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Model-based estimates of the resilience of mortgages at origination

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Abstract

Using a probability of default model estimated over the period 2008-2015 for Irish mortgages, this *Letter* provides model-based estimates of the resilience of mortgages at origination. Cohorts of loans issued with lower aggregate probabilities of default based on their originating characteristics are deemed to have been more resilient at origination. We compare each annual cohort of loans issued from 2003 to 2016, differentiating between loans issued in 2015 that were within and outside the scope of Central Bank of Ireland mortgage market regulations. The results suggest that at-origination resilience was deteriorating in the Irish mortgage market from 2003 to 2008, before improving significantly in 2009 and 2010. The post-crisis period was characterised by increases in portfolio probability of default for the 2011 to 2014 cohorts, while the model suggests that resilience has improved relative to previous years for mortgages issued in 2015 and 2016.

1 Introduction

Enhancing the resilience of borrowers to financial shocks is one of the stated aims of recent Central Bank of Ireland restrictions on Loan to Value (LTV) and Loan to Income (LTI) ratios at origination (hereon "regulations"). The recent financial crisis and resulting rapid increase in mortgage default has put into sharp relief the damaging effects that financially unsustainable mortgages can have on individuals and households, as well as on the broader financial system and economy. In this *Letter* we use a Probability of Default (PD) model developed at the Central Bank of Ireland to provide model-based estimates of the financial resilience of pools of mortgages. We analyse the *originating characteristics* of cohorts of mortgages originated between 2003 and 2016. Focusing on loans as they appeared at origination allows a fair comparison of the risk profile of loans as they were issued across a thirteen-year time horizon.

The theme of borrower resilience has been studied extensively in recent years in Ireland. As part of the International Monetary Fund (IMF) Financial Sector Assessment Program (FSAP), an assessment of the financial vulnerability of all mortgaged households *using current household characteristics as of December 2014* is contained within the "Technical Note on Nonbank Sector Stability Analyses".[2] This analysis uncovered substantial variation in estimated vulnerability among those mortgages that remained performing at end-2014.

Box 1 of the Central Bank's most recent *Household Credit Market Report* (Central Bank of Ire-

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[2]https://www.imf.org/external/pubs/ft/scr/2016/cr16317.pdf

land, 2016) provides an analysis that is similar in spirit to that carried out in this *Letter*. The Box measures the ratio of mortgage repayment to net monthly income (the Debt Service Ratio, DSR) at origination for all loans issued since 2003 and observes how this ratio responds to adverse hypothetical economic shocks. The analysis suggests that the resilience of mortgages has improved greatly since 2009, with loans issued in-scope of the regulations being similarly resilient to loans issued in previous recent years.[3]

The analysis in this *Letter* combines elements from the aforementioned work in the IMF FSAP and *Household Credit Market Report*, in that a model is deployed to calculate one-year PDs for all loans issued between 2003 and 2016, using the originating rather than current characteristics of all mortgages. In line with the DSR-based analysis mentioned above, the model's estimates suggest that the at-origination profile of mortgage loans was getting more risky over the period 2003 to 2007. According to our model, after a sharp correction in 2008 and 2009, loans began to originate at higher levels of risk over the 2009 to 2013 period, while finally over the period 2014 to 2016 loans' origination profile has become less risky. Loans issued under the regulations in 2015 and 2016 are shown to be lower-risk than those issued in 2015 outside the scope of the regulations.

2 Data

In this *Letter* we calculate a predicted value for a one-year transition Probability of Default (PD) for every loan outstanding in five Irish banks' mortgage books. The banks submitting the mortgage data are Allied Irish Banks (including all loans originally issued by EBS), Bank of Ireland, Permanent TSB, KBC Ireland and Ulster Bank Ireland Limited. The data come from two separate sources. Firstly, for all loans issued up to the end of 2014, we take information on the originating characteristics of these loans from the Central Bank's Loan Level Data (LLD), which captures information on all loans outstanding at participating banks on a six-monthly basis. From the LLD, the originating profile of all mortgages issued between 2003 and 2014 (and still outstanding at 2014) is compiled. This is combined with information on all new loans issued in 2015 and 2016 in a "Monitoring Template" (MT) database which is submitted by all mortgage lenders to the Central Bank to allow monitoring of compliance with the regulations. All loan types are included in the analysis: both Buy to Let as well as Primary Dwelling House mortgages, as well as refinancing mortgages, equity releases or top-up loans captured in the mortgage data of the participating banks.

