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Lending Conditions and Loan Default: What Can We Learn From UK Buy-to-Let Loans?

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Abstract

This research considers one approach as to how originating lending conditions on debt-service ratios and loan-to-value ratios affect future default risk in the "Buy-to-Let" market. Using a sample of mortgage loans for the UK, we estimate a "double trigger" default model, with originating equity and affordability terms. We find default increasing with originating loan-to-value (OLTV) and falling in original rent coverage (ORC). A non-linear cubic spline model is used to identify threshold effects in the relationship between OLTV, ORC and default, with loans of OLTV greater than 75 and ORC below 1.5 showing a large increase in default risk. These results provide empirical evidence for the non-linear nature of default in these origination terms and provides useful insights into for understanding OLTV and ORC limits in a macro prudential context. In addition, we investigate how multiple loan portfolios interact with these thresholds. While there is no impact on the main findings of 75 and 1.5, there is strong evidence to support tighter restrictions on loans for second and subsequent properties.

Keywords: Macroprudential, Credit Risk, Mortgages, UK.
JEL Classification: E32, E51, F30, G21, G28

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Non Technical Summary

With an aim towards boosting systemic resilience in the financial system, there has been a recent refocusing of financial regulation towards the use of macroprudential instruments. Regulators globally are engaged in a process of introducing, and designing, measures to limit aggregate risk through a toolbox of macroprudential regulations.

While there are a range of instruments available to policymakers such as capital buffers and risk weight management, one area of considerable focus has been the introduction of limits on mortgage lending such as loan-to-value and loan-to-income ratios. This is mainly in response to the elevated level of mortgage delinquency in many economies following the crisis, the link between the mortgage market and the wider financial turmoil and the evidence linking looser mortgage credit conditions through credit growth to increases in house prices.

In order to set the parameters of macroprudential policy appropriately, information is needed on the role of originating lending conditions in determining subsequent loan default. In this paper, we draw on a unique loan-level dataset for the UK which contains the loans of Irish bank's subsidiaries in that jurisdiction. This is one of the few loan-level datasets available for the UK which spans the period pre and post the financial crisis and also contains information on current and origination income and loan-to-values. Our estimation strategy uses a standard mortgage default model augmented to explore non-linearities in the relationship between original rent coverage (ORC: our proxy for the debt-service-ratio) and original loan-to-values (OLTV) using non-linear cubic splines.

We find default is increasing with LTV at origination and falling in original rent coverage. We also find threshold effects suggesting there are indeed non-linearities in the relationship between originated OLTV, ORC and subsequent default. We also extend our empirical framework to control for portfolio values of OLTV and ORC for borrowers with multiple loans outstanding and find default rates double in the case of multi-loan properties, with significantly greater sensitivity to OLTV and ORC increases.

1 Introduction

With an aim towards boosting systemic resilience in the financial system, there has been a recent refocusing of financial regulation towards the use of macroprudential instruments. Regulators globally are engaged in a process of introducing, and designing, measures to limit aggregate risk through a toolbox of macroprudential regulations (Kashyap et al., 2011; IMF, 2013; Claessens and Kodres, 2014; Claessens, 2014).

While there are a range of instruments available to policymakers such as capital buffers and risk weight management, one area of considerable focus has been the introduction of limits on mortgage lending such as loan-to-value and loan-to-income ratios. This is mainly in response to the elevated level of mortgage delinquency in many economies following the crisis (Gerardi et al., 2008; Elul et al., 2010; Jiang et al., 2014; Lydon and McCarthy, 2013; Kelly and OMalley, 2016), the link between the mortgage market and the wider financial turmoil (Brunnermeier, 2009; Duca et al., 2010) and the evidence linking looser mortgage credit conditions through credit growth to increases in house prices (Gerlach and Peng, 2005; Duca et al., 2011). While there has been a large number of papers considering the efficacy of such measures, there has been less work undertaken on the specific calibration of the level of LTI and LTV limits and less still on the important investment mortgage asset class. One possible method to inform such measures is to focus on how macroprudential limits on debt-service-ratios and loan-to-value ratios could be set to limit default in residential investment ("Buy-to-Let" (BTL)) mortgages. We use a unique loan-level administration dataset for the UK which contains the loans of Irish banks' subsidiaries in that market. The dataset links originating mortgage credit terms to the current loan performance and spans the period pre and post the financial crisis.

Using these data, our contribution to the literature is threefold. First, our empirical strategy specifies a "double trigger" model which links mortgage default to originating values of loan-to-value and rent coverage (our proxy for the debt-service-ratio[1]) controlling for a range of other loan and borrower characteristics. The focus on originating conditions allows us to test how limits on these variables could impact default. Second, we allowing a non-linear relationship between originating LTV (OLTV) and originating rent coverage (ORC) and default to test whether there are particular turning points which could provide useful information on understanding the relationship between originating values of OLTV and ORC and future default. These turning points indicate where increases in risk occur and could be informative to regulators as one input into the design phase of policy caps. Thirdly, we investigate whether there are differences in the default rates between borrowers who have one loan and borrowers who have a portfolio of loans across multiple properties. We then extend our empirical

[1] Rent coverage is the proportion of the monthly installment covered by the current rent. Rental pricing is captured at the property level in the dataset and is updated using local area rental yields driving from the younger loans in the dataset. For further information, see Section 2.1.

framework to control for portfolio values of loan-to-value and rent coverage for borrowers with multiple loan relationships.

Banks cannot control ex-post how borrowers are hit by equity or affordability shocks. They can simply be regulated to manage loan conditions ex-ante with the expectation that this provides adequate buffers. Therefore, following Kelly et al. (2015), default is modeled as a function of OLTV and ORC and not the more common current equity and income shock approach, although results are tested for robustness to current characteristics. Our research is novel in that no existing studies have evaluated a "double trigger" default model of residential investment mortgages with a view to exploring the possible parameterisation of originating macroprudential regulations for both single and portfolio investors.

Our research is linked to three main literatures. First, our work is related to the emerging research on the effectiveness and calibration of macroprudential regulation in housing markets.[2] A majority of these studies use aggregate data to assess the interaction between these measures and house-prices through the credit-growth channel (Arregui et al., 2013; Nabar and Ahuja, 2011; Gerlach and Peng, 2005; Vandenbussche et al., 2015; Wong et al., 2014) and find such limits are effective in managing credit growth with less certainty on the link to house prices.

Closer to our research are the studies in this field using micro data. Claessens et al. (2013) use bank balance sheet data across 48 countries and find that limits on debt-to-income and loan-to-value ratios are effective in reducing leverage, asset and noncore to core liabilities of banks during boom times. Igan and Kang (2011) use survey data for Korea and find that loan-to-value and debt-to-income limits are associated with a decline in house price appreciation and transaction activity. Fuster and Zafar (2014) evaluate borrower willingness to pay based on different loan-to-value ratios.

However, none of this research focuses on the potential impact of macroprudential instruments on default or informing the levels of caps should be specified to best achieve acceptable bank and borrower resilience. In fact, Jacome and Mitra (2015) note that to date the setting of cap levels has been done on a completely arbitrary and ad-hoc basis. One study which does address this concern is Kelly et al. (2015) who estimate whether there is justification from a default perspective to provide first time homebuyers with differential regulatory treatment. However, they do not consider the calibration of investment mortgages which is the focus of our research. Additionally, our paper is also linked to the studies which assess the efficacy of other macroprudential measures such as capital requirements (Gauthier et al., 2012; Aiyar et al., 2014) or measures to manage liquidity shocks (Valderrama, 2015).

