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Abstract

In understanding the determinants of mortgage default, the consensus has moved from an 'option theory' model to the 'double trigger' hypothesis. Nonetheless, that consensus is based on within-country studies of default. This paper examines the determinants of mortgage default across five European countries, using a large dataset of over 2.3 million active mortgage loans originated between 1991 and 2013 across over 150 banks. The analysis finds support for the double trigger hypothesis: changes in unemployment are important determinants of default, while negative equity itself is a relatively small contributor to default. Nonetheless, the effect of variables such as the interest rate and unemployment is stronger for those in negative equity. The double trigger, however, varies by country: country-specific factors are found to have a large effect on default rates. For any given level of LTV, and as LTV changes, borrowers were more sensitive to the interest rate and unemployment in Ireland and Portugal than in the UK or the Netherlands.

JEL Classifications: G01, G21, D04, E58.

Keywords: Mortgage default; negative equity; double trigger; European Union.

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1. Introduction

Housing and its financing matters for the macroeconomy. Not only does housing represent a significant fraction of consumer expenditure but it is also the largest asset in the typical household's portfolio, with a corresponding debt liability. Boom-bust cycles in housing across the developed world over the last two decades have generated a renewed interest in the determinants of mortgage default. It is easy to understand why. Non-performing mortgage loans precipitated the failure of a number of financial institutions during the financial crisis, both in the EU and further afield. These failures in turn had significant fiscal and social implications, with the result that the macro-prudential policy context has been changed by policies aimed at preventing mortgage defaults from recurring on such a large and costly scale.

This study examines the determinants of default, using a large dataset of over 2.3 million active mortgage loans originated between 1991 and 2013 across over 150 banks in five European countries. Using a binary logit model of the probability of default, and controlling for a rich set of borrower and loan characteristics, we find support for the 'double trigger' hypothesis, which posits that the joint occurrence of negative equity and an income shock causes mortgage default. We find that changes in the unemployment rate and loan interest rate are particularly important determinants of default. Moreover, there is substantial cross-country variation in default rates and in the effect of the double trigger variables, which cannot be explained by a substantial number of loan and borrower covariates. This implies a strong role for cross-country institutional differences – such as lending practices, legal, and political impediments to enforcing rights over collateral – in determining the level of mortgage default, a third trigger in determining default.

This paper contributes to a literature which has long emphasised the importance of negative equity and income for mortgage default, but which up to now has lacked the data to test this hypothesis in a cross-country context. While early work on mortgage default by Foster & Van Order (1984) stressed the importance of negative equity, this 'option theory' model has been replaced by a consensus on the importance of the 'double trigger'; see, for example, Bhutta, et. al. (2011), Gerardi et. al. (2015), and Foote et. al. (2008). This retains the key insight that negative equity is important for default but adds that this a necessary, rather than sufficient, condition for default and that the intersection of negative and a liquidity shock precipitates default: while those with positive equity can simply sell their home following a shock, the best response for those in negative equity is to default (Riddiough, 1991).

The double trigger model enjoys broad empirical support. Examples include Campbell and Cocco (2015), Gerardi et. al. (2015), who that find that 30% of defaulting households suffered an employment loss, while 80% suffered a major cash-flow shock, and Herkenhoff (2012) finds that job loss makes an individual 8.2% more likely to default, while combined negative equity *and* job loss make an individual 37% more likely to default. But until now, granular data required to such analysis have not been available in European countries. Instead, papers that cover Europe mostly use household surveys, which omit vital information concerning loan characteristics. Therefore the literature's conclusions pertain to loans whose characteristics – such as recourse – and institutional setting often differ greatly from those in Europe.[3]

This paper contributes to the literature in three ways. First, and most importantly, it is the first to combine a cross-country analysis with loan-level data. It tests the double trigger hypothesis while allowing for the first time a consideration of the cross-country institutional differences that contribute to default. Secondly, it is the first to analyse loan-level data (LLD) for Spain and Portugal. Finally, it adds to the literature on Irish mortgage default using a new dataset. In doing so, it challenges the consensus: unlike previous work, the analysis here finds no effect of first-time buyer status on the default rate, once a full range of controls is included. This has important policy implications given the changes to macro-prudential rules in Ireland in 2015.

The paper is structured as follows. The following section outlines the dataset used, while Section 3 describes the methodology. Given the existing literature, the empirical specifications focus on negative equity, the unemployment rate, the interest rate and measures of liquidity constraints as key explanatory variables. The results of these specifications are described in section 4, while the final section concludes.

2. Data

This paper uses data from the 'European DataWarehouse' (EDW). Established in July 2012 as an initiative of the ECB, the EDW manages, stores, and monitors the loan level data required of any securitisation if it is to be used as collateral in the ECB's open market operations. The dataset, after cleaning, contains 2,345,545 loans originated over the period between 1992 and 2013 by lenders in

[3] European papers which do consider loan level data (LLD) include many from Ireland, such as Kelly & O'Malley (2014), Kelly (2012), Kelly et. al. (2015), McCarthy (2014), Kelly & McCann (2015), and Lydon & McCarthy (2013). Other European contributions utilising LLD include Kroot & Giouvris (2016) in the Netherlands, Lambrecht et. al. (2003) in the UK and Gauthier & Leece (2015), also in the UK. Cross-country papers include Burcu & Grant (2006) and Gerlach and Lyons (2015), both of which use cross-country panel data in conjunction with aggregate proxies for LTV ratios and outstanding principal.

Ireland, the UK, Spain, the Netherlands, and Portugal. 157 loan level variables are available[4]; 8 identify the borrower, lender, originator, servicer, etc.; 35 collect borrower information at origination, such as year of birth and occupation type; 47 collect information on loan characteristics such as the loan's balance and term; 32 collect information on the loan's interest rate; 33 collect information on the property and associated collateral, and 18 collect performance information.

Data coverage for most variables is sporadic. While 'core' variables such as the interest rate, payment due, and current balance have good coverage, many variables are present in but a subset of the loans[5] and implausible values are common. For this reason, regressions are limited to what is ostensibly a small sub-sample of the covariates available and sample sizes vary between specifications.

Two potential issues arise from the use of data obtained from securitisations. First it may be that loans entered into securitisations are subject to selection bias because lenders securitise riskier loans in order to remove risk from their balance sheet. However, Bonner et. al. (2016) finds that the main motivation for Eurozone banks to issue Asset Backed Securities is for funding rather than a risk reduction tool. As a result, any selection bias is likely to operate in the opposite direction. Second, it may be that the data suffers from bias induced by right censoring. To this end, work by Francke & Schilder (2014), who find that the peak in loss probability lies around a duration of approximately 4 years, and Gathergood (2009), who finds that the majority of defaults occur early on, is relevant. Given 96% of loans in the data are 'seasoned' with a vintage of at least 4 years it seems plausible that any right-censoring bias is small.

The data was subjected to an extensive cleaning procedure. Loans in several parts, which arise from the practice of splitting loans for tax purposes, were aggregated into a single row. As a result, a number of loans were dropped for operational reasons, including those with more than one further advance, loans with second and subsequent advances, and those with duplicate borrower and lender ID's. Loans were also removed where it is known that the borrower or loan has features which make it likely that the borrower operates like a firm. Loans with more than 2 borrowers and loans which are not for house purchase or construction, such as equity releases, were removed as a result. Such exclusions were undertaken in order to pin down the type of borrower and incentives under consideration.

[4] The relevant data taxonomy and template can be found at https://www.ecb.europa.eu/paym/coll/loanlevel/transmission/html/index.en.html

[5] Notably, the ECB 'data quality score' attached to each securitisation does not consider variables which are 'Not relevant at the present time' (ND,5) as impacting upon data quality. Thus, even securitisations with an 'A1' Data Quality rating may still lack a significant amount of data.

Extraterritorial loans and loans without geographical information were also excluded as were loans with a current balance of 0, and loans originated before 1991 and after 2013, in order to be able to generate explanatory variables used in the below specifications. Finally, the data was cleaned to remove loans with an operative LTV of over 200 in order to remove outliers, and observations for continuous variables in the cleaned dataset were Winsorized, and set to a *null* value where they fell outside the 0.5^{th} or 99.5^{th} percentile in the data, on the basis that extremely large and implausible outliers were severely affecting the distribution of the variables in question.

