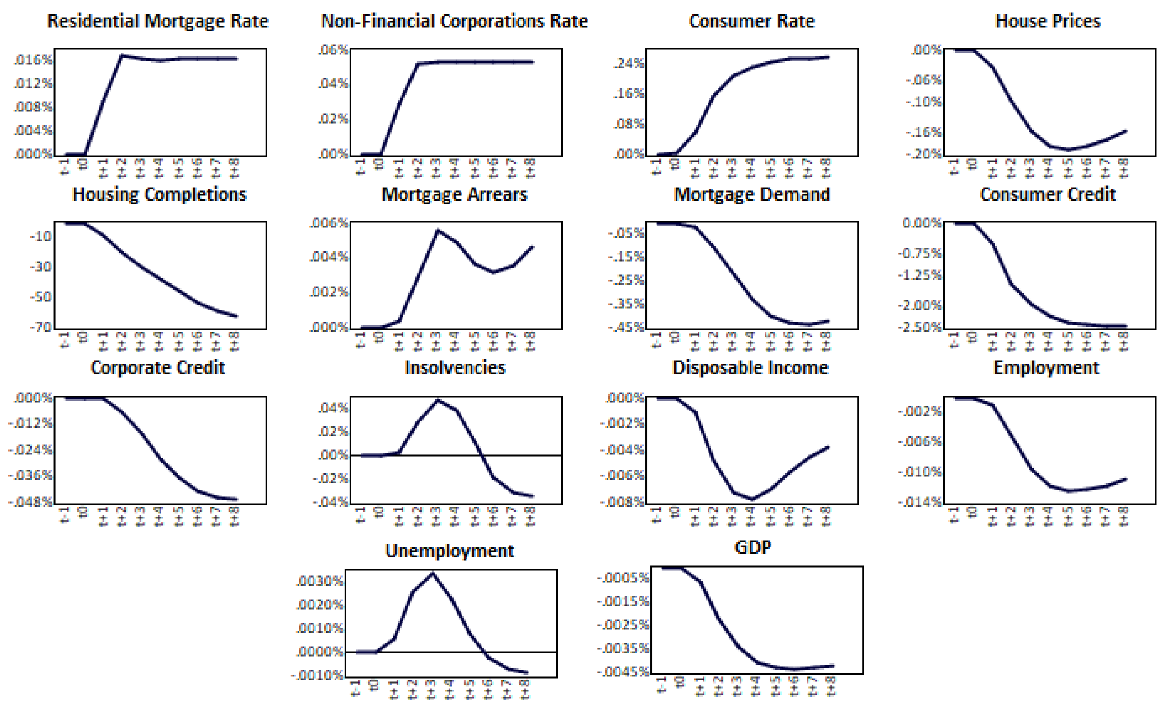
In the below illustration the blue nodes represent the financial blocks endogenously estimated variables and the grey nodes are exogenous policy levers. See Appendix A for details of variable mnemonics.



Appendix E How Does Bank Capital Affect Credit, Housing Markets the Real Economy



Appendix F Response to 1% Shock to Banking Sector Capital Ratio



References

Acharya, V., Engle, R., & Pierret, D. (2014). Testing macroprudential stress tests: The risk of regulatory risk weights. *Journal of Monetary Economics*, *65*(C), 36-53. Retrieved from http://EconPapers.repec.org/RePEc:eee:moneco:v:65:y:2014:i:c:p:36-53

AddisonSmyth, D., McQuinn, K., & OReilly, G. (2009). Modelling credit in the irish mortgage market. *The Economic and Social Review*, *40*(4), 371-392. Retrieved from https://EconPapers.repec.org/RePEc:eso:journl:v:40:y:2009:i:4:p:371-392

Ambrocio, G., Hasan, I., Jokivuolle, E., & Ristolainen, K. (2020). Are bank capital requirements optimally set? evidence from researchers views. *Journal of Financial Stability*, *50*(C), S1572308920300711. Retrieved from https://EconPapers.repec.org/RePEc:eee:finsta:v:50:y:2020:i:c:s1572308920300711

Bergin, A., Conroy, N., Garcia Rodriguez, A., Holland, D., McInerney, N., Morgenroth, E., & Smith, D. (2017). *Cosmo: A new core structural model for ireland* (Papers No. WP553). Economic and Social Research Institute (ESRI). Retrieved from https://EconPapers.repec.org/RePEc:esr:wpaper:wp553

Bergin, A., & Egan, P. (2022). The impact of government spending on the construction sector and housing market – the case of ireland. *forthcoming ESRI working paper*.