As a second major contribution, our work provides a bridge between the general research on modelling default in investment mortgages (Grovenstein et al., 2005; Archer et al., 2002; Goldberg and Capone, 2002) and the broader macroprudential stress testing literature (Acharya et al., 2014; Borio et

[2] Further detailed summaries of the literature on macroprudential policy can be found in Galati and Moessner (2013) or Galati and Moessner (2014).

al., 2014; Gaffney et al., 2014) of which modelling mortgage default is an important aspect of assessing bank resilience to shocks (Buncic and Meleck, 2013). Regarding the traditional literature on commercial or investment mortgage default, theoretical models suggest a "double trigger" consideration of negative equity and income shocks which drive default (Goldberg and Capone, 2002). In these models, investors exercise the default option when they experience a) an equity shock which reduces the value of the asset to lower than the loan size or b) an income shock whereby the rental earnings do not cover interest payments. Empirically, these channels are tested by linking current loan-to-value ratios and debt-service ratios to default. However, while there are numerous studies that test these channels as noted above, we can find no existing research which links such investment mortgage default models to macroprudential policy measures. Given the high level of delinquency in this loan class in many crisis economies, it is important that macroprudential authorities appropriately assess and set the measures in this market to manage systemic risks. It may even be more important to manage credit conditions in this market as investors are potentially more sensitive to equity triggers of default (exercising the option) due to not having home ownership links to the underlying property.[3] Our research is the first study to address this gap in the literature.

Third, our research is linked to the broader literature on modelling default and arrears in the UK mortgage market. There are relatively few studies in this space due to a lack of adequate micro data. One obvious exception is McCann (2014) who uses panel data on UK mortgages to estimate default transitions. This research finds important roles for housing equity, unemployment and interest rates in determining loan defaults and loan cures. Our research differs from this study by both incorporating a borrower-specific income channel and focusing on an originating macroprudential specification.

A number of findings emerge. As expected, we find a positive and significant impact of OLTV on default and a negative and signficant effect of ORC, controlling for a range of other loan and borrower characteristics. To provide some insight into the magnitude of the effects, a one standard deviation increase in OLTV would increase the default rate by 28 per cent while a one standard deviation decrease in ORC would increase default rates by 23 per cent.

To help provide useful information for understanding the link between originating credit conditions and future loan performance, we test whether the effect of OLTV and ORC is non-linear and whether there exist turning points in these relationships that could inform the selection of cap levels i.e. does the default risk spike at particular values of OLTV or ORC and could these be used to influence policy measures? Using a non-linear cubic spline approach, we find that for OLTV values below 75 per

[3]There are a number of examples of regulatory authorities imposing specific macroprudential limits on investment loans. Ireland introduced an LTV limit of 70 per cent on buy-to-let mortgages. Different LTV limits for non-owner occupiers have been used in Hong Kong, Israel, Malaysia, New Zealand, and Singapore, with limits ranging from 70 per cent (New Zealand) to 20 per cent (for non-individuals in Singapore with one or more outstanding loans). For more details please see Jacome and Mitra (2015).

cent, there is no considerable difference in default rates. However, above 75 per cent, there is a steep increase in the predicted default rates. Regarding the effects of ORC, default risk falls with higher values but begins to taper out after approximately 1.5 (widening error bands after this level). These results provide empirical evidence for the non-linear nature of default in these origination terms and provides guidance for the setting of OLTV and ORC limits in a macro prudential context.

As the above assessment was estimated at the loan-level, it did not take into account any considerations relating to whether investors have portfolios of loans across multiple properties. Having multiple loans may provide differential risk to borrowers with single investment mortgages. To assess this issue, we investigate whether there are differences in the default rates between borrowers who have one loan relative to those who have a portfolio of loans and extend our empirical framework to control for portfolio values of OLTV and ORC for borrowers with multiple loan relationships. In general, the default profiles across OLTV and ORC distributions are broadly similar to the loan level estimates above, with sharp increases in default risk for OLTV above 75 per cent and ORC below 1.2. However, the spline of multi-loan borrowers is a statistically significant level-shift higher than those for single-loan borrowers from approximately 60 OLTV to close to 95 OLTV and between ORC values of 0.3 and 1.2. These results suggest there are potential gains in terms of default mitigation, by designing rules which bind at more stringent OLTV and ORC levels on second and subsequent investment mortgages. In addition, this will also act to lean against the amplifying effect of the credit cycle by restricting the extent to which housing equity gains can be used as further collateral. Counter-cyclical aspects of macroprudential policies are important to ensure financial cycles are not reinforced.

From a macroprudential policy setting perspective, a number of implications arise from our research. Using this methodology, we have been able to identify turning points in the relationship between OLTV, ORC and default which could be one useful input when regulators are considering potential cap parameterisation. This assumes the policymakers' objective function is purely building balance sheet resilience without consideration to wider economic developments. As our model is reduced form, it cannot provide an assessment of the feedback loops between capping credit conditions and the real economy that can be assessed in a structural or dynamic stochastic general equilibrium setting. In this respect, our methodology could be seen as one part of the toolkit for parameterising macroprudential limits in investment mortgages and used in conjuction with DSGE or other macroeconomic approaches (Buncic and Meleck, 2013; Clancy and Merola, 2014). Nonetheless, our non-linear default model with loan conditions included at origination can provide insight for policymakers attempting to manage future default risk through macroprudential limits.

The rest of this paper is structured as follows: Section 2 presents the data, empirical model and summary statistics. Section 3 outlines the main empirical findings and Section 4 concludes.

2 Data and Empirical Model

2.1 Data

This research uses loan-level data from the UK subsidiaries of Irish headquartered banks: Allied Irish Banks (AIB, including EBS Building Society), Bank of Ireland (BoI), and Permanent TSB (PTSB). These data were collected by the Central Bank of Ireland as part of the Financial Measures Programme (FMP) which assessed the capitalisation and liquidity requirements of the Irish banks as part of the IMF-EC-ECB official financing support. The Irish sample of these data has been used extensively in research on the performance and credit market functionality in Ireland (Kelly and OMalley, 2016; Kelly et al., 2015; Lydon and McCarthy, 2013). It was also used to assess the recapitalisation requirements of the banking sector following the recent Irish financial crisis. Additional information on this dataset is presented in Kennedy and McIndoe Calder (2011). While these data are some of the only loan-level information available for the UK, it is instructive to assess their potential representativeness to the wider UK market. McCann (2014) notes Irish-headquartered banks represent approximately 2 per cent of the total UK mortgage market.

These loan-level data (LLD) contain a range of information fields that are filled by the borrower at mortgage application stage and subsequently used by the bank as part of the credit assessment. This includes the following items valued at origination: drawn balance, initial installment, borrower income, the valuation of the underlying collateral, the mortgage term, interest rate type and payment type (e.g. amortising or interest-only). For BTL mortgages, information is also available on the original rent, some borrower-specific information such as borrower age and further data on the dwelling the loan is used to acquire (the postcode and region of location and whether the property is an apartment or house). There is also information on a range of current loan information which is reported by the financial institution including: the current non-performing status of each loan, the current loan-to-value, current installment, and the current interest rate type and level.