The dependant variable in all regressions is the binary variable 'default', where a loan is defined as being in default when one of 3 conditions is met: either it is classified as being in default, it is 90 days past due, or the 'default/foreclosure'[6] column is populated. Default rates in the data as a whole are low, with only 2.5% of loans in the entire dataset entering default. The vast majority of loans are originated between 2004 and 2008, while default rates begin to increase in 2008. Consistent with Gathergood (2009), defaults tend to occur within the first 4 years of origination, and occur around a period during which unemployment rates rose and house prices fell. Turning to a breakdown by country, Ireland stands out has having the largest proportion of loans in default at almost 10%, while both the Netherlands and the UK have very low default rates. Low default rates in the Netherlands are particularly notable given house price declines there were similar to those in Portugal; given unemployment rates were higher in Portugal, this outcome is consistent with the double trigger hypothesis.

The data permits a rich set of explanatory variables, key among them the Operative LTV ("OpLTV") ratio, the unemployment rate, and the Operative Interest Rate ("OpIR"). The Operative LTV ratio is the LTV ratio as at the time the borrower made the decision to default or stay current, calculated using data on each property's value and a house price index specific to each country. Given the data records an individual's employment status at origination, and not subsequently, the quarterly percentage change in the unemployment rate[7] as at the quarter the loan entered default is used as a proxy for liquidity shocks associated with unemployment. The use of unemployment as such a proxy is common in the literature. The change in the unemployment rate as opposed to its level is used on the basis that it is liquidity *shocks,* i.e. sudden changes, which are thought to precipitate default. Finally the Operative Interest Rate is the interest rate payable on the loan as at the time the borrower made the decision to default.

[6] This column provides the total default amount before the application of sale proceeds and recoveries.

[7] This is the percentage change in the unemployment rate, not the change in percentage points. For example, a change in the unemployment rate from 5% to 4% is encoded in the data as -20(%) (a fall of 20%), not -1.

In addition a number of measures of liquidity constraints are utilised; the LTV of the loan at origination, the term of the loan in months, whether the borrower has other loans, the type of income verification, the gross monthly repayment due, the borrower's employment status (i.e. type of employment) at origination, the Loan to Income ratio ("LTI") of the loan at origination, the Mortgage Repayment to Income ratio[8] ("MRTI") of the loan at origination, and total income at origination. It should be noted that the for the LTI ratio at origination and MRTI ratio the sample size for these variables is significantly lower, constrained as they are by the presence of the 'total income' variable, which has a more limited coverage.

Additionally, research by Lanot & Leece (2015) and Campbell and Cocco (2015) indicates that a borrower's choice of mortgage contract is at least in part a function of private information regarding the probability that the borrower will default; in other words, riskier borrowers may select into certain types of interest or principal repayment type. As such, controls are included for both the type of interest repayment on each loan, and its principal repayment type.

Given the option theory literature implies that borrowers under-exercise the default option due to the presence of transaction costs, use is made of the occupancy type variable, as well as a variable which captures whether the borrower in question is a foreign national, as a test of whether transaction costs are operative in the Spanish data.

Finally, a number of other controls are utilised. Dummies for each country capture the potential for institutional differences which Burcu and Grant (2006) find to be important in the European case, and marginal effects are examined on a country by country basis. Origination year dummies are used in order to capture time varying changes in credit conditions and risk appetite which are otherwise not captured by the data. Borrower age at the time of default is also included as a standard control.

3. Methodology

Given the hypothesis at hand examines whether an individual makes the discrete choice to default or not, binomial and multinomial logit and probit models are popular in the literature. Not only are such models tailored to the discrete nature of the outcome at hand, the coefficients on explanatory variables can usefully be interpreted, upon transformation, as the change in the percentage probability of the outcome. Such models are typically applied to cross sectional household or loan level data available for a single period; examples include papers by Costa (2012), Gerardi et. al (2015), Kelly et. al. (2015), and Lydon & McCarthy (2013). In line with the literature, this paper also utilises a simple binary logit model estimated using maximum likelihood estimation.

[8] The MRTI is calculated yearly total income at origination, divided by the yearly current 'payment due'.

TABLE 1 – CLEANED DATA: DESCRIPTIVE STATISTICS BY COUNTRY

	Ireland			Netherlands			Portugal			Spain			UK[i]		
	Mean	std. dev	p50	Mean	std. dev	p50	Mean	std. dev	p50	Mean	std. dev	p50	Mean	std. dev	p50
Loan Size inc. further adv. (€)	226,701	156,010	200,000	198,240	138,074	173,500	102,112	61,093	90,000	362,715	1.60E+06	130,500	192,261	146,515	156,649
Purchase Price (€)	299,357	150,736	270,000	287,929	168,402	240,000	166,678	114,639	132,000	197,624	118,745	172,339	276,073	195,345	221,000
Operative Value (€)	255,178	185,547	216,793	292,978	210,621	236,094	153,668	125,351	120,419	187,561	397,831	158,700	368,966	340,556	276,236
Borrower Characteristics															
Gross Income (€)	58,225	34,638	50,000	51,332	27,303	45,793	50,680	40,421	33,255	41,859	36,387	29,781	64,958	46,313	51,867
Operative Age*	45.11	8.318	44	52.1	13.42	51	45.12	8.876	43.5	46.28	8.867	45	42.15	9.353	41
Loan Characteristics at Origination															
Original LTV	74.5	21.05	80.75	74.35	32.21	78.54	73.91	20.78	80.85	74.45	18.41	78.77	68.68	22.35	75
Original LTI	4.246	3.795	3.991	4.562	2.501	4.312	3.611	3.856	2.911	8.616	31.05	4.337	3.189	1.324	3.157
MRTI[4]	21%	10%	19%	21%	12%	20%	12%	11%	10%	21%	14%	18%	18%	8%	17%
Payment Due (€)	949.2	1,210	812.2	841.8	2,203	609.6	268	303.6	252.4	526.4	383.6	461.4	843	594.62	701.48
Term	350.9	79.62	372	444.8	150.5	372	412	104.4	384	346.9	84.46	372	301.7	73.87	312
Operative Loan Characteristics															
Operative Interest Rate	3.298	2.136	2.45	4.348	1.189	4.5	2.031	1.369	1.674	2.054	1.065	1.767	3.385	1.204	3.48
Operative LTV*	72.12	36.31	74	66.2	35.53	65	55.3	28.96	52	57.95	32.49	61	48.91	17.94	51
Negative Equity (%)*	24.95%			21.29%			5.60%			8.80%			0.03%		
Vintage	139	32.65	134	133.4	52.34	126	142.2	43.16	138	134.2	35.62	134	80.25	22.48	80
Current Balance (€)	174,405	145,232	155,682	174,776	128,371	151,721	76,025	53,634	67,894	97,572	72,336	86,400	162,075	129,260	132,431
Months since Default[n]	28.79	48.44	20	7.706	28.84	4	24.69	28.22	15	28.63	24.55	25	4.777	6.043	3

Notes:

***For loans in the default, the 'operative' value is the value taken by that variable in the quarter it went into default. For performing loans, the 'operative' value is the value taken by the variable the at latest date for which data is available.

i: For UK loans, the values presented here are in EUR, converted from GBP at the average rate for the year 2015; £1 buys €1.30

n: No. months since the loan crossed the 90 days-past-due default threshold.

4: Percentage of Gross annual income spent on mortgage repayments

In such models, the outcome of interest can be thought of as arising from a 'latent' regression in which individuals compare the utility arising from one option against a single (or several) alternatives. In the case at hand, individuals compare $U_{default}$ against $U_{repayment}$. Individuals enter default if $U_{default} > U_{repayment}$, and this net utility calculation can be conceptualised as arising from the latent regression

$$default_i^* = X\beta + \varepsilon \quad (1)$$

where $default_i^*$ is the unobserved net utility of borrower i arising from default and X is a matrix of explanatory variables. ε is the error term, and in this case is assumed to have a logistic distribution.

Given the outcome of the net utility calculation is unobserved, we observe only the binary outcome $default_i$ for each loan:

$$default_i = \begin{cases} 1 \; if \; default^* > 0 \\ 0 \; if \; default^* < 0 \end{cases} \quad (2)$$

The probability that a loan takes one of these binary outcomes is a function of the explanatory variables in the latent regression

$$\Pr(default_i = 1|X) = F(X_i\beta) \quad (3)$$

Where X_i consists of the explanatory variables noted above, and differs in each of the specifications we model.