Berrospide, J. M., & Edge, R. M. (2010, December). The Effects of Bank Capital on Lending: What Do We Know, and What Does It Mean? *International Journal of Central Banking*, *6*(34), 1-50. Retrieved from https://ideas.repec.org/a/ijc/ijcjou/y2010q4a2.html

Blanchard, O., Dell'ariccia, G., & Mauro, P. (2010). Rethinking macroeconomic policy. *Journal of Money, Credit and Banking*, *42*(s1), 199-215. Retrieved from http://EconPapers.repec.org/RePEc:mcb:jmoncb:v:42:y:2010:i:s1:p:199-215

Brooke, M., Bush, O., Edwards, R., Ellis, J., Francis, B., Harimohan, R., & Siegert, C. (2015). *Financial Stability Paper No. 35: Measuring the macroeconomic costs and benefits of higher UK bank capital requirements* - (Bank of England Financial Stability Papers No. 35). Bank of England. Retrieved from https://ideas.repec.org/p/boe/finsta/0035.html

BSBS. (2010). *An assessment of the long-term economic impact of stronger capital and liquidity requirements* (Tech. Rep.). Basel Committee on Banking Supervision.

Buncic, D., & Melecki, M. (2013). Macroprudential stress testing of credit risk: A practical approach for policy makers. *Journal of Financial Stability*, *9*(3), 347-370. Retrieved from http://EconPapers.repec.org/RePEc:eee:finsta:v:9:y:2013:i:3:p:347-370

Caballero, R. (2010). Macroeconomics after the crisis: Time to deal with the pretense-of-knowledge syndrome. *Journal of Economic Perspectives*, *24*(4), 85-102. Retrieved from https://EconPapers.repec.org/RePEc:aea:jecper:v:24:y:2010:i:4:p:85-102

Cameron, G., Muellbauer, J., & Murphy, A. (2006). *Was there a british house price bubble? evidence from a regional panel* (ERES). European Real Estate Society (ERES). Retrieved from https://EconPapers.repec.org/RePEc:arz:wpaper:eres2006$_1$50

Claessens, S. (2014). *An overview of macroprudential policy tools* (IMF Working Papers No. 14/214). International Monetary Fund. Retrieved from http://EconPapers.repec.org/RePEc:imf:imfwpa:14/214

Cronin, D., & Quinn, K. M. (2021). House prices and the credit-driven household demand channel: The case of the irish economy. *Credit and Capital Markets*, *54*(2), 199-221. Retrieved from https://EconPapers.repec.org/RePEc:kuk:journl:v:54:y:2021:i:2:p:199-221

De Jonghe, O., Dewachter, H., & Ongena, S. (2020). Bank capital (requirements) and credit supply: Evidence from pillar 2 decisions. *Journal of Corporate Finance*, *60*, 101518. Retrieved from https://www.sciencedirect.com/science/article/pii/S0929119918307521 doi: https://doi.org/10.1016/j.jcorpfin.2019.101518

DiPasquale, D., & Wheaton, W. (1994). Housing market dynamics and the future of housing prices. *Journal of Urban Economics*, *35*(1), 1-27. Retrieved from https://EconPapers.repec.org/RePEc:eee:juecon:v:35:y:1994:i:1:p:1-27

Duca, J. V., Muellbauer, J., & Murphy, A. (2011). Shifting credit standards and the boom and bust in U.S. house prices. *Federal Reserve Bank of Dallas, Working Paper*(1104).