In our analysis, we take a cross-section of loans that were held on the banks' books in December 2014. Given the variables above, our sample contains a mix of characteristics that are measured either at the time of loan origination or as of December 2014. Given the focus of our research, the sample is limited to only mortgage for residential investment purposes or "Buy-To-Let" loans. In total the sample contains 106,775 observations. The sample includes loans that were originated between the years 1987 and 2014 so we observe loans allocated across the credit boom and financial crisis period. A listing of the variable definitions is presented in table 1. To measure loan performance, we use a binary indicator of default as defined by standard Basel II definitions ($>$ 90 days in arrears). Interest rate type controls are either fixed or adjustable rate (variable and tracker loans) while payment status

Table 1: Main Variable Definitions

Variable	Description
Dependent Variable	
Default Status	> 90 days in arrears
Borrower Controls, $\mathbf{X_i}$	
Borrower Age	Borrower age at origination (in months)
Region	Groups (London, East Midlands etc.)
Loan Controls, $\mathbf{Z_i}$	
Bank	Dummies for each banking group
Loan Age	Number of months since loan origination.
Term	Loan term at origination (in months)
Interest Rate Type	Interest rate type at origination. i.e. Fixed, Variable
Payment Type	Dummy for interest only
DBO	Log drawn balance at origination
Macro Prudential	
OLTV	Loan to value at origination.
ORC	Rental value to installment at origination
Additional Controls, $\mathbf{C_i}$	
ADBO	Total Drawn Balance of Equity Release
Property Type	Indicator for Apartment

is a binary indicator for whether or not the loan is amortising or interest only. Drawn loan balance at origination is measured in natural logs.

To provide insight into the calibration of macroprudential measures in the mortgage market, we require information on variables that are commonly subjected to such limits. In the case of BTL mortgages, two commonly used limits are on the loan-to-value ratio and the rent coverage ratio which imposes minimum downpayment or affordability conditions on borrowers.[4] From the perspective of a macroprudential supervisor, limits on these credit conditions are set at loan origination with a view to providing default buffers in future. The standard literature on investment mortgage default suggests a role for both loan-to-value and income (rental) channels in driving future delinquency. In our data, we focus on both originating loan-to-value (OLTV) and originating rent-coverage (ORC) (rent as a fraction of the loan installment both at loan origination)[5] as defined in table 1 and discuss how they affect future mortgage default.

Summary statistics for the main variables are included in table 2. The average default rate across the sample is 2 per cent of loans. For comparison, the average default rate in our data is higher than that reported in the mortgage backed pools of UK BTL loans (Moodys, 2015). Our sample therefore has somewhat poorer loans than those allocated by other institutions in the UK. However, from a research perspective, our sample is still one of the largest loan-level datasets available for the UK

[4] The Bank of England Financial Policy Committee notes the use of interest coverage ratios as the standard debt-to-income measure for buy-to-let loans. See http://www.bankofengland.co.uk/financialstability/

[5] With this definition, a value of 1 indicates that the rent exactly covered the required loan installment

and, given the high delinquencies, these loans are potentially important to analyse in the context of potential financial stability risks and the appropriateness of macroprudential oversight.

Table 2: Loan Level Summary Statistics

	Mean	St. Dev
Default(%)	2.35	15.18
DBO (pounds)	114,707.20	73,606.93
Loan Term (months)	253.85	58.54
Loan Age	91.49	23.48
IntType		
Fixed(%)	2.48	NA
Variable(%)	97.52	NA
Pay Type, IO(%)	87.61	32.95
Borrower Age (years)	43.86	9.78
Origin Rental Yield (%)	5.61	5.45
OLTV (%)	72.87	13.30
ODSR	1.19	0.43
Location		
East Midlands(%)	0.01	NA
East Anglia(%)	6.91	NA
London(%)	9.52	NA
North East(%)	17.39	NA
North West(%)	3.96	NA
Scotland(%)	14.15	NA
South East(%)	3.58	NA
South west(%)	14.41	NA
Wales(%)	9.93	NA
West Midlands(%)	5.06	NA
York-Humber(%)	6.80	NA
Observations	106,326	

The average drawn loan size in our data was 114,539 with a standard deviation of 73,620. The average term length at origination was circa 254 months (just over 21 years). The majority of originating mortgage interest rates were adjustable (ARMs), nearly 98 per cent[6] with the remainder fixed rate (FRM). Over 87 per cent of the mortgages were interest only, non-amortising loans. In terms of the regional breakdown of lending, the highest lending shares were 17 per cent of loans to the North East, 14 per cent for the South West and Scotland and just under 10 per cent for Wales and London. The average rental yield in the data is approximately 6 per cent[7].

For the macroprudential variables, the average OLTV for loans in the dataset was 73 per cent i.e. borrowers posted a 27 per cent deposit. However, there is considerable variation across the distribution of loan-to-value ratios as presented in figure 6. While a considerable clustering of the distribution is evident between 75 and 90, there is a large portion of loans that were allocated at above 100 per cent LTV. Average rent coverage ratio (ORC) was 1.2, i.e. rent was approximately 20 per cent greater than loan installment at origination. However, there is considerable variation in ORCs as noted in figure

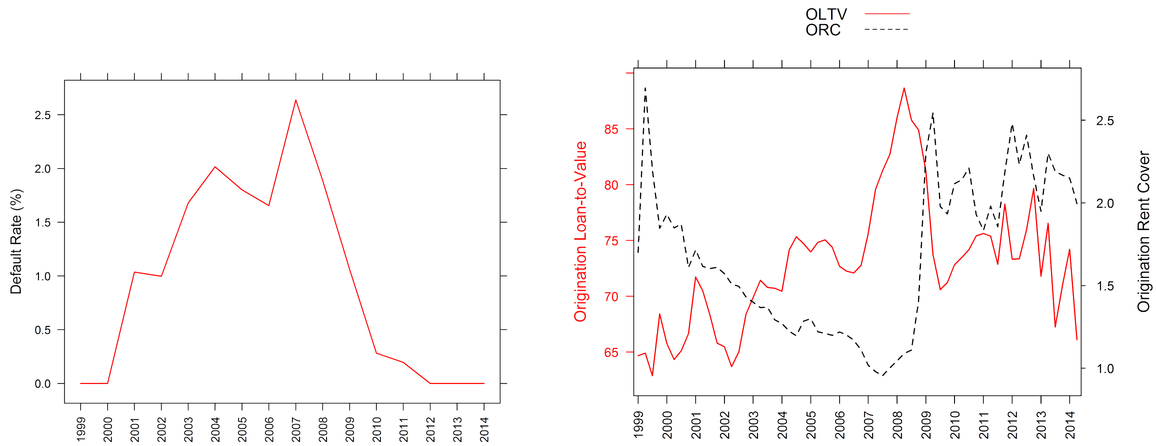
[6] This includes both variable rates as well as tracker mortgages which vary with a fixed spread over a reference rate.

[7] Yield is defined as originating rent divided by collateral valuation.

Figure 1: Default, OLTV and ORC of UK BTL Loans by Origination Year

1.A: Default Rate

1.B: OLTV and ORC



6. Many loans were allocated with a rent coverage lower than 1 (rent does not cover the installment fully). The distribution of this variable also has a long right tail with some loans granted with very high rent coverage ratios.