An important consideration when estimating binary choice models is the assumption regarding the distribution of the error term; this drives the distribution of $F(X_i\beta)$ used within the likelihood function. As is common in the literature we assume that $F(X_i\beta)$ is logistically distributed rather than normally distributed:

$$F(X_i\beta) = \Lambda(X\beta) = \frac{e^{X\beta}}{1+e^{X\beta}} \quad (4)$$

This assumption is justified on the basis that the logistic distribution has 'heavier' tails is better suited to data in which the dependant variable has relatively few positive outcomes and there is large variation in some of the explanatory variables (Greene, 2002). This is the case with the present data.

Heteroscedasticity is of particular importance when estimating logit and probit models. As shown in Yatchew & Griliches (1985), a non-linear (e.g. probit or logit) model in which there is an omitted variable or heteroscedasticity is present and uncorrected for will be mis-specified, and will have biased and inconsistent parameter estimates; in contrast under Ordinary Least Squares, orthogonal

omitted variables or heteroscedasticity lead to inefficient parameter estimates rather than biased ones. A complication arises in that testing for misspecification in this context is difficult; not only can such tests not delineate between the types of misspecification present, but the large sample size in the present case makes it likely that such tests will be statistically significant. As such, we estimate all models using robust standard errors, and use as many explanatory variables as possible in order reduce the chance that there are omitted variables.

4. Empirical Results

Our empirical strategy is as follows: we develop a baseline model of the probability of default, as defined in Section 3. We then extend this to include further measures of liquidity constraints. We then utilise subsets of the data to examine the effect of FTB status in Ireland and the effect of transaction costs in Spain. The marginal effects from each of the specifications tested are presented in table 2.

4.1 Baseline Model

The baseline models (1 and 2) use a limited number of covariates with the broadest coverage in the data. Default is regressed against the negative equity dummy, the change in the unemployment rate, the 'other loans' dummy, a term dummy, and the operative Interest Rate. Measures of unobserved borrower heterogeneity – Principal Repayment Type, Principal Repayment Method, and Interest Rate Type – are included, as are country and origination year dummies. Model 2 replaces the negative equity dummy in model 1 with the continuous *OpLTV* variable, as we are interested in the interaction between the *OpLTV* and other variables for varying levels of the *OpLTV*. Model 2, with negative equity incorporated as a continuous 'Operative LTV' variable rather than a 'negative equity' dummy, has the lower AIC and BIC of the two models and highest log-likelihood and Pseudo-R^2 values and so is the preferred model for examining interactions and marginal effects in detail.

All marginal effects have the expected sign; negative equity as well as increases in the OpLTV, unemployment rate, term, and interest rate are all associated with increases in the probability of default, while the marginal country effects relative to Ireland are all negative. Additionally, all are statistically significant at the 99% level, though the primary cause of this result may be the very large sample size. The marginal effects of origination year dummies are in general not significant.

Turning to the economic significance of the unconditional average marginal effects, the effect of negative equity is small; its presence increases the probability of default by just 0.6 percent. The marginal effect for the continuous *OpLTV* variable is similarly small and the effect of the Operative LTV is low across all countries and for all values of the Operative LTV ratio. This is consistent with the

double trigger hypothesis, which emphasises the conditional effect of negative equity and other variables. Similarly, the average marginal effect of the operative interest rate is low; a one standard deviation increase in the operative interest rate increases the probability of default by less than one percent across all models. The effect of other loans is also small, but consistent.

In contrast, pure country effects and the effect of changes in the unemployment rate by itself are large; in particular, a ten percent increase in the unemployment rate increases the probability of default by c.a. 9 percent. Though the unconditional probability of default is very low, this is still quite a strong result. Regarding country effects, loans located outside of Ireland have a 15%-18% lower probability of default which cannot be attributed to other variables in the model.

The double trigger predicts that the marginal effect of variables such as the operative interest rate and the unemployment rate will be stronger for those in negative equity. To explore whether such an effect is present, figures 1 and 2 plot the average marginal effect of the change in the unemployment rate, and the operative interest rate, respectively, for increasing values of the OpLTV ratio. Both figures provide strong support for the double trigger hypothesis; the marginal effect of both the interest rate and the unemployment rate is amplified as a loan progresses deeper into negative equity, in a result that is consistent with Campbell and Cocco (2015) in particular. For example, the average marginal effect of a unit increase in the interest rate is 0.0064 for those with an LTV between 10 and 100, more than doubling to 0.028 for those with an OpLTV greater than 100.

Turning to differential effects by country, figures 3 and 4 show large cross-country differences in the extent to which the 'double trigger' is operative. Borrower sensitivity to the interest rate and unemployment is much greater in Ireland and Portugal than in the UK or the Netherlands, both in terms of absolute magnitude across OpLTV levels, and in terms of how that magnitude changes with the Operative LTV ratio. In particular, the relationship between OpLTV and default probability is highly non-linear in Ireland and Portugal, in contrast to other countries. This result is consistent with the existence of differing institutional factors, such as those noted by Burcu & Grant (2006) between countries. However, the exact nature of these differences cannot be tested with these data.

TABLE 2 - REGRESSION RESULTS

	Baseline		Bridge	Liquidity Constraints				
	Model 1	Model 2	Model 3	Model 4	Model 5	**Model 4 and 5 Additional Variables**	Model 4	Model 5
Negative Equity, Yes	0.00663***			-0.000275		LTI at Origination	-1.28e-05**	-1.04e-05*
	(0.000357)			(0.000308)			(6.51e-06)	(6.15e-06)
Operative LTV ratio		0.000292***	0.000245***		0.000225***	MRTI at Origination	0.00740***	0.00426***
		(4.62e-06)	(4.99e-06)		(6.16e-06)		(0.000849)	(0.000864)
%Δ UE Rate	0.00962***	0.00944***	0.00765***	0.00753***	0.00748***	Repayment Due	2.00e-06***	8.46e-07***
	(5.33e-05)	(5.32e-05)	(5.75e-05)	(5.74e-05)	(5.72e-05)		(2.58e-07)	(2.84e-07)
Netherlands	-0.215***	-0.180***	-0.187***	-0.210***	-0.189***	LTV Ratio at Origination	0.000194***	3.64e-05***
	(0.00510)	(0.00443)	(0.00487)	(0.00525)	(0.00497)		(6.27e-06)	(7.16e-06)
Portugal	-0.188***	-0.155***	-0.162***	-0.181***	-0.161***	**Income Verification Type**		
	(0.00427)	(0.00366)	(0.00405)	(0.00429)	(0.00410)	Other	0.0115***	0.0104***
Spain	-0.196***	-0.163***	-0.174***	-0.197***	-0.176***		(0.00106)	(0.00107)
	(0.00439)	(0.00376)	(0.00424)	(0.00460)	(0.00435)	Self Cert no Checks	-0.00787***	-0.00797***
UK	-0.214***	-0.179***	-0.186***	-0.210***	-0.188***		(0.000979)	(0.00101)
	(0.00493)	(0.00427)	(0.00474)	(0.00508)	(0.00483)	Self Cert w/ checks	-0.00353***	0.00157
Other Loans, Yes	0.0110***	0.0177***	0.0221***	0.0188***	0.0259***		(0.00104)	(0.00120)
	(0.000675)	(0.000814)	(0.00109)	(0.00104)	(0.00122)	Verified	-0.00157*	-0.00260***
Term	9.06e-06***	-2.98e-05***	-1.86e-05***	7.97e-06***	-1.54e-05***		(0.000859)	(0.000883)
	(9.82e-07)	(1.39e-06)	(1.51e-06)	(1.06e-06)	(1.49e-06)	**Employment Status at Orig**		
Operative IR	0.00646***	0.00636***	0.00506***	0.00488***	0.00484***	Employed / Subsidy	0.00341***	0.00303***
	(6.11e-05)	(6.12e-05)	(6.99e-05)	(6.98e-05)	(6.98e-05)		(0.000730)	(0.000712)
						Legal Entity	-0.00800***	-0.00797***
Pseudo-R2	0.233	0.245	0.225	0.228	0.234		(0.00115)	(0.00114)
Observations	2,289,968	2,289,968	1,742,718	1,742,718	1,742,718	Other	0.00709***	0.00690***
Year Dummies	YES	YES	YES	YES	YES		(0.000411)	(0.000407)
Country Dummies	YES	YES	YES	YES	YES	Pensioner	-0.000384	7.83e-05
Principal Repayment Type	YES	YES	YES	YES	YES		(0.000622)	(0.000635)
Principal Rep. Mthd.	YES	YES	YES	YES	YES	Protected Job	-0.00935***	-0.00926***
Interest Rate Type	YES	YES	YES	YES	YES		(0.000315)	(0.000314)
Liquidity Constraints	NO	NO	YES	YES	YES			