Duffy, D., McInerney, N., & McQuinn, K. (2016). Macroprudential policy in a recovering property market: too much too soon? *International Journal of Housing Policy*, *16*(4), 491-523. Retrieved from https://EconPapers.repec.org/RePEc:taf:intjhp:v:16:y:2016:i:4:p:491-523

Elul, R., Souleles, N., Chomsisengphet, S., Glennon, D., & Hunt, R. (2010). What "triggers" mortgage default? *American Economic Review*, *100*(2), 490-94. Retrieved from http://EconPapers.repec.org/RePEc:aea:aecrev:v:100:y:2010:i:2:p:490-94

Firestone, S. B., Lorenc, A., & Ranish, B. (2017). *An Empirical Economic Assessment of the Costs and Benefits of Bank Capital in the US* (Finance and Economics Discussion Series No. 2017-034). Board of Governors of the Federal Reserve System (U.S.). Retrieved from https://ideas.repec.org/p/fip/fedgfe/2017-34.html doi: 10.17016/FEDS.2017.034

Follain, J. R. (1979). The price elasticity of the long-run supply of new housing construction. *Land Economics*, *54*(2), 190-199. Retrieved from https://EconPapers.repec.org/RePEc:uwp:landec:v:54:y:1979:i:2:p:190-199

Foote, C., Gerardi, K., & Willen, P. S. (2008). Negative equity and foreclosure: Theory and evidence. *Journal of Urban Economics*, *64*(2), 234-245. Retrieved from http://EconPapers.repec.org/RePEc:eee:juecon:v:64:y:2008:i:2:p:234-245

Gambacorta, L., & Marques-Ibanez, D. (2011, May). *The bank lending channel: lessons from the crisis* (BIS Working Papers No. 345). Bank for International Settlements. Retrieved from https://ideas.repec.org/p/bis/biswps/345.html

Gavalas, D. (2015). How do banks perform under basel iii? tracing lending rates and loan quantity. *Journal of Economics and Business*, *81*, 21-37. Retrieved from https://www.sciencedirect.com/science/article/pii/S0148619515000259 doi: https://doi.org/10.1016/j.jeconbus.2015.05.003

Goggin, J., Holton, S., Kelly, J., Lydon, R., & McQuinn, K. (2012). *The financial crisis and the pricing of interest rates in the irish mortgage market: 2003-2011* (Research Technical Papers No. 01/RT/12). Central Bank of Ireland. Retrieved from http://EconPapers.repec.org/RePEc:cbi:wpaper:01/rt/12

Haughwout, A., Peach, R., & Tracy, J. (2008). Juvenile delinquent mortgages: Bad credit or bad economy? *Journal of Urban Economics*, *64*(2), 246 - 257. Retrieved from http://www.sciencedirect.com/science/article/pii/S0094119008000685 doi: http://dx.doi.org/10.1016/j.jue.2008.07.008

Honohan, P., Donovan, D., Gorecki, P., & Mottiar, R. (2010). *The irish banking crisis: Regulatory and financial stability policy* (MPRA Paper). University Library of Munich, Germany. Retrieved from https://EconPapers.repec.org/RePEc:pra:mprapa:24896

Houston, J., James, C., & Marcus, D. (1997). Capital market frictions and the role of internal capital markets in banking. *Journal of Financial Economics*, *46*(2), 135-164. Retrieved from https://www.sciencedirect.com/science/article/pii/S0304405X97815115 doi: https://doi.org/10.1016/S0304-405X(97)81511-5

Kelly, R., & McQuinn, K. (2014). On the hook for impaired bank lending: Do sovereign-bank interlinkages affect the net cost of a fiscal stimulus? *International Journal of Central Banking*, *10*(3), 95-128. Retrieved from https://EconPapers.repec.org/RePEc:ijc:ijcjou:y:2014:q:3:a:3

Kelly, R., McQuinn, K., & Stuart, R. (2011). Exploring the steady-state relationship between credit and gdp for a small open economy:the case of ireland. *The Economic and Social Review*, *42*(4). Retrieved from https://EconPapers.repec.org/RePEc:eso:journl:v:42:y:2011:i:4:p:455-477

Kelly, R., & O'Malley, T. (2016). The good, the bad and the impaired: A credit risk model of the irish mortgage market. *Journal of Financial Stability*, *22*, 1 - 9.