In the MT data, loans can be classified as "in-scope", meaning that they are subject to the regulations, or "out-of-scope", meaning that the loan was originated in 2015 but is not subject to the restrictions set out in the regulations. Loans can be out-of-scope because they were originated before the regulations' introduction date of 9/2/2015, or because they were drawn down after the regulations' introduction but approved beforehand, as well as for other reasons.

3 Method

For all loans in the data, we aim to calculate a "year one PD" in order to measure the risk profile of mortgages as they appeared at the time they were originated. These default probabilities are calculated over a one-year horizon, as such a horizon is commonly used in stress testing exercises. Expanding to a longer time horizon will increase the absolute values of the estimates without changing the relative ranking of PD across loans or cohorts. The predicted values for PD are calculated using the coefficients from an updated version of the Central Bank of Ireland's Loan Loss Forecasting (LLF) PD model, modified to incorporate data on default transitions from 2008 through to end-2015, as well as to incorporate additional loan characteristics as explanatory variables. An earlier version of this model has been used as a key input to numerous loan loss forecasting and stress testing exercises since its development in 2013, with examples including the European Banking Authority - Single Supervisory Mechanism stress tests in 2013, the International Monetary Fund's FSAP in 2015 as well as for internal prudential and financial stability analysis. An early version of the residential Irish mortgage PD model is available

[3] By "in-scope", we refer to loans that were issued in 2015 and 2016 which were issued under the restrictions set out by the regulations. "Out-of-scope" refers to loans that were issued in 2015 but were not subject to the restrictions set out by the regulations due to pre-approval or other technical reasons.

in Kelly and O'Malley (2016), while the broader LLF framework of the Central Bank of Ireland is discussed in detail in Gaffney et al. (2014).

The model utilised is a Multi-State Model (MSM), first introduced by Jackson (2011) whereby coefficients are estimated on a set of covariates affecting both the transition into and out of default. The covariates used in the updated version of the model used in this study are:

- Time since default (TSD, the number of months a loan has spent in arrears).
- Originating Debt Service Ratio (ODSR).
- Current Loan to Value ratio (CLTV).
- Regional unemployment.
- Current interest rate.
- Interest rate type (fixed, standard variable rate, tracker).
- Loan age, divided into five buckets to allow for non-linear effects.
- A "multi-loan" indicator, taking a one when a facility has more than one loan, and zero otherwise.
- Buy to Let (BTL) indicator.

The model's statistically significant coefficient estimates confirm that the longer loans spend in default, the less likely they are to return to performing status ("cure"). Loans with a higher ODSR are shown to have a higher PD. Loans with a higher CLTV are shown to have both a higher PD and a lower probability of cure. The same is true of loans in regions with higher unemployment and loans with higher interest rates. Standard Variable Rate and Tracker mortgages are shown to have higher PDs than fixed rate loans, while loans attached to multi-loan facilities are also shown to have higher PDs. The effect of loan age is shown to be non-linear: as loans age from their first year through to their eighth, the PD continues to rise, and falls thereafter. Finally, BTL loans are shown to have both higher PD and lower probability of cure than primary dwelling loans.

The aim of this *Letter* is to compare the risk profile of mortgage loans originated under the regulations to cohorts of loans issued earlier. Coefficients from the above model are applied to all loans in the data (regardless of whether the loans themselves were included in the estimation sample for the model) in a process often referred to as "credit scoring". In order to fairly compare the risk profile of in-scope loans to those that came before, we transform all loans outstanding at December 2014 so that they take on the characteristics that prevailed at origination. With this "at-origination view" (AOV) of the data, we can make comparisons across years of the originating risk profile of mortgages by calculating a "year one PD" for all loans, as they appeared at the beginning of their lifetime.