Note: Country marginal effects reported relative to Ireland as a base Category.
Standard errors in parentheses *** *p<0.01*, ** *p<0.05*, * *p<0.1*

FIGURE 1 - QOQ% CHANGE IN THE UNEMPLOYMENT RATE: AVERAGE MARGINAL EFFECTS BY LTV RATIO

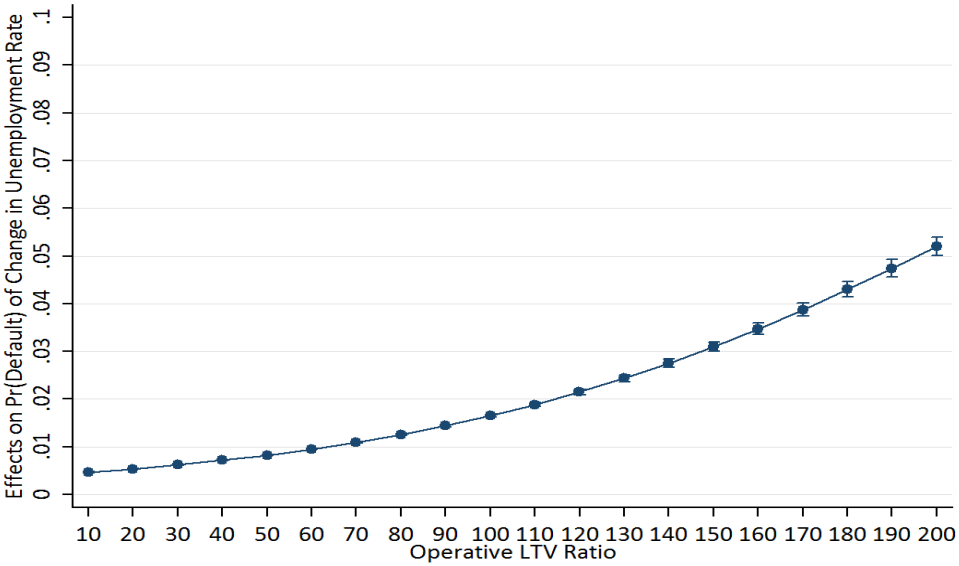


FIGURE 2 - OPERATIVE INTEREST RATE: AVERAGE MARGINAL EFFECTS BY LTV RATIO

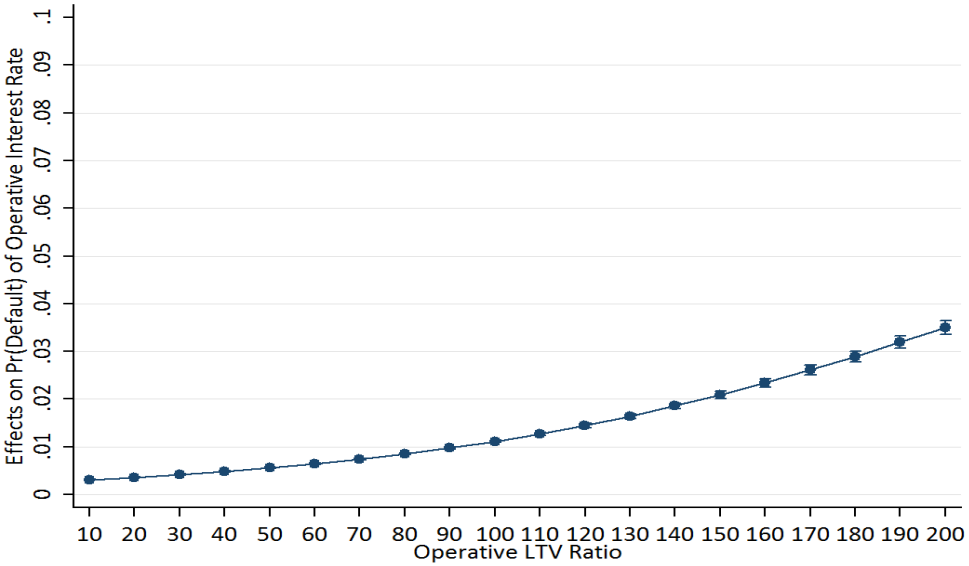


FIGURE 3 - QOQ% CHANGE IN UNEMPLOYMENT RATE - AVERAGE MARGINAL EFFECTS

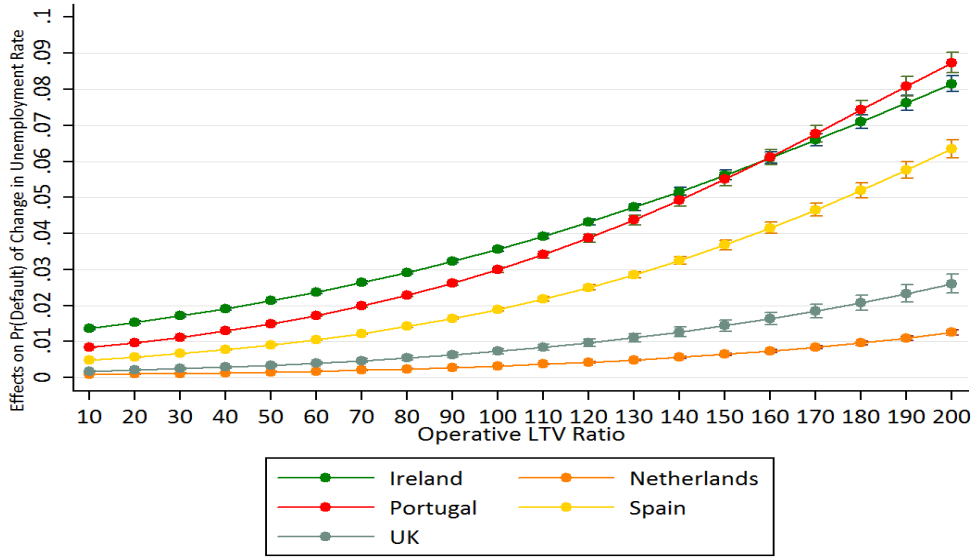
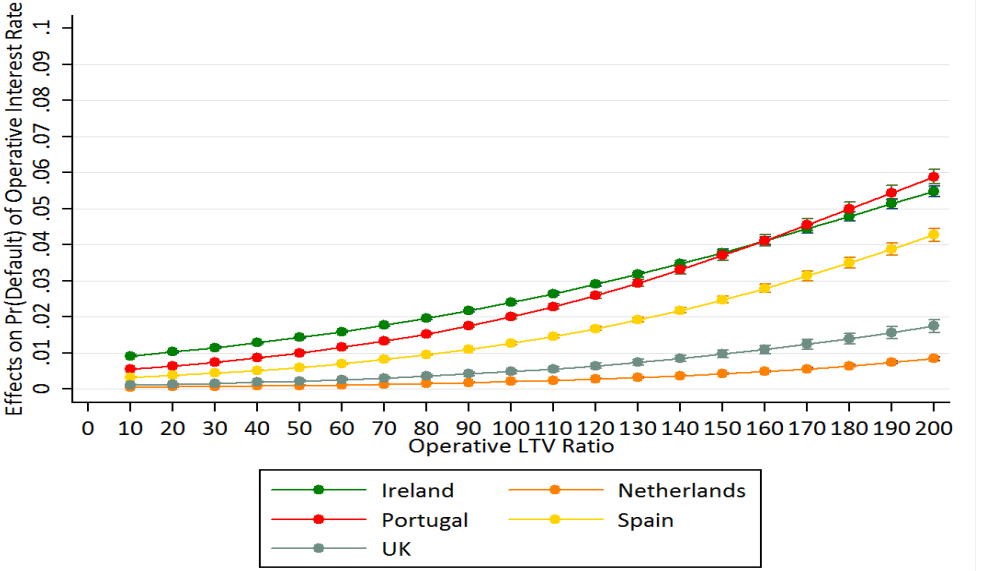


FIGURE 4 - OPERATIVE INTEREST RATE: AVERAGE MARGINAL EFFECTS BY LTV RATIO



4.2 Additional Liquidity Constraints

Models 4 and 5 use a larger number of covariates with slightly reduced coverage. In general, these variables are proxies for liquidity constraints; specifically, the LTV at origination, income verification, repayment due, employment status, LTI, and MRTI variables are added to models 1 and 2. As a test of whether the data has not changed in a systematic way which would render comparisons invalid, a bridge regression – model 3 - provides the full results from model 2 when run using the observations included in models 3 and 4. In general, the marginal effects for the key explanatory variables are the same, though some control variables now have a stronger effect.