Our dataset contains loans originated across the credit boom and financial crisis period up to December 2014. It is instructive to consider whether we observe varying credit conditions and loan allocation terms over this period and whether, for the period in which credit conditions were looser, do these loans have a worse delinquency performance. Figure 1.A presents the average default rate as well as median OLTV and ORC by the year of loan origination. The default rate is highest for loans originated in the pre financial crisis period (2006-2007). There is a steady increase in the default rate on loans allocated between 2001 and 2008 with a fall off more recently. Figure 1.B presents the median values of OLTV (left side) and ORC (right side) for loans allocated over the period 1999 to 2014. There was a steady increase in the median OLTV over the period 2002 to 2008 as well as a loosening of median rent coverage. Directly preceeding the crisis period (2006/2007), over 50 per cent of loans were allocated on properties whose rent did not cover the monthly installment. These findings are in line with research documenting the general loosening of credit conditions which predated the global financial crisis (Duca et al., 2010, 2011). More recently, as credit conditions have tightened, OLTVs have fallen while ORCs have increased as banks now apply more prudent assessment criteria. While we formally provide an econometric strategy in the next section to explore these linkages, this would suggest a potential role for macroprudential limits on credit conditions during the boom period which may have provided additional loan default buffers.

2.2 Empirical Model and Identification Strategy

The aim of this research is to test the relationship between originating credit limits on OLTV, ORC and loan default with an aim to inform the calibration of macroprudential policy. Their exists a large literature which tests the determinants of default in relation to the standard "double trigger" hypothesis of equity and affordability concerns. This literature posits that, for investors, as the loan moves into negative equity or as cash flows become insufficient to service loan terms, the propensity to default increases (Grovenstein et al., 2005; Archer et al., 2002; Goldberg and Capone, 2002). In an empirical model, this would suggest a positive (negative) relationship between contemporaneous LTV (RC) and default.

However, using this approach is insufficient for our purposes. Macroprudential supervisors set regulatory limits at origination. They do not have control over ex-post house price or affordability shocks that may compromise the borrowers ability or desire to repay. They must therefore calibrate the limits on LTV or RC at origination to provide sufficient buffers against such shocks. This leads to the challenge of what specific level to set for the measures.

To address these issues, our identification strategy is as follows. First, we propose a cross-sectional default model which links current loan performance to OLTV and ORC, the factors regulators might want to limit. Second, we test whether the relationship between OLTV (ORC) and default is non-linear and whether there exist turning points in these relationships which might suggest values or ranges for calibration of the macroprudential policy. A visual of the average default rate at different values of the distribution of OLTV and ORC (figure 3) would suggest their are some non-linearities in the relationship. In particular, there is a significant increase in the default risk for OLTV ratios above 75 and a leveling in the default lowering for ORC above 1.4. Finally, we undertake robustness checks to test whether our findings on the originating terms hold controlling for current house price and affordability shocks. By including originating characteristics, we rule out any potential reverse causality between these terms and default.

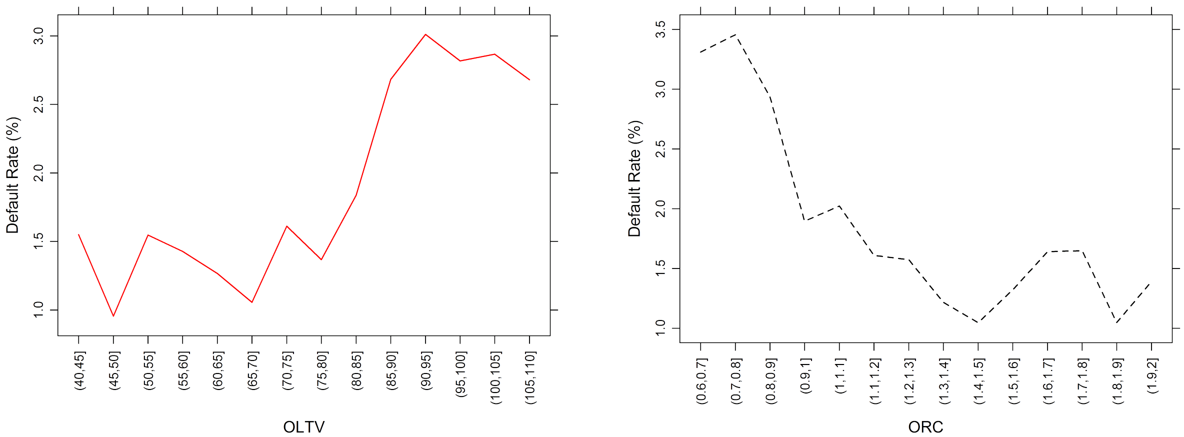
2.2.1 Baseline Model

Our empirical approach uses a standard model of default which is common in the existing literature (Jiang et al., 2013, 2014; Haughwout et al., 2008). Let the realisation of the latent propensity to default for residential investment loans be characterised as:

$$NP_i = \begin{cases} 1 & NP_i^* \geq 0; \\ 0 & NP_i^* < 0. \end{cases}$$

where NP_i^* represents the censored underlying latent variable and NP_i the observed indicator for

Figure 2: Default Rate by OLTV, ORC Cuts



default. Our baseline model uses a cross sectional logistic specification and estimates the probability that a BTL mortgage defaults as a function of the macroprudential controls at origination, borrower characteristics, loan characteristics and dwelling controls as indicated in table 1:

$$Pr(NP_i = 1) = \mathbf{F}\left(OLTV_i, ORC_i, \mathbf{X_i}, \mathbf{Z_i}, \mathbf{C_i}\right) \tag{1}$$

where $OLTV_i$ is the originating loan-to-value ratio and ORC_i is the originating rent coverage. Our a-priori expectations for the signs on these variables are:

- H1: $\beta_{OLTV} > 0$
- H2: $\beta_{ORC} < 0$

H1 states that default is increasing in originating loan-to-value ratios while H2 states that default is decreasing in originating rent coverage. Regarding other controls, $\mathbf{X_i}$ contains a vector of borrower-specific or dwelling controls including borrower age and a full set of regional dummies in all regressions. $\mathbf{Z_i}$ is a vector of loan terms at origination including the log of drawn balance, loan vintage, term length, binary indicators for interest rate type, interest only payment and bank of origination.

The vector $\mathbf{C}$ contains other controls that may affect the performance of the original BTL loan. We include additional debt that may have been taken out on the property since the first loan. In many cases, these equity releases may be used to invest in additional properties or used as household consumption financing. The additional leverage potentially provides more limited capacity of borrowers to manage shocks and is therefore expected to positively affect default. We also include a binary indicator for apartment property type. If apartments experience different house price shocks than other dwellings, the default rate may be higher for these properties.

2.2.2 Calibration Using a Non-Linear Approach

As noted above, to inform the specific calibration of macroprudential limits, we wish to test for threshold effects of the impact of different LTV and RC levels at origination on default risk. One methodology might be to split the distributions of OLTV and RS into groups of categories and test whether the slope is constant across a variable. For example, we could group OLTV into arbitrary buckets [0-5,5-10 etc.] and include these into the regression framework. However, this assumes that the effect within each group is constant and that jumps in the relationship happen at the boundaries of the bands.