The model is well-suited to being adapted for the "at-origination" analysis carried out in this *Letter*, given that at any point when such models are used for stress testing purposes, there will be loans in their first year of existence being assigned a PD based on the model's coefficients. The only difference between a typical stress test and the analysis in this *Letter* is that in this case *all loans* in the data will appear as if they were in their first year of existence.

Transforming the Loan Level Data and Monitoring Template data to an AOV is straightforward given the information available therein. Originating LTV (OLTV) is reported directly for all loans in the data and is therefore used instead of CLTV when calculating PD at origination. In the case of the current interest rate, the rate at origination can be retrieved based on a historical series on advertised mortgage rates varying by bank and quarter. Loan age and time since default are both set to zero for all loans, while BTL status is time-invariant and can therefore be used as reported in the current data. In the case of the multi-loan indicator, if a loan is the oldest loan on a facility that is outstanding in the current data, then this loan is considered to *not have been* part of a multi-loan facility at origination, given that it is the oldest known loan in the data. All loans apart from the oldest loan on a multi-loan facility are considered to have been multi-loan at origination in our AOV. All loans that are not part of a multi-loan facility are considered to have been single-loan facilities at origination. Finally, regional unemployment is fixed at end-2015 to allow comparisons across time to be driven solely by the characteristics *of the loans drawn down in each year*, avoiding the possibility that part of any PD differential observed is explained by changes in the aggregate economic environment.

In all cases, the statistic calculated, PD_{it} is the probability that a performing loan i, issued in year t will transition into default over a one-year horizon. By definition, these transition probabilities will be lower than those observed in Kelly and O'Malley (2016) or published as part of stress-testing exercises, given that all loans are modeled based on their characteristics as of their first year of existence in this study. There are two very obvious reasons for this. The first is a mechanical one, in that the model predicts that as loans age from their first to eighth year, their PD rises, but in the credit scoring exercise in the current study, every loan will be assessed as if it was in the first year of existence. Secondly, for loans issued in the pre-2008 period, the likelihood that the property's value at end-2014 was lower than the value at origination is quite high, meaning for many of these loans, CLTV will be higher now than it was at origination. For these reasons, many of the loans have significantly lower PDs in our AOV than they would have in a stress testing exercise based on more recent information.

4 Findings

We begin with density plots of the PD distribution for selected cohorts: the 2015 loans both within and outside the scope of the regulations, 2014 loans and 2007 loans (Figure 1a). The risk distribution appears to be lowest among the 2015 in-scope cohort (purple curve), suggesting that the loans originated under the regulations are lower-risk than other comparator groups, consistent with the regulations' stated aim of improving the resilience of bank and borrower balance sheets. Another way of displaying information on the PD distribution is to take selected percentiles and plot them across all available years (Figure 1b). This chart shows that, at the median and even the 75th percentile, decreases in originating loan risk in the 2008-2010 period were relatively minor, with PDs rising by 2014 to be comparable to levels seen in 2008. However, at the right tail of the distribution, the post-crisis correction in banks' and borrowers' risk appetite is much more apparent, with large falls from 2008 in at the 90th, 95th, 98th and 99th percentiles. While the period from 2010 has been associated with a slight increase in these tail PDs, for all four of these points, PD levels up to mid-2016 are significantly below those experienced during the pre-2008 phase.