A direct comparison with the baseline model is difficult due to variations in sample size. However, to the extent that comparisons are possible it is again the case that the model with the OpLTV ratio is the preferred model for examining interactions and marginal effects in detail. Notably, the overall fit of the models, as measured by the Pseudo-R^2, was not improved by the inclusion of the liquidity constraint variables. Moreover, while most marginal effects have the expected sign and are statistically significant at the 99% level, inclusion of liquidity constraints renders the negative equity dummy insignificant.

Turning to economic significance, the inclusion of measures of liquidity constraints has a very small or no effect on the magnitude of unconditional marginal effects. Regarding the consideration of the double trigger and its associated interactions, the shape of the double trigger effect is somewhat attenuated; however re-calculating the interactions for the baseline model on the restricted sample indicates that the attenuation is a result of the changed sample size, rather than the additional covariates.

That the unconditional coefficients from the baseline model are ultimately robust to the inclusion of extra variables and changes to the sample size is promising, providing evidence that the values obtained are the 'true' values of these coefficients. Similarly, that the attenuation of the double trigger effect arises from the sample size change and not the additional variables speaks to the robustness of the effect found in the baseline model.

The marginal effects of the additional proxies for liquidity constraints are presented in the same table. All are statistically significant, and many have what intuition and the literature would suggest are the correct sign; higher repayments and a higher LTV at origination are associated with a higher probability of default; those with 'other' income verification are more likely to default than those with fast track verification, and the self-employed and unemployed are more likely to default than those who are employed or have a fully guaranteed mortgage. In contrast, those with verified incomes are less likely to default than those with un-verified incomes, and those whose employment

status is classified being in a protected job are less likely to default than those in the employed or fully guaranteed base category. Not all marginal effects have the expected sign, however; it is unclear why subsidized loans are more likely to default than guaranteed ones, and in particular the marginal effect of the Loan-to-Income ratio at origination is negative, contrary to the literature (e.g. Kelly et. al, 2015).

Turning to economic significance, given the model's fit has not materially improved we should not expect the marginal effects of these variables to be large. Indeed, only the 'other' income verification category and 'unemployed' income category alter the probability of default by 1%, though the 'protected job' and 'self-employed' categories come do come close to this magnitude. Regarding the payment due variable, an increase by one standard deviation of €447 increases the probability of default by 0.038%. In general, inclusion of liquidity constraints therefore indicates that the OpLTV, OpIR, and unemployment rate are the dominant factors in determining default. This result is consistent with both the literature and the double trigger hypothesis. Though the literature often implies a stronger role for other liquidity constraints – Lydon & McCarthy (2013) predict that the MRTI should have a larger impact – this is usually in the context of models with fewer explanatory variables; for example, Lydon and McCarthy do not include the interest rate as an explanatory variable in their model.

As a further test of the double trigger and the variables with respect to which it is operative, we plot in appendix 1 the average marginal effect of the Payment Due, the MRTI Ratio, and the LTI for varying levels of the *OpLTV* ratio and for each country. The graphs for the Payment Due and MRTI do indeed provide further evidence for the double trigger; both variables have a stronger impact for those who are in negative equity. A unit increase in the MRTI ratio at origination has double the impact on the probability of default for those with an OpLTV of 160 versus those with an OpLTV of 100, while a unit increase in the payment due has a similar *relative* effect. The effect of the MRTI variable is particularly notable in this context; while its unconditional effect is not strong, for those with an OpLTV greater than 150, the MRTI ratio increases the probability of default by 1%. Turning to the country-by-country marginal effects, these again indicate the presence of border effects, though there exists considerable ambiguity as to the relative strength of the effects given the extent to which the confidence intervals at each point overlap. These findings broadly confirm those of Lydon & McCarthy (2013) and Aron & Muellbauer (2010) with respect to the MRTI and Kelly & McCann (2015) with respect to the repayment amount.

Turning to the LTI at origination figure, however, we see that this variable is not statistically different from 0 at any level of the OpLTV. This is at odds with the literature; for example, Kelly et. al (2015)

show that LTI has a particularly strong impact upon default probabilities. To ascertain whether the impact of the LTI ratio has been attenuated by the inclusion of the other liquidity constraint variables, we compute the marginal effects of the LTI ratio for a regression which utilises Specification 2 observations but from which all additional specification 2 liquidity controls have been removed. The results indicate that the MRTI variable has indeed attenuated the effect of the LTI as a predictor of default, as the effect is significantly different from 0 when other controls have been removed. Interestingly, the direction of the effect regarding the LTI is in the opposite direction to what might be expected.

4.3 First-Time-Buyers in Ireland

The issue of whether first time buyers have a greater propensity to default is important from the perspective of macro-prudential policy. Kelly et. al. (2015; hereafter KOMOT) utilise LLD from four major Irish mortgage lenders – AIB, Bank of Ireland, PTSB, and EBS – and find that FTBs have a lower propensity to default than other borrowers. This finding has been incorporated into the CBI's macro-prudential mortgage lending policy, which permits FTBs to obtain loans with a higher LTV than other borrowers.

This specification revisits the model utilised by KOMOT. The loans in this data have been originated by a number of smaller Irish lending institutions – First Active Bank and Ulster Bank Ireland – as well as PTSB. Of the 150,378 Irish loans in the data, 107,677 have data pertaining to the FTB status of the borrower. Appendix 2 provides a comparison between the data utilised by KOMOT and the present EDW data. Notably, loans in this data are larger, with a higher LTV, LTI, a longer term, and younger borrowers with lower incomes. In spite of this, however, default rates are lower in the present data.

Marginal effects are presented in table 3. A table comparing the variables used in the present specification with those used by KOMOT provided in Appendix 2. The results using the present data show a much weaker effect for the FTB variable. While KOMOT find that being an FTB reduces the probability of default by 4%, the results below indicate that this effect is at most 1%, and the effect disappears entirely in the full specification once employment status at origination has been controlled for. There is broad agreement with respect to the effect of other variables, primarily regarding sign, and in particular for the Original LTV ratio, which is the same in terms of both sign and magnitude.

Table 4 presents the results for a subset of the robustness checks conducted by KOMOT. First, the full specification is tested separately against pre- and post-2004 data, on the basis that credit conditions began to loosen considerably after 2004. Then, a variable capturing the change in the LTV ratio since origination is included to capture the impact of changes in house prices. County dummies

are included to better capture regional shocks which might precipitate default, and a (current) negative equity dummy variable is included to capture the effect of negative equity. The effect of these robustness checks is mixed, but ultimately none recover the point estimates for FTB estimated by KOMOT. While Model (3) does come close, the effect in this instance is an order of magnitude weaker than that found by KOMOT.

TABLE 3 – IRELAND FTB MARGINAL EFFECTS

VARIABLES	(1) Basic	(2) Emp. Status	(3) BTL	(4) Full
Original LTV	0.00106***	0.00110***	0.000987***	0.00104***
	(5.48e-05)	(5.47e-05)	(5.53e-05)	(5.54e-05)
Original Loan-to-Income	-0.000137	-8.01e-05	-7.13e-05	-5.16e-05
	(0.000388)	(0.000306)	(0.000309)	(0.000270)
Ln(DBO)	-0.00619***	-0.00878***	-0.00789***	-0.00983***
	(0.00215)	(0.00213)	(0.00213)	(0.00212)
Term	9.13e-05***	0.000106***	0.000135***	0.000141***
	(1.41e-05)	(1.41e-05)	(1.43e-05)	(1.43e-05)
Int Type, SVR	0.0440***	0.0416***	0.0405***	0.0384***
	(0.00741)	(0.00733)	(0.00744)	(0.00736)
Int Type, Tracker	0.0132**	0.0119*	0.00862	0.00799
	(0.00655)	(0.00653)	(0.00656)	(0.00655)
Income Verification Type, Verified	-0.290***	-0.273***	-0.264***	-0.255***
	(0.0599)	(0.0607)	(0.0570)	(0.0584)
Dublin, Yes	-0.0178***	-0.0171***	-0.0180***	-0.0174***
	(0.00178)	(0.00179)	(0.00178)	(0.00179)
FTB, Yes	-0.0114***	-0.00641***	-0.00732***	-0.00314
	(0.00202)	(0.00208)	(0.00209)	(0.00215)
Employment Status, Other		0.0192***		0.0202***
		(0.00320)		(0.00323)
Employment Status, Pensioner		0.0454		0.0448
		(0.0318)		(0.0314)
Employment Status, Self Employed		0.0595***		0.0555***
		(0.00360)		(0.00356)
Employment Status, Unemployed		-0.0104		-0.0110
		(0.00986)		(0.00975)
Occupancy Type, Other			0.401***	0.405***
			(0.0420)	(0.0417)
Occupancy Type, Owner-Occupied			-0.0253***	-0.0192***
			(0.00295)	(0.00290)
Observations	104,339	103,512	104,310	103,483

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Notes:

Controls for borrower age, loan age, and originator are included in all regressions.