Kenny, G. (1999). Modelling the demand and supply sides of the housing market: evidence from ireland1. *Economic Modelling*, *16*(3), 389-409. Retrieved from https://EconPapers.repec.org/RePEc:eee:ecmode:v:16:y:1999:i:3:p:389-409

Kenny, G. (2003). Asymmetric adjustment costs and the dynamics of housing supply. *Economic Modelling*, *20*(6), 1097-1111. Retrieved from https://EconPapers.repec.org/RePEc:eee:ecmode:v:20:y:2003:i:6:p:1097-1111

Lydon, R., & McCarthy, Y. (2013). What lies beneath? understanding recent trends in irish mortgage arrears. *The Economic and Social Review*, *44*(1). Retrieved from http://EconPapers.repec.org/RePEc:eso:journl:v:44:y:2013:i:1:p:117-150

Malovana, S., Hodula, M., Bajzik, J., & Gric, Z. (2021). *A Tale of Different Capital Ratios: How to Correctly Assess the Impact of Capital Regulation on Lending* (Working Papers No. 2021/8). Czech National Bank. Retrieved from https://ideas.repec.org/p/cnb/wpaper/2021-8.html

Malpezzi, S., & Maclennan, D. (2001). The long-run price elasticity of supply of new residential construction in the united states and the united kingdom. *Journal of Housing Economics*, *10*(3), 278-306. Retrieved from https://EconPapers.repec.org/RePEc:eee:jhouse:v:10:y:2001:i:3:p:278-306

Martynova, N. (2015). *Effect of bank capital requirements on economic growth: a survey* (DNB Working Papers). Netherlands Central Bank, Research Department. Retrieved from https://EconPapers.repec.org/RePEc:dnb:dnbwpp:467

Mayer, C., Pence, K., & Sherlund, S. M. (2009). The rise in mortgage defaults. *Journal of Economic Perspectives*, *23*(1), 27-50. Retrieved from http://EconPapers.repec.org/RePEc:aea:jecper:v:23:y:2009:i:1:p:27-50

Mayer, C., & Somerville, C. (1996). Regional housing supply and credit constraints. *New England Economic Review*(Nov), 39-51. Retrieved from https://EconPapers.repec.org/RePEc:fip:fedbne:y:1996:i:nov:p:39-51

McCarthy, Y., & McQuinn, K. (2017). Credit conditions in a boom and bust property market: Insights for macro-prudential policy. *The Quarterly Review of Economics and Finance*, *64*(C), 171-182. Retrieved from https://EconPapers.repec.org/RePEc:eee:quaeco:v:64:y:2017:i:c:p:171-182