All PD values presented in Figures 1a and 1b treat every loan with equal weighting, taking no account of the potential correlation between loan size and loan risk. Such representations may not accurately reflect loan portfolio risk if loans with high right-tail PDs happen to have relatively small loan balances. To account for such a possibility, in Figure 2a we calculate the balance-weighted portfolio PD, PD_{pt} across all loans issued in each year t:

$$PD_{pt} = \frac{\sum_{i=1}^{n} OB_{it} \times PD_{it}}{\sum_{i=1}^{n} OB_{it}} \quad (1)$$

where OB_{it} is the drawn balance at origination of each loan i issued in year t, which is summed across all loans issued in year t. The chart illustrates that the loans issued within the scope of the regulations are low-risk in an aggregate historical perspective, with PD_{pt} being the lowest since 2011. In Figure 2b we re-calculate PD_{pt} across both borrower type and year, with separate estimates for the First Time Buyer (FTB), Second and Subsequent Buyer (SSB) and Buy to Let (BTL) sectors. Across all years the BTL sector is estimated to have higher originating PDs, with the pattern within this sector again following the cycle: growth in risk-taking between 2003 and 2008, a sharp downwards correction between 2008 and 2010. The BTL sector differs from the overall market in the post-2010 pattern however, with PD_{pt} in the BTL sector growing through 2010 to 2014 to levels surpassing those seen in 2008 (albeit with loan volumes being orders of magnitude smaller in the post-2010 period). The main driver of this sustained increase in at-origination risk profile among BTL loans is the increase in originating interest rates among these loans over the period, combined with a large increase in the share of Standard Variable Rate mortgages in the cohorts from 2008 onwards (which are deemed the highest-risk loan type in the model). For both the FTB and SSB segment, a similar pattern is observed through the cycle, with PDs falling slightly since 2014, and the in-scope loans in 2015 and 2016 being lower-risk than those issued out-of-scope in 2015.

Figure 3 splits each year's originating loan size distribution into deciles and calculates the average PD within each year-decile. The average PDs from 2003 to 2008 follow the pattern that one would expect given the property price boom experienced in

Ireland during the period, with PDs rising within each decile in each year. During that period there is also a clear relationship between loan size and risk: PDs increase with the majority of increases in loan decile. By 2008, the average PD in the top decile of loan size was close to double that in the bottom decile. The post-2008 period however brought about compression in the spread of loan risk across the loan size distribution. In the years up to 2013, larger loans continued to have higher PDs, but differentials across loan size deciles were smaller. The 2014-2015 period has seen this relationship overturned, with the largest loans having lower PDs on average.

While there has been a change in the correlation between loan size and OLTV, as outlined in McCann and Ryan (2016), this is only part of the explanation for the lowering of PDs in recent years. On top of this change in the LTV distribution, more high-balance loans are now being issued with fixed mortgage interest rates (and commensurately lower interest rates due to banks' pricing policies), and more low-balance loans are now being issued to BTL borrowers. Given that the model assigns a higher PD to loans with higher interest rate, SVR loans and Tracker loans (relative to fixed-rate loans), and BTL loans, the aforementioned changing patterns in lending across the loan size distribution are all contributing to changes in aggregate cohort PDs through time.

This realignment in the PD-loan size relationship has important prudential and financial stability implications, in that overall portfolio Expected Losses will always be lower, all other things equal, in cases where loans with larger balances are lower-risk.

5 Conclusion

In this *Letter* we have used a loan-level probability of default model to assess the credit risk of mortgages issued between 2003 and 2016 based on their characteristics at origination. The model assesses the risk profile of mortgages based on the loan to value ratio, regional unemployment rate, interest rate, interest rate type, originating Debt Service Ratio, loan age, Buy to Let status, and whether they are part of a facility with multiple loans against the same property. The 2003-2008 period is characterised by continued increases in the aggregate balance-weighted PD of loans issued in each year in the Irish mortgage market, with the years 2009 and 2010 showing a sharp fall in aggregate PD as banks and borrowers reacted to the financial crisis with markedly changed lending and borrowing practices.

Growth in model-predicted PDs had been experienced in the recovery period 2011 to 2014, with part of this being explained by the higher interest rates being charged by banks. The 2015 and 2016 period has seen a fall-off in PDs, returning to levels seen in 2005, 2009 and 2011. A detailed analysis of the relationship between loan size and PD suggests that banks are no longer issuing the highest-risk loans at the largest balances, due to changing patterns of prevalence of high-LTV, Buy to Let loans and fixed-rate mortgages across the loan size distribution. This reduction in the loan size-PD correlation relative to the 2003 to 2013 period is of great benefit from a prudential and financial stability perspective.