The base category for Interest Rate Type is 'fixed'

The base category for Employment Status is 'Employed'

The base category for Occupancy Type is 'BTL'

TABLE 4 – IRELAND FTB ROBUSTNESS CHECKS

VARIABLES	(1) Full Pre-2004	(2) Full Post 2004	(3) ΔLTV	(4) County Dummies	(5) Negative Equity
FTB, Yes	0.00455	-0.000985	-0.00370*	-0.00255	0.00627***
	(0.00391)	(0.00306)	(0.00216)	(0.00213)	(0.00218)
ΔLTV			-0.000787***		
			(5.42e-05)		
Negative Equity, Yes					0.00402*
					(0.00227)
Observations	32,708	55,407	103,483	103,483	103,892

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

4.4 Transaction Costs in Spain

The option theory literature implies that borrowers may under-exercise the default option, due to the presence of transaction costs arising from the decision to default. As a test of whether transaction costs are relevant, we use the occupancy type variable, as well as a variable which captures whether the borrower in question is a foreign national. This specification is confined to the Spanish data, on the basis that the Spanish data has the largest absolute coverage for these variables as well as the greatest variation in responses. While the number of observations in relative terms is small – 34.3% of Spanish observations have both variables - in absolute terms this comprises 392,022 observations (once a full suite of explanatory variables has been added).

The baseline model used in this specification – to which the 'foreign' and 'occupancy type' variables are added – differs from those used in the previous section of this paper. First, regional controls at a NUTS1 level are utilised in place of the now obsolete country dummies. Second, iteratively testing a number of specifications showed that a model containing just the *OpLTV*, unemployment, other loans, *OpIR*, payment type, and origination year variables had the best fit for the data. Table 5 presents the marginal effects for the regressions from this specification.

To examine the interaction between transaction costs and the double trigger, we calculate the marginal effect of the unemployment rate and interest rate with respect to the OpLTV, for each occupancy type and each nationality status. We find evidence that transaction costs are an important extra dimension, with respect to the double trigger model. The slope of the marginal effects indicates that the 'double trigger' with respect to both the Operative Interest rate and unemployment rate is stronger for second homes and BTL properties than it is for other property types. Turning to whether a borrower is a foreign national, however, the effect is contrary to what was initially hypothesised; as figure 5 demonstrates nationals have a higher probability of default, and the double trigger is stronger with respect to nationals than it is foreign nationals.

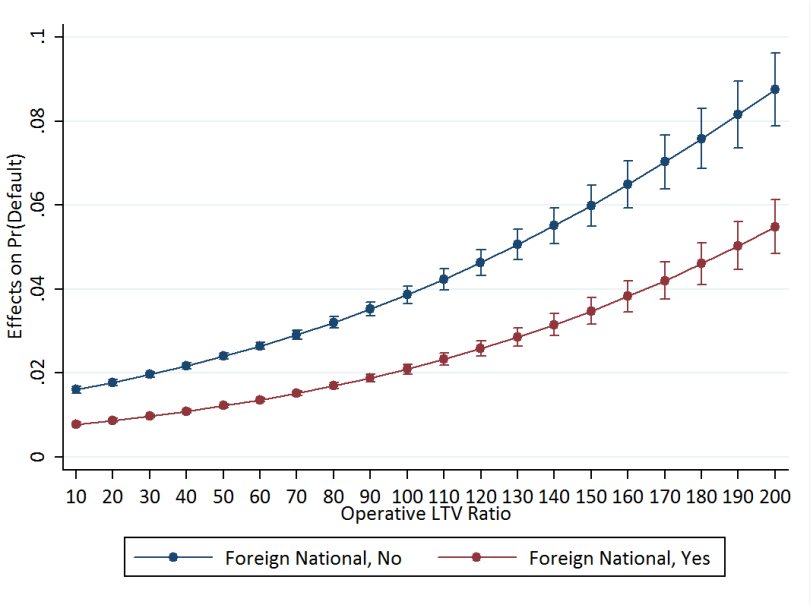


FIGURE 5 - OPERATIVE INTEREST RATE: AVERAGE MARGINAL EFFECTS BY FOREIGN NATIONAL STATUS

TABLE 5 - SPECIFICATION 3 MARGINAL EFFECTS

VARIABLES	(0) Baseline	(1) Foreign. Nat.	(2) Occ. Type	(3) Full
Foreign National, Yes		-0.00458***		-0.00443***
		(0.000610)		(0.000609)
Occupancy Type				
Other			-0.0346***	-0.0347***
			(0.00908)	(0.00906)
Owner-Occupied			-0.0229**	-0.0228**
			(0.00892)	(0.00890)
Partly Rented			-0.0426***	-0.0424***
			(0.00938)	(0.00941)
Second Home			-0.0175*	-0.0178**
			(0.00895)	(0. 00893)
Negative Equity, Yes	0.0180***			
	(0.00147)			
Operative LTV		0.000278***	0.000273***	0.000281***
		(1.36e-05)	(1.34e-05)	(1.36e-05)
%Δ Unemployment Rate	0.0161***	0.0104***	0.0108***	0.0104***
	(0.000267)	(0.000208)	(0.000184)	(0.000208)
Other Loans, Yes		0.00256	0.000761	0.00286
		(0.00178)	(0.00168)	(0.00180)
Term		3.42e-05***	3.69e-05***	3.72e-05***
		(4.40e-06)	(4.39e-06)	(4.40e-06)
Operative Interest Rate		0.0173***	0.0171***	0.0173***
		(0.000233)	(0.000226)	(0.000234)
Observations	392,022	391,943	391,943	391,943
Principal Repayment Type	NO	YES	YES	YES
Year FE	NO	YES	YES	YES
Region FE	NO	YES	YES	YES

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Note: The base category for Occupancy type is Buy-to-Let

5. Conclusions

This study examined the determinants of mortgage default across five European countries, using a large loan-level dataset of over 2.3 million active mortgages originated between 1991 and 2013. Using a binary logit model of the probability of default, and controlling for a rich set of borrower and loan characteristics, we find support not just for the 'double trigger' hypothesis, which posits that the joint occurrence of negative equity and an income shock causes mortgage default, but also in favour of a third trigger. Specifically, the institutional and policy framework matters for default rates, as reflected both in country-specific categorical variables. Borrower sensitivity to the interest rate and unemployment is much greater in Ireland and Portugal than in the UK or the Netherlands, both in terms of absolute magnitude across LTV levels, and in terms of how that magnitude changes with the Operative LTV ratio.

The institutional differences include legal and regulatory impediments to foreclosure, differing macro-prudential frameworks, differences in bankruptcy law, and differing political environments. For example, competent authorities in Ireland, the Netherlands, the UK, and Portugal each implement a suite of macro-prudential rules designed to limit credit growth with respect to housing. In each of these countries there exist limits on either the loan's LTV ratio, and/or the LTI ratio of the borrower. In Spain however, no such rules exist. And more importantly, while all countries in our sample are legally 'full recourse', there exist cross country variations in the ease with which lenders can in practice foreclose upon a home in each country. While the process is relatively efficient in the UK, the Netherlands, and Spain, legal and regulatory impediments in Ireland have reinforced lenders' hesitance to repossess residential properties.

The results are not without their limitations. Most obviously, notwithstanding the inclusion of a rich set of borrower and loan controls, the country-specific categorical variables at best proxy for institutional differences and may reflect other factors, including social and cultural norms. A second limitation relates to the dataset. The study here uses a dataset of on loans that have been securitized at some point. As was clear in moving from a baseline model to one with additional liquidity constraints, the results are somewhat sensitive to changes in the composition of the dataset and this must be borne in mind when considering external validity.