An alternative approach is to use a spline function which addresses these issues by fitting a piecewise regression which takes a functional form between points, known as knots, of the continuous variable. Following a number of applications in the medical literature (Desquilbet and Mariotti (2010), Marrie et al. (2009)), we allow for non-linear relationship between the knots using a restricted cubic spline (RCS). When using a RCS, one obtains a continuous smooth function that is linear before the first knot, a piecewise cubic polynomial between adjacent knots, and linear again after the last knot. In general, the logit RCS model, with restricted spline function $f(S)$, with k knots is given by:

$$Pr(NP_i = 1) = \mathbf{F}\left(OLTV_i, ORC_i, \mathbf{X_i}, \mathbf{Z_i}, \mathbf{C_i}, f(S)\right)$$
$$\text{with } f(S) = \beta_0 + \beta_1 S_1 + \beta_2 S_2 + ... + \beta_{k-1} S_{k-1}$$

where $\mathbf{X_i}$,$\mathbf{Z_i}$ and $\mathbf{C_i}$ are defined as in Equation 1. S is the variable upon which the spline function is estimated, in our case OLTV and ORC. We locate knots at the 5, 27.5, 50, 72.5 and 95 percentiles of the distributions of OLTV and ORC. This is in line with previous research (Kelly et al., 2015; Harrell, 2001).

3 Empirical Results

3.1 Baseline Results

The results of our baseline logit specifications are presented in table 3. Marginal effects are presented with standard errors robust to heteroskedasticity. Column 1 presents the basic specification without controls for OLTV and ORC. Columns (2) and (3) introduce these variables in a stepwise fashion while column (4) includes the full specification.

The main variables of interest are OLTV and ORC. In Column (2), OLTV is introduced with the baseline control variables. The marginal effect is positive and significant as expected. In column (3), ORC is included and the effect is negative and significant also as expected. Column (4) introduces both factors simultaneously and the findings hold: default is increasing with LTV at origination and falling in original rent coverage. To get a sense of the magnitude of the effects, a one standard deviation increase in OLTV would increase the default rate by 28 per cent while a one standard deviation decrease in rent coverage would increase default rates by 23 per cent.[8]

Regarding the control variables, we find a positive and significant effect of the original drawn balance on default: a one per cent increase in drawn balance increases the default probability by 0.009. The sign on this variable is as expected and indicates that, controlling for other factors, larger loans are more risky. The marginal effect of additional drawn balance is also positive and significant indicating that additional loans on the same collateral as the original facility heighten the default risk. The magnitude of the effect is slightly smaller than that for drawn balance but indicates that a 1 per cent increase in the log of additional balance increases the default risk by 0.002. To recall the average default in the sample is only 2 per cent so these effects are economically meaning full.

Loan age or vintage controls for the number of months since origination of the loan. This captures the timing of origination and has a statistically significant and negative effect on default in the full specification.[9] We find loan terms have a negative effect on the probability of default controlling for other factors. If terms are increased, ceteris paribus, this should reduce the installment and improve affordability. We find no statistical difference in default risk between loans on fixed interest rates or variable rates. Borrowers who have interest only contracts at origination are more likely to default. Default is also decreasing in borrower age and is higher for apartments than other dwelling types.

While the baseline findings point to positive (negative) effects for OLTV (ORC), we are interested to test whether there are thresholds in these relationships which may provide insight for policy calibration. To do this, we use the model given by column (4) but allow both OLTV and ORC to enter with a cubic spline. We then estimate the predicted probabilities of default from the model for values of OLTV and ORC holding all other variables at their mean values. The results are presented in figure 3. For OLTV, it appears that for values below 75, there is no considerable difference in default rates. However, from 75 OLTV onwards, there is a very steep increase in the predicted default rates. This suggests if supervisors are focused on building resilience against future default then calibrating the OLTV limit to circa 75 will protect against the steep rise in default risk that is associated with greater levels of OLTV.

[8] This is based on the sample mean default rate of 0.02, the marginal effect estimate for OLTV (ORC) of 0.0005 (-0.0128) and a standard deviation of 13.29 (0.426).

[9] As a robustness check we also run the model with origin year fixed effects replacing loan age and the results are unchanged.

Table 3: Marginal Effects of Logit Model

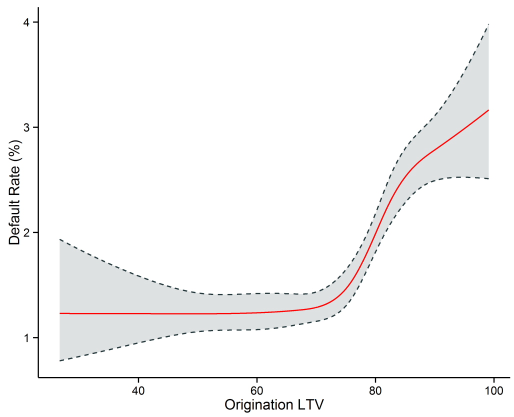
	Baseline	LTV	DSR	Full
ln(Loan Balance)	0.0129***	0.0113***	0.0100***	0.0094***
	(0.001)	(0.001)	(0.001)	(0.001)
ln(Additonal Balance)	0.0019***	0.0025***	0.0024***	0.0029***
	(0.000)	(0.000)	(0.000)	(0.000)
Loan Age	−0.0000	−0.0000	−0.0001**	−0.0001**
	(0.000)	(0.000)	(0.000)	(0.000)
IntType, Variable	−0.0005	0.0012	0.0016	0.0024
	(0.004)	(0.004)	(0.004)	(0.004)
Loan Term	−0.0000*	−0.0000**	−0.0000*	−0.0000**
	(0.000)	(0.000)	(0.000)	(0.000)
Pay Type, IO	0.0161***	0.0140***	0.0200***	0.0169***
	(0.002)	(0.002)	(0.003)	(0.003)
Borrower Age	−0.0002**	−0.0001*	−0.0002**	−0.0001*
	(0.000)	(0.000)	(0.000)	(0.000)
PropType, Apt	0.0093***	0.0088***	0.0087***	0.0084***
	(0.001)	(0.001)	(0.001)	(0.001)
Region Controls				
East Anglia	−0.0050*	−0.0051*	−0.0048*	−0.0050*
	(0.002)	(0.002)	(0.002)	(0.002)
London	−0.0100***	−0.0069**	−0.0099***	−0.0074**
	(0.002)	(0.002)	(0.002)	(0.002)
North East	−0.0239***	−0.0207***	−0.0233***	−0.0210***
	(0.002)	(0.002)	(0.002)	(0.002)
North West	−0.0015	−0.0033	−0.0013	−0.0030
	(0.003)	(0.003)	(0.003)	(0.003)
Scotland	0.0036*	0.0010	0.0040*	0.0017
	(0.002)	(0.002)	(0.002)	(0.002)
South East	−0.0074*	−0.0091**	−0.0068*	−0.0087**
	(0.003)	(0.003)	(0.003)	(0.003)
South west	−0.0210***	−0.0219***	−0.0204***	−0.0214***
	(0.002)	(0.002)	(0.002)	(0.002)
Wales	−0.0147***	−0.0123***	−0.0140***	−0.0121***
	(0.002)	(0.002)	(0.002)	(0.002)
West Midlands	−0.0040	−0.0052*	−0.0044	−0.0056*
	(0.003)	(0.003)	(0.003)	(0.003)
York-Humber	−0.0084***	−0.0116***	−0.0089***	−0.0119***
	(0.002)	(0.002)	(0.002)	(0.002)
Macro Prudential				
OLTV		0.0006***		0.0005***
		(0.000)		(0.000)
ORC			−0.0163***	−0.0128***
			(0.002)	(0.002)

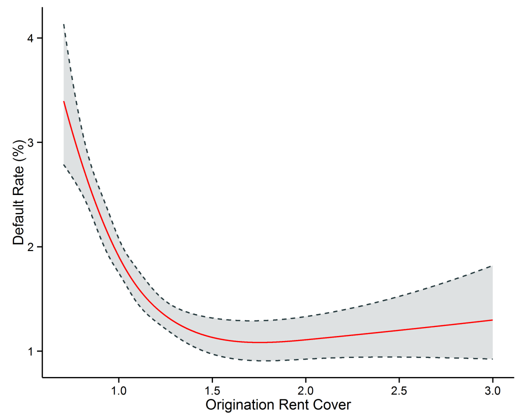
Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure 3: RSC Fit of Mortgage Default

3.A: OLTV

3.B: ORC





Similarly, the predicted probabilities of default are much higher for lower levels of ORC. The effects appear to taper out after approximately 1.5 ORC with widening error bands after this level. This result suggests that if policymakers set the limit of original rent to 1.5 times the original installment amount, this will provide buffers to mitigate future default risk.