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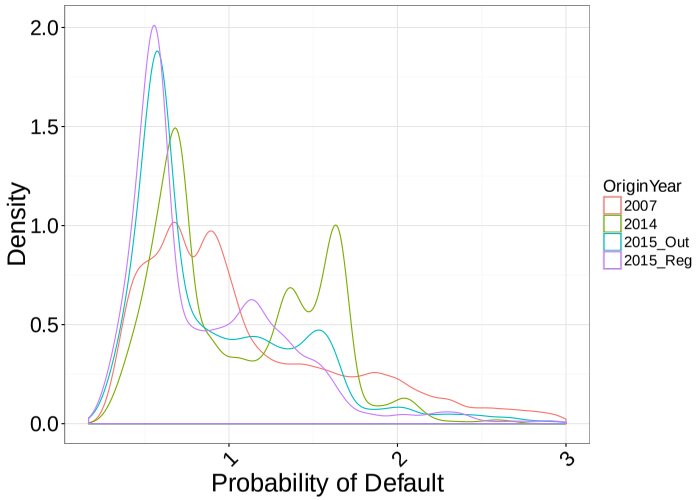
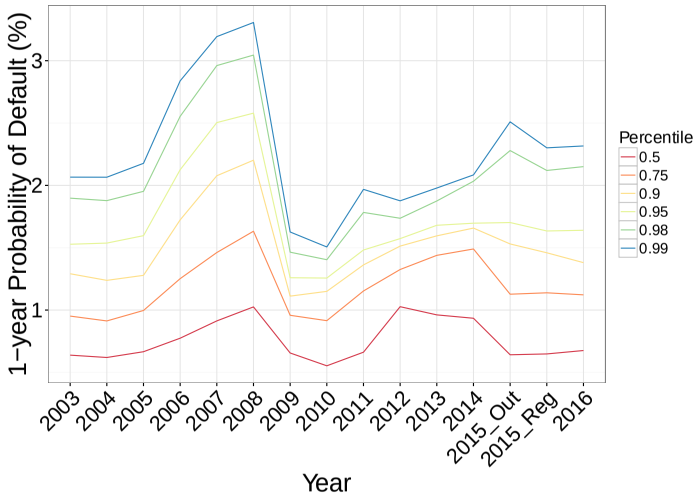
Figures

Figure 1: Probability of default distribution, by selected years and selected percentiles