Nonetheless, there are policy implications. Extending the loan-level analysis from the U.S.-focused literature to a cross-country did not affect the overall finding that the 'double trigger' is important in understanding default. That said, the obvious differences across countries in default rates for otherwise similar borrowers and loans is at least strongly suggestive of that the double trigger has a local context. Lastly, the evidence presented in Section 4.3, that neither LTI at origination nor first-

time buyer status has any effect on the probability of default in Ireland once adequate controls are included, has obvious implications for the reform of macroprudential policy there.

The findings here also have implications for future research. They strengthen the growing consensus that the 'option theory' model of mortgage default is inadequate to fully understand when and why borrowers default on their mortgages. But they also give researchers cause to consider the limits of the 'double trigger' model that is now at the heart of the consensus on default. The huge importance of country-specific factors in determining default rates in this analysis suggests an obvious avenue for future research, in measuring the broader institutional, regulatory and policy framework and understanding how it affects mortgage default.

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Appendix 1: Average Marginal Effect of Additional Liquidity Constraints

FIGURE 6 - MRTI: AVERAGE MARGINAL EFFECT BY LTV RATIO

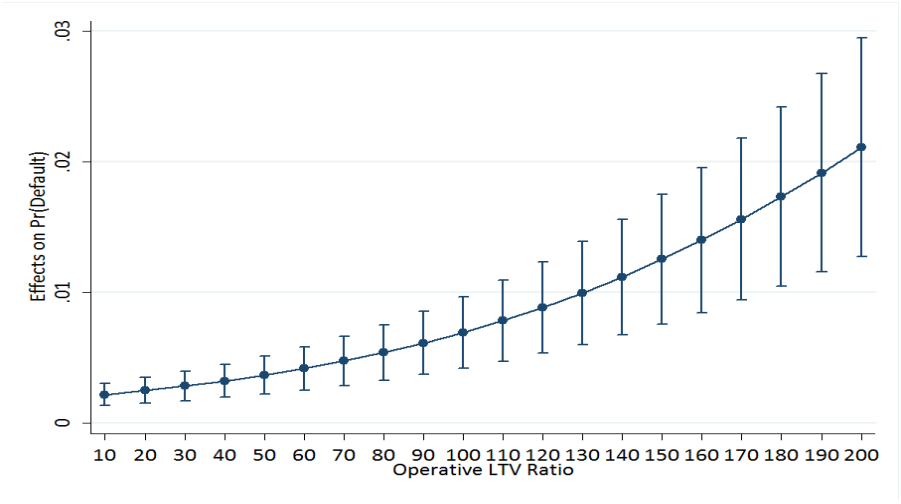


FIGURE 7 - PAYMENT DUE: AVERAGE MARGINAL EFFECT BY LTV RATIO

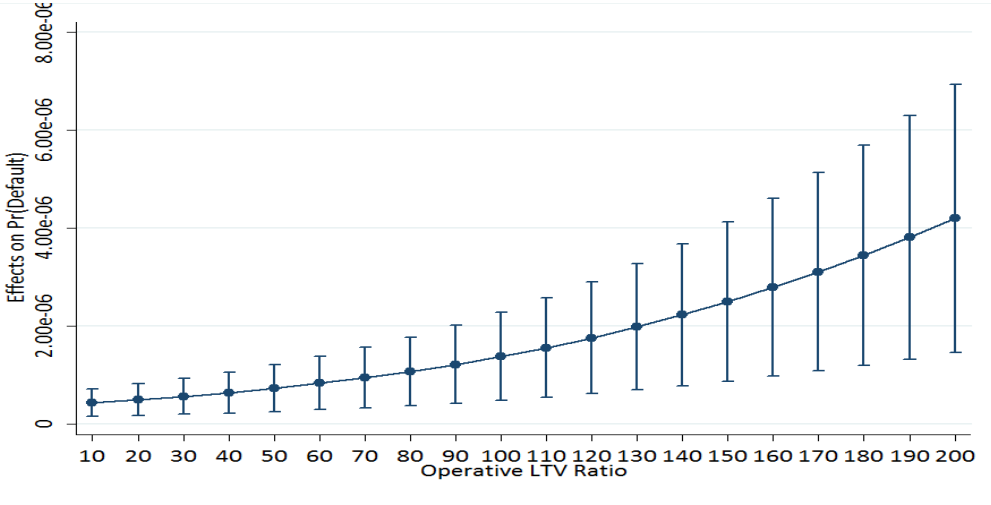


FIGURE 8 - MRTI: AVERAGE MARGINAL EFFECTS BY LTV RATIO AND COUNTRY

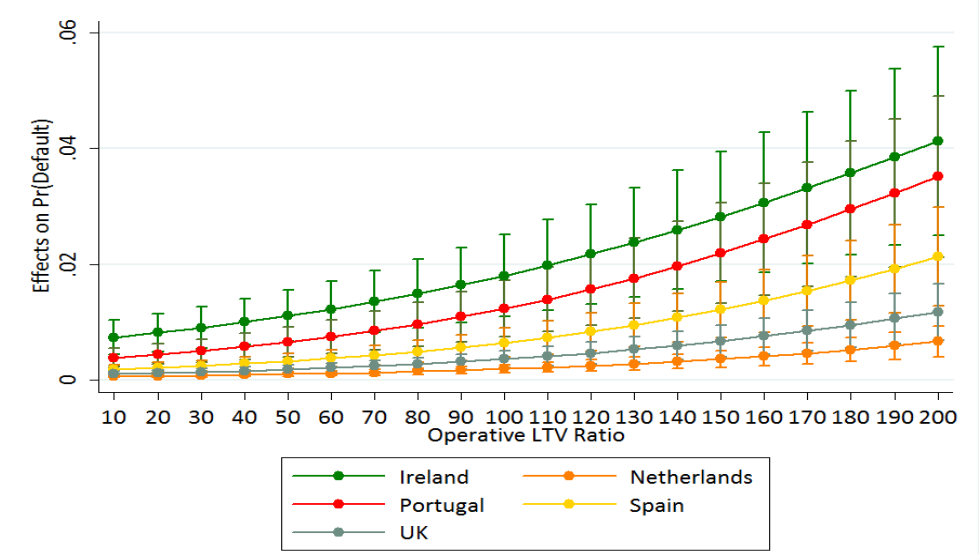
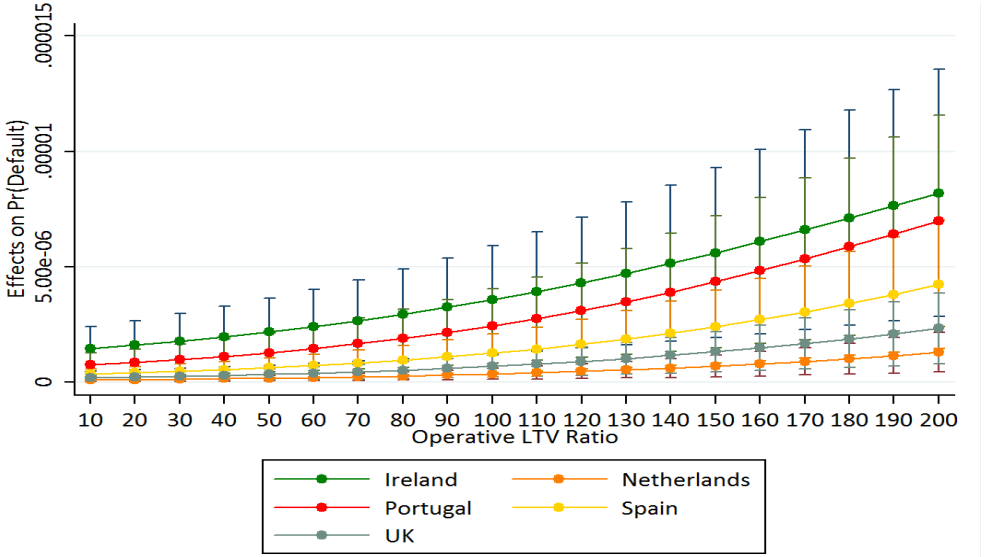