To summarise, our approach has demonstrated that there do appear to be turning points in the relationship between default and originating levels of both OLTV and ORC. If minimising default risk is the objective function of macroprudential supervisors, tailoring the measures to take into account these non-linearities may be appropriate.

3.2 Difference by Multi-Loan Grouping

Section 3.1 provides an assessment of the relationship between default, OLTV and OLTI on an individual loan-by-loan basis. That may be an appropriate strategy when the borrower is likely to be limited to a single dwelling purchase and any equity releases are controlled for (as we have done above). However, with BTL investments, it is highly likely that many borrowers build up an investment portfolio and have multiple loans across multiple properties. If this is the case, it may have implications for macroprudential policy if the default risk on the multi-loan borrowers is different. Furthermore, the relationship between OLTV, ORC, and default may depend on the borrowers' multiple loans or portfolio in particular where built up housing equity from the portfolio is used to access new credit.

In our data, we are able to ascertain whether individual borrowers have more than one property as well as numerous loans on those collaterals with the same institution.[10] We can therefore test whether

[10]One limitation of our LLD is that we do not have a full borrower view of lending. Instead, we can only evaluate the extent to which an investor has loans outstanding with the same institution. If it is expected that borrowers are drawing down loans from multiple institutions then our research is not able to capture this.

there is a difference in default risk for the group of borrowers with multiple loans. If this is the case, then further consideration must be given to addressing how our calibration assessment is refined to account for this heterogeneity in risk.

In table 4, we re-run the baseline model at the loan level as per column (4) of table 3 but now include a dummy indicator that takes the value of one for borrowers with more than one loan in the data (Multi-Loan). For brevity we only display the marginal effect on the OLTV, ORC and Multi-Loan. The coefficient on this variable is statistically significant and positive: borrowers with multi-loans have a higher default risk than those with a single loan. The magnitude of the effect indicates that such loans have a 1.13 per cent higher probability of default. With a sample mean default rate of 2.2 per cent, the default rate for multi-loan borrowers is nearly 50 per cent higher than single-loan borrowers controlling for other factors that affect loan risk at origination.

To explore whether the relationship between OLTV, ORC and default is also different for this group, we interact Multi-Loan with OLTV and ORC. The estimates are presented in column (2) of table 4. The own effects of OLTV and ORC remain significant and carry the expected signs. However, the interaction of Multi-Loan with both OLTV and ORC suggest that the impact of these variables is greater for these borrowers: the effect of a one per cent increase in OLTV (ORC) on default is 0.0003 (-0.007) for single-loan borrowers and 0.001 (-0.0273) for multi-loan borrowers.

Table 4: Marginal Effects of Logit Model w/Multi-Loan

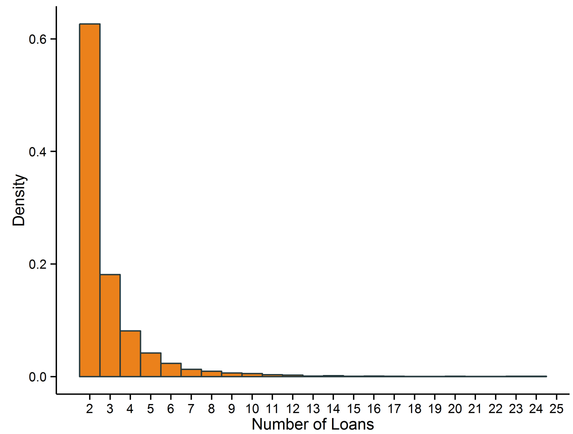
	Dummy	Interaction
ORC	-0.0131^{***}	
	(0.002)	
OLTV	0.0005^{***}	
	(0.000)	
Multi-Loan	0.0112^{***}	
	(0.001)	
ORC (Single-Loan)		-0.0069^{***}
		(0.002)
ORC (Multi-Loan)		-0.0249^{***}
		(0.005)
OLTV (Single-Loan)		0.0003^{***}
		(0.000)
OLTV (Multi-Loan)		0.0009^{***}
		(0.000)

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

3.3 Towards a Borrower Level Macroprudential Policy

Section 3.2 shows a significant difference in the risk profile of investors with multi-property portfolios and as such modeling default risk at the loan level is flawed given correlation in default risk between

Figure 4: No of Properties for Multi Property Borrowers



loans connected to the same borrower. Therefore, it makes sense that macroprudential policy in residential investment is implemented at the borrower level. To address these considerations, we shift from a loan level to a borrower view. The dataset is constructed at the origination of the most recent loan drawdown with a portfolio view of LTV and RC considered. In the case of single loan borrowers, there will be no change from earlier description but in the case of multi-loan borrowers, OLTV will be calculated as the sum of all balance outstanding plus the new balance drawn over the total value of all collateral at the origination of the most recent property purchase. Similarly, ORC will be calculated as total rent over installments of all loans at the origination of the most recent property purchase. This allows us to capture the cross subsidisation of house equity and rent growth used by borrowers to increase their property portfolio. This is of particular importance in a macroprudential context as this housing investment is driven by, and further contributes to, house price bubbles.

Table 5 presents summary statistics for key loan and borrower characteristics from the dataset depending on whether or not the borrower has multiple properties. The difference between the mean values for each group is also presented with tests of statistical significance. Consistent with Table 4, the default rate for multi-loan borrowers is more than twice that of single. While individual loan sizes are not significantly different between the groups, as expected, porfolio value and gross income (includes rent) are both significantly larger. In terms of the main macroprudential lending instruments, while there is a statistical difference between the groups for both, portfolio OLTV is less than 3 percentage larger and portfolio ORC is 4 per cent smaller for single loan borrowers.

Table 6 replicates at the borrower level the logit specification presented in table 3. Marginal effects are presented with standard errors robust to heteroskedasticity. Column 1 presents the basic

Table 5: Borrower Level Summary Statistics by Number of Loans

	Single Loan (SL)	Multi Loan (ML)	Diff	% Diff from ML
Default (%)	1.5	3.1	1.6	51.6***
Loan Size (£)	115,740	116,919	1,179	1.0
Portfolio Purchase Value (£)	155,049	405,886	250,836	61.8***
Portfolio Current Value (£)[1]	181,390	444,012	262,622	59.1***
Borrower Characteristics				
Gross Income (£)	67,122	96,564	29,442	30.8***
Age (yrs)	43	45	2	4.44***
Loan Characteristics				
Term (months)	255	248	-7	2.8***
Vintage (months)	92	88	-4	4.5***
Rate Type, IO (%)	84.3	92.9	8.6	9.3***
London (%)	9.7	8.5	1.2	14.1
Portfolio OLTV (%)	76.8	79.69	2.92	3.7***
Portfolio Originating Rent (£)	8,844	23,241	14,397	61.9***
Portfolio ORC (%)[2]	1.14	1.19	0.05	4.2***

Notes: Significant difference is based on t-tests on the equality of means.
$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$
[1] Current valuation as of December 2013.
[2] Originating rent cover defined as the % of installment covered by rent.

specification without controls for OLTV and ORC. Columns (2) and (3) introduce these variables in a stepwise fashion while column (4) includes the full specification. The findings hold with default is increasing with LTV at origination and falling in original rent coverage.