(a) All loans, selected years



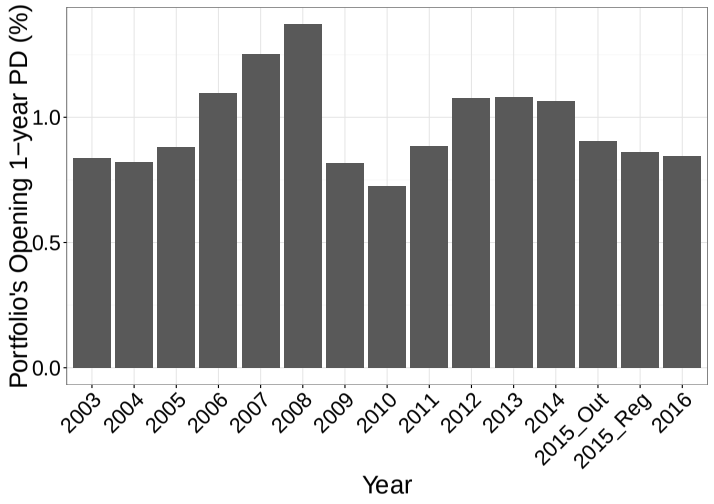
(b) All years, selected percentiles



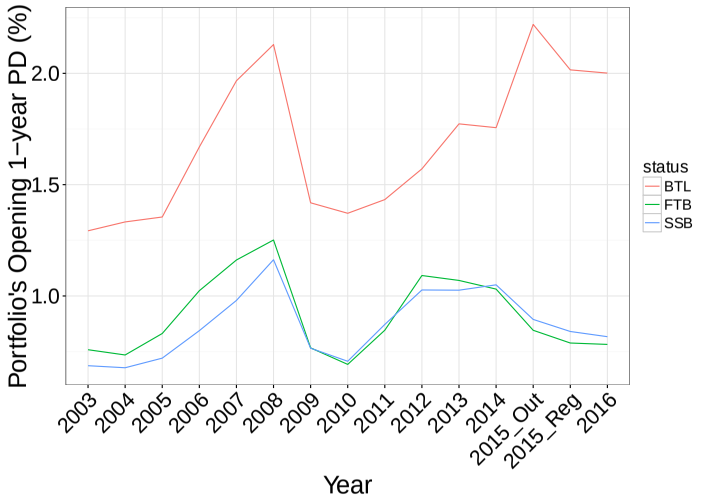
In all cases, probabilities reported are one-year probabilities of transition into default (PD) based on originating characteristics of loans issued in each year 2003 to 2016. Distribution is limited to a PD of 3 per cent, which allows for clearer exposition of the data while still including over 99 per cent of all loans. 2015-Out refers to loans drawn down in 2015 which are not within the scope of the Central Bank of Ireland's mortgage regulations. 2015-Reg refers to loans issued in 2015 and within the scope of the regulations.

Figure 2: Percentage of total drawn balance predicted to enter default as per originating characteristics of mortgages

(a) All loans

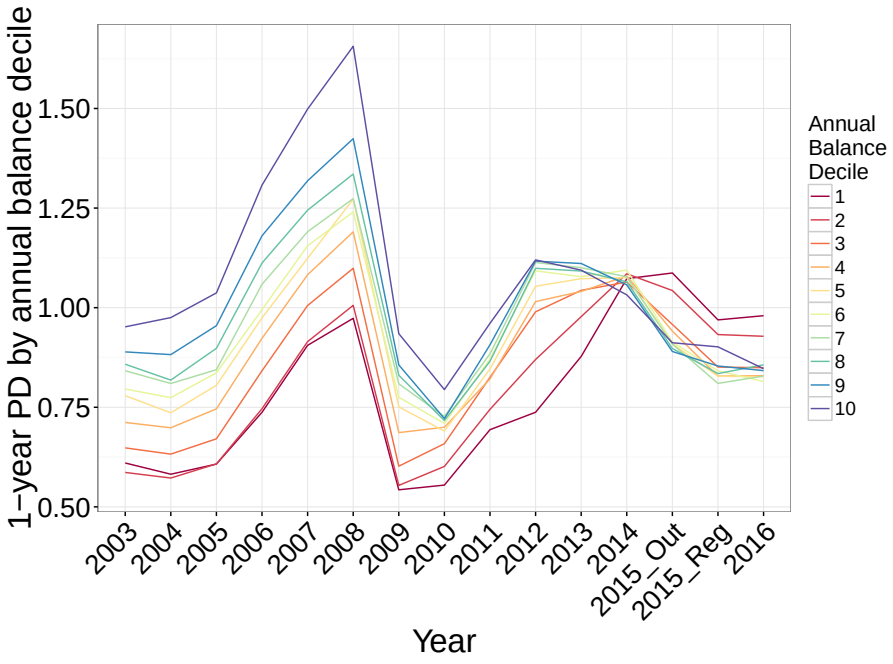


(b) By loan type



Each point on the graph refers to the balance-weighted one-year probability of default across all loans originated within a year in each loan type group. 2015-Out refers to loans drawn down in 2015 which are not within the scope of the Central Bank of Ireland's mortgage regulations. 2015-Reg refers to loans issued in 2015 and within the scope of the regulations.

Figure 3: Average PD per decile of each year's originating loan balance distribution



Each point on the graph refers to the balance-weighted one-year probability of default across all loans originated within a year in each loan balance decile. 2015-Out refers to loans drawn down in 2015 which are not within the scope of the Central Bank of Ireland's mortgage regulations. 2015-Reg refers to loans issued in 2015 and within the scope of the regulations.