FIGURE 9 - PAYMENT DUE: AVERAGE MARGINAL EFFECT BY LTV RATIO AND COUNTRY



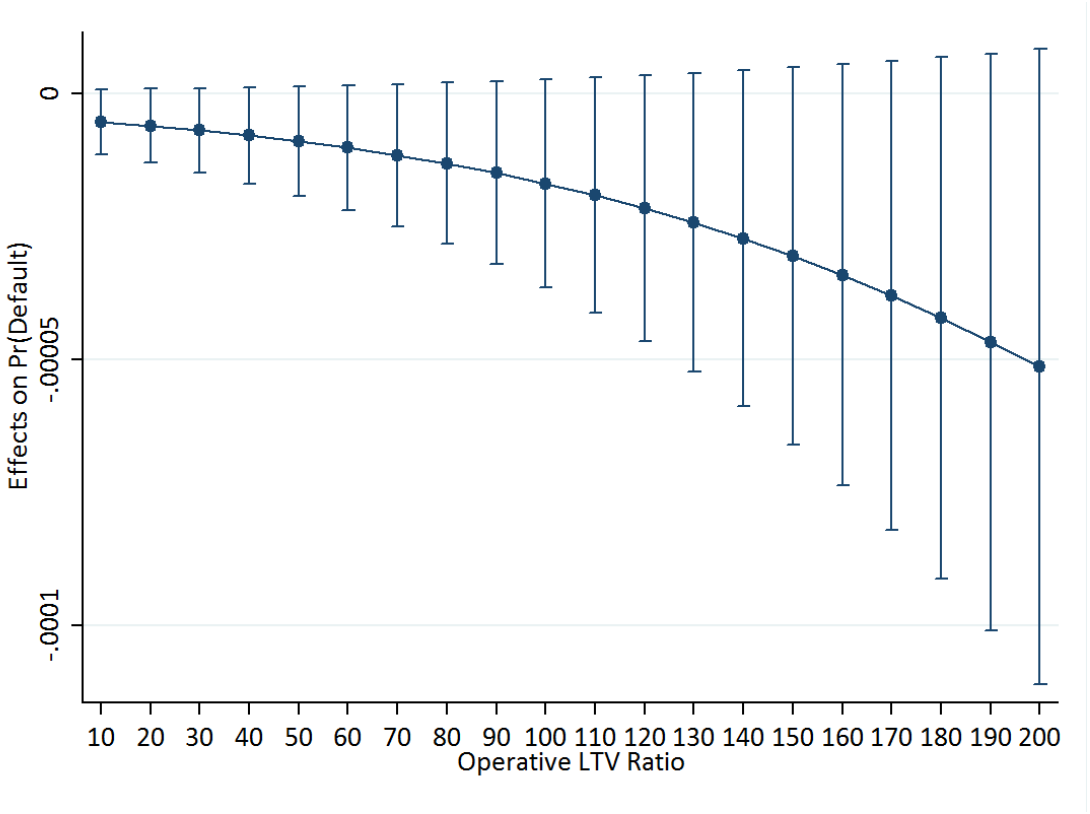


FIGURE 10 - AVERAGE MARGINAL EFFECTS OF LTI- INCLUDING OTHER LIQUIDITY CONTROLS

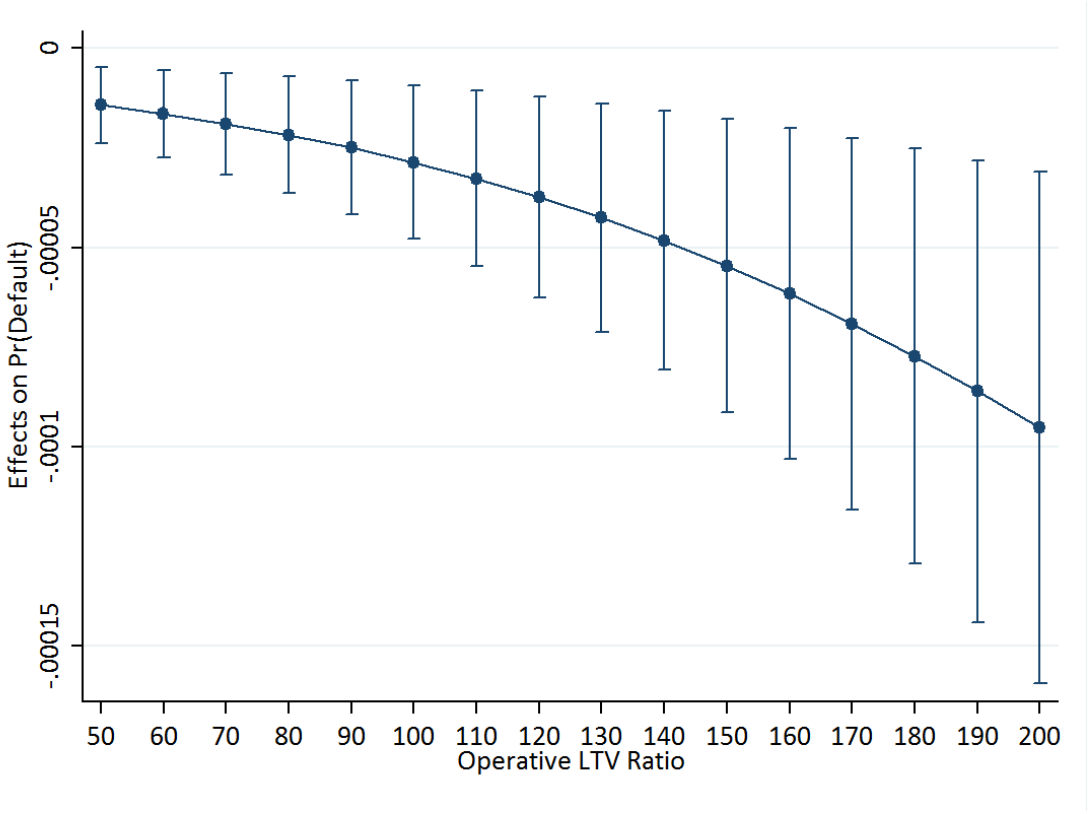


FIGURE 11- AVERAGE MARGINAL EFFECTS OF LTI - EXCLUDING OTHER LIQUIDITY CONTROLS

Appendix 2: Correspondence and comparison between Variables used in Specification 3 and those in Kelly et. al.

TABLE 6 – CORRESPONDENCE BETWEEN EDW VARIABLES AND KELLY ET. AL. VARIABLES

Kelly et. al.	European DataWarehouse Variables
Original LTV	ar135 (Original LTV)
Original LTI	Numerator: ar66 (Original Balance) + ar88 (further advances) Denominator: ar26 (primary income) + ar28 (secondary income)
Ln(DBO)	ar66 (Original Balance)
Term	ar56 (maturity date) - ar55 (origination date)
Interest Rate Type	ar108 (current interest rate index) -Tracker if ar108=10 -Fixed if ar108 = 12 or 13 -SVR if ar108 =11
Single Assessment	ar27 (Income Verification for Primary Income)
Dublin	ar129 (Property Postcode)
Marital Status	Unavailable, omitted
FTB	ar22(First-time Buyer)
Employment Status	ar21 (Borrower's Employment Status)
Equity Release dummy	Unavailable, Omitted
Ln(additional DB)	Inclusion precluded convergence, omitted
BTL	ar130 (Occupancy Type)

TABLE 7 - QUANTITATIVE COMPARISON BETWEEN EDW DATA AND KELLY ET. AL. DATA

	Kelly et. al.		EDW	
	FTB	SSB	FTB	SSB
Default (%)	10.3	14.9	6.92	8.67
Loan Size (€)	182,514	182,199	220,486	232,922
Purchase Price (€)	254,814	339,163	270,570	316,203
Current Value (€)	182,414	237,963	213,491	257,617
Borrower Characteristics				
Income (€)	56,280	68,995	53,264	64,631
Age (yrs)	31.8	39.3	30.75	37.5
Employed (%)	77.1	68.4	91.26	57.89
Self Employed (%)	11.9	15.6	6.61	12.67
Loan Characteristics				
OLTV	74.23	55.86	82.65	68.7
OLTI	3.44	2.83	4.35	3.98
Term (months)	348	286	381	329
Vintage (months)	91	95	136	140
Dublin (%)	25.8	25.7	24.38	32.67
Fixed (%)	11.5	6.9	12.25	42.44
SVR (%)	53.8	48.4	44.45	22.24
Tracker (%)	34.7	44.7	43.3	35.33