If macroprudential policy was to reflect the higher default risk for multiple property loan portfolios and a greater sensitivity to ORC and OLTV through lending limits, additional analysis on the interaction and threshold effects between portfolio size and the main policy tools is required. We undertake the following: (i) estimate a borrower-level model which explores non-linearities between default and OLTV/ORC and (ii) test how the single and multiple property portfolios differs across originating ORC and OLTV levels.

We address these questions by re-estimating the logit model at the borrower level including the non-linear splines and the interactions of the spline variables with the flag for borrowers with multiple loans. All other controls and variables are included as in table 6. Figure 5 presents the predicted probabilities of default across the values of OLTV and ORC for both single-loan borrowers (red) and multiple-loan borrowers (blue). Standard error bands at the 5 per cent level are also presented.

In relation to OLTV, there is no statistically significant difference in the default rates for the two groups up to OLTV of approximately 60 per cent as the error bands cross. However, from 60 to approximately 95 LTV, multi-loan borrowers have a statistically significant higher default rate than single-loan borrowers. The slope of both splines begin to increase between 75 to 80 OLTV indicating considerably heightened risk of default for loans with LTVs above this point.

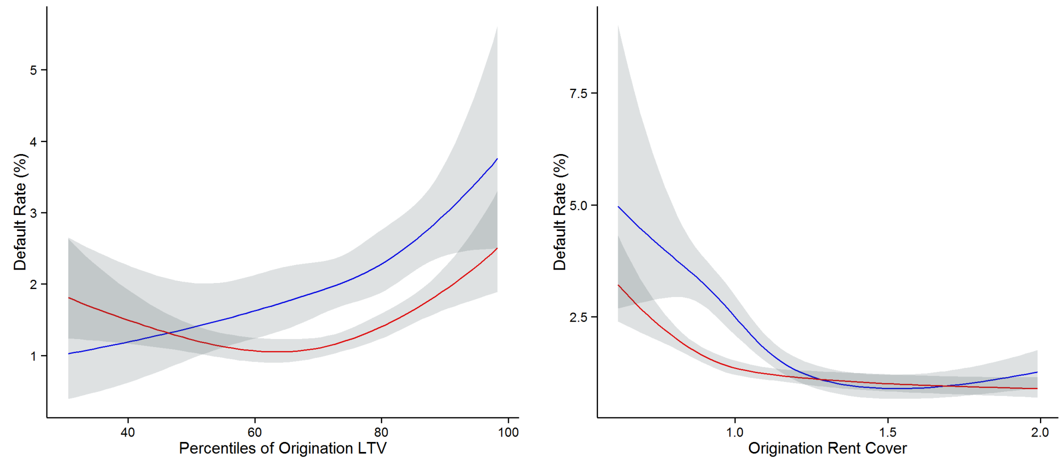
Table 6: Marginal Effects of Logit Model

	Baseline	OLTV	ORC	Full
Ln(Loan Balance)	0.0115***	0.0105***	0.0101***	0.0091***
	(0.001)	(0.001)	(0.001)	(0.001)
Ln(Additonal Balance)	0.0016***	0.0020***	0.0016***	0.0019***
	(0.000)	(0.000)	(0.000)	(0.000)
Loan Age	0.0000	0.0000	−0.0001	−0.0000
	(0.000)	(0.000)	(0.000)	(0.000)
IntType, Variable	−0.0061	−0.0043	0.0017	0.0040
	(0.003)	(0.003)	(0.004)	(0.005)
Loan Term	−0.0000	−0.0000*	−0.0000	−0.0000*
	(0.000)	(0.000)	(0.000)	(0.000)
Pay Type, IO	0.0104***	0.0092***	0.0124***	0.0114***
	(0.002)	(0.002)	(0.002)	(0.002)
Multi-Loan	0.0106***	0.0107***	0.0119***	0.0121***
	(0.001)	(0.001)	(0.001)	(0.001)
Borrower Age	−0.0002**	−0.0001*	−0.0002*	−0.0001*
	(0.000)	(0.000)	(0.000)	(0.000)
PropType, Apt	0.0057***	0.0053***	0.0055***	
	(0.001)	(0.001)	(0.001)	
Region Controls				
East Anglia	−0.0038	−0.0041	−0.0034	−0.0040
	(0.002)	(0.002)	(0.002)	(0.003)
London	−0.0103***	−0.0083***	−0.0103***	−0.0077**
	(0.002)	(0.002)	(0.002)	(0.002)
North East	−0.0162***	−0.0140***	−0.0152***	−0.0112***
	(0.002)	(0.002)	(0.002)	(0.002)
North West	−0.0004	−0.0014	0.0001	−0.0005
	(0.003)	(0.003)	(0.003)	(0.003)
Scotland	0.0025	0.0008	0.0028	0.0017
	(0.002)	(0.002)	(0.002)	(0.002)
South East	−0.0041	−0.0052	−0.0034	−0.0017
	(0.003)	(0.003)	(0.003)	(0.003)
South west	−0.0179***	−0.0185***	−0.0172***	−0.0166***
	(0.002)	(0.002)	(0.002)	(0.002)
Wales	−0.0116***	−0.0098***	−0.0110***	−0.0088***
	(0.002)	(0.002)	(0.002)	(0.002)
West Midlands	−0.0031	−0.0038	−0.0036	−0.0044
	(0.003)	(0.003)	(0.003)	(0.003)
York-Humber	−0.0036	−0.0053*	−0.0037	−0.0048
	(0.002)	(0.002)	(0.002)	(0.002)
Macro Prudential				
OLTV		0.0004***		0.0004***
		(0.000)		(0.000)
ORC			−0.0117***	−0.0114***
			(0.002)	(0.002)

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure 5: Differential in Default Rates by OLTV and ORC for Single and MultiLoan Borrowers



As the spline of multi-loan borrowers is a level-shift higher, it is potentially the case that these borrowers should be subject to tighter LTV caps on all loans after the first so as to bring the risk back towards that of single-loan borrowers. Our results would suggest that LTV caps could be calibrated between 75 to 80 per cent for the borrowers first investment mortgage but that the LTV on the portfolio for any subsequent loan should be tighter to build more resilience for portfolio borrowers.

For ORC, the findings are somewhat similar. For low levels of ORC, the default risk of multi-loan borrowers is considerably higher than that of single-loan borrowers. The difference becomes statistically insignificant between the two groups at between 1.15 and 1.20 ORC. Overall, the default risk falls with ORC for both groups until it flattens out at approximately 1.5. The results suggest that a calibration for single-loan borrowers of approximately 1.5 ORC and a tightening on further loans added to the portfolio would be appropriate to build in buffers for borrowers to withstand shocks.