McInerney, N. (2016). *A structural model of macroprudential policy: the*

case of ireland (EcoMod2016 No. 9643). EcoMod. Retrieved from https://EconPapers.repec.org/RePEc:ekd:009007:9643
McInerney, N. (2019). *Macroprudential policy, banking and the real estate sector* (MPRA Paper). University Library of Munich, Germany. Retrieved from https://EconPapers.repec.org/RePEc:pra:mprapa:91777
McInerney, N. (2020). *Macro-financial linkages in a structural model of the irish economy* (Research Technical Papers No. 03/RT/20). Central Bank of Ireland. Retrieved from https://EconPapers.repec.org/RePEc:cbi:wpaper:03/rt/20
McQuinn, K., & Morely, C. (2015). *Standard variable rate (svr) pass through in the irish mortgage market an updated assessment* (Research Notes No. RN2015/2/3). Economic and Social Research Institute (ESRI). Retrieved from https://EconPapers.repec.org/RePEc:esr:resnot:rn2015/2/3
Meen, G. (1996). Ten propositions in uk housing macroeconomics: An overview of the 1980s and early 1990s. *Urban Studies*, *33*(3), 425-444. Retrieved from https://EconPapers.repec.org/RePEc:sae:urbstu:v:33:y:1996:i:3:p:425-444
Meen, G. (2000). Housing cycles and efficiency. *Scottish Journal of Political Economy*, *47*(2), 114-140. Retrieved from https://EconPapers.repec.org/RePEc:bla:scotjp:v:47:y:2000:i:2:p:114-140
Melis, A., & Weissenberg, K. (2019). Eu banks journey towards an enhanced capital framework. *European Banking Authority Research Paper*, *3*.
Muellbauer, J., & Murphy, A. (1997). Booms and busts in the uk housing market. *Economic Journal*, *107*(445), 1701-27. Retrieved from https://EconPapers.repec.org/RePEc:ecj:econjl:v:107:y:1997:i:445:p:1701-27
Myers, S., & Majluf, N. (1984). Corporate financing and investment decisions when firms have information that investors do not have. *Journal of Financial Economics*, *13*(2), 187-221. Retrieved from https://EconPapers.repec.org/RePEc:eee:jfinec:v:13:y:1984:i:2:p:187-221
OToole, C., & Slaymaker, R. (2021). Repayment capacity, debt service ratios and mortgage default: An exploration in crisis and non-crisis periods. *Journal of Banking & Finance*, *133*(C), S0378426621002272. Retrieved from https://EconPapers.repec.org/RePEc:eee:jbfina:v:133:y:2021:i:c:s0378426621002272
Peek, J., & Rosengren, E. S. (1997). The International Transmission of Financial Shocks: The Case of Japan. *American Economic Review*, *87*(4), 495-505. Retrieved from https://ideas.repec.org/a/aea/aecrev/v87y1997i4p495-505.html
Peek, J., & Wilcox, J. A. (1991). The measurement and determinants of single family house prices. *Real Es-*

tate Economics, *19*(3), 353 to 382. Retrieved from https://EconPapers.repec.org/RePEc:bla:reesec:v:19:y:1991:i:3:p:353-382

Poterba, J. (1991). House price dynamics: The role of tax policy. *Brookings Papers on Economic Activity*, *22*(2), 143-204. Retrieved from https://EconPapers.repec.org/RePEc:bin:bpeajo:v:22:y:1991:i:1991-2:p:143-204

Rousseas, S. (1985). A markup theory of bank loan rates. *Journal of Post Keynesian Economics*, *8*(1), 135-144. Retrieved from https://EconPapers.repec.org/RePEc:mes:postke:v:8:y:1985:i:1:p:135-144

Slaymaker, R., OToole, C., McQuinn, K., & Fahy, M. (2018). *Monetary policy normalisation and mortgage arrears in a recovering economy: The case of the irish residential market* (Papers No. WP613). Economic and Social Research Institute (ESRI). Retrieved from https://EconPapers.repec.org/RePEc:esr:wpaper:wp613

Stevenson, S., & Young, J. (2007). Forecasting housing supply: Empirical evidence from the irish market. *European Journal of Housing Policy*, *7*(1), 1-17. Retrieved from https://EconPapers.repec.org/RePEc:taf:eurjhp:v:7:y:2007:i:1:p:1-17

Stover, M. E. (1986). The price elasticity of the supply of single-family detached urban housing. *Journal of Urban Economics*, *20*(3), 331-340. Retrieved from https://www.sciencedirect.com/science/article/pii/0094119086900239 doi: https://doi.org/10.1016/0094-1190(86)90023-9

Topel, R., & Rosen, S. (1988). Housing investment in the united states. *Journal of Political Economy*, *96*(4), 718-40. Retrieved from https://EconPapers.repec.org/RePEc:ucp:jpolec:v:96:y:1988:i:4:p:718-40