3.4 Robustness Checks: The Case of Current Shocks and Other Borrower Income

To test the robustness of our findings, we undertake a range of additional checks. First, we control for the current house price of the collateral and the current rent coverage ratio. The main literature on commercial mortgage default highlights that it is current equity or current rent coverage that matter for default (Grovenstein et al., 2005; Archer et al., 2002; Goldberg and Capone, 2002). That is, when borrowers are hit with shocks to the asset value (house price falls) or shocks to the cash flows (declines in the rent), they may exercise the underlying option to default. This is particularly the case if the loan enters negative equity or if the rent no longer covers the monthly installment. As our model is based on determining default using originating values of LTV and RC, it does not capture these dynamics. It is important that we undertake a robustness check to test that our findings are not altered by these omitted factors.

Second, we control for the borrowers non-rental income. In many cases, BTL investors may not be professionals but are borrowers who purchase a single investment property for example as part of a pension plan or for a single investment. If fact, our data suggest that many BTL borrowers have single loans. In these cases, the household may see the BTL income as part of the normal household income flow and intertwine the BTL returns with other borrower income. If BTL rent receives a shock, the borrower may choose to substitute other income to avoid a default on the BTL payments. This is more likely to be the case if the BTL rent only accounts for a small share of total gross income thus the shock would be more manageable.

To control for both of these influences, we employ a number of tests. First, to capture the current position of equity and affordability, we calculate the change in house prices and rent between origination and December 2014 (the date of our data drop from the institutions). Using data on the current installment of the loan, we then include the updated RC and the change in house prices in the full model.[11] The results are presented in table 7. Column (1) presents the main model again while column (2) includes the current values for house prices as well as the current RC ratio. The current RC ratio is negative and significant as expected: higher rent coverage currently lowers the default probability. We do not find an effect of the change in house prices. However, this may not be surprising as many borrowers in our data experienced increases in house prices during the period and are unlikely to exercise the option to default in these circumstances. It is more likely that borrowers who are experiencing negative equity or facing house price falls will default. To assess whether borrowers who experienced such declines have a higher default rate, we replace the change in house price variable with a dummy which takes the value of one if the borrower had a price decline. The results are presented in column (3). The variable is positive and statistically significant indicating that suffering a property price fall increases the default rate by 0.0004, a 2 per cent increase given the sample average default rate of 0.02. Importantly for our assessment of the origination conditions, both OLTV and ORC are still statistically significant and signed as expected. Similarly, the predicted probabilities of default are much higher for lower levels of ORC.

Our final robustness check is to control for other borrower income, we include the share of rental income in total borrower income to capture the degree to which there is available financial capacity to manage falls in rent or periods of vacancy through the use of other financial resources. It must be noted that in our data we do not observe the other borrower income after origination so the ratio

[11] We do not include the current LTV ratio given the endogeneity between current LTV and default. Please see Kelly and McCann (forthcoming) for details.

uses origination values of both series. The results are presented in column (4). While the variable is insignificant in the specification, our main findings on OLTV and ORC remain. Column (5) includes all robustness checks simultaneously. More broadly, our findings appear to be robust to the inclusion of these additional variables. The fitted splines also maintain their original shape. This suggests that our calibration of macroprudential policies using originating values of LTV and RC are appropriate and informative for supervisors in their attempt to build resilience from the borrower and the bank perspective.

Table 7: Robustness Checks: Marginal Effects of Logit Model

	(1) Full Model	(2) Current	(3) House Price Fall	(4) Other Income	(5) All
Multi Prop	0.0078***	0.0075***	0.0074***	0.0083***	0.0079***
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)
OLTV	0.0003***	0.0002***	0.0002***	0.0003***	0.0003***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ORC	−0.0139***	−0.0068**	−0.0054*	−0.0152***	−0.0067*
	(0.003)	(0.002)	(0.003)	(0.003)	(0.003)
Current RC		−0.0036***	−0.0037***		−0.0037***
		(0.001)	(0.001)		(0.001)
Δ HP		−0.0000			
		(0.000)			
HP Fall			0.0004*		0.0004*
			(0.000)		(0.000)
Rent/Income				−0.0023	−0.0020
				(0.009)	(0.009)

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

4 Conclusions and Policy Implications

In this paper, we present a default model aimed at understanding the link between originating lending conditions on debt-service-ratios and loan-to-value ratios and subsequent loan performance for residential investment (BTL) mortgages. We use a unique loan-level dataset for the UK which contains the loans of Irish bank's subsidiaries in that jurisdiction. This is one of the only loan-level datasets available for the UK which spans the period pre and post the financial crisis. We provide two contributions which can be a useful input into regulatory policy formation.

First, our empirical strategy specifies a "double trigger" model which links mortgage default to originating values of loan-to-value and rent coverage (our proxy for the debt-service-ratio) controlling for a range of other loan and borrower characteristics. We find default is increasing with LTV at origination and falling in original rent coverage. To compare the magnitude of the effects, a one standard deviation increase in OLTV would increase the default rate by 28 per cent while a one standard deviation decrease in ORC would increase default rates by 23 per cent.

To examine potential threshold effects, we test how default changes across the OLTV and ORC distributions by estimating the relationship between these variables and delinquency using a non-linear cubic spline. For OLTV, it appears that for values below 75, there is no considerable variation in the level of default. However, from 75 OLTV onwards, there is a very steep increase in the predicted default rates. Regarding the originating affordability channel, the effects appear to taper out after approximately 1.5 ORC with widening error bars after this level. These results provide empirical evidence for the non-linear nature of default in these origination terms and may be a useful input for the setting of OLTV and ORC limits in a macro prudential context.

Second, we investigate whether there are differences in the default rates between borrowers who have one loan relative to those who have a portfolio of loans. We extend our empirical framework to control for portfolio values of OLTV and ORC for borrowers with multiple loans outstanding. We find default rates double in the case of multi-loan properties, with significantly greater sensitivity to OLTV and ORC increases. We investigate how multiple property portfolio interacts with the threshold finding and while there is no impact on the main findings of 75 and 1.5, there is strong evidence to support tighter restrictions on second and subsequent properties.

A number of policy implications arise from our research. The impact of 2008-2009 financial crisis on mortgage delinquency rates resulted in the development of revised accounting standards (International Financial Reporting Standards (IFRS) 9) for loan provisioning and a series of stress tests with a strong focus on collateral valuation through an Asset Quality Review Process. The main aim of both is ensuring a banking system adequate to absorb potential losses. These measures focus on the current LTV ratios, as these form the major component of the loss given a default.

However, a broader suite of macroprudential measures on limiting LTV and affordability at the loan origination phase have been proposed since the onset of the crisis and introduced in many countries. This is unsurprising given the rise in mortgage defaults, the link between the mortgage market and the wider financial turmoil and the link between credit conditions and housing asset inflation.

Macroprudential policies implemented at loan origination, such as restrictions on high LTV and affordability ratios, can provide buffers against adverse shocks. Lower originating LTV ratios will provide greater resilience to house price falls while lowering originating ORC levels will provide a buffer against affordability shocks. Investment mortgages play a vital part of a functioning housing market through the financing of the provision of additional units for the rental sector. However, is important to ensure that lending for housing investment is undertaken in a manner that does not compromise financial stability. Our findings may provide useful insights for policymakers attempting to parameterise lending limits on investment mortgages.

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5 Appendix

Figure 6: Distribution of OLTV and ODSR