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SME Collateral: risky borrowers or risky behaviour?

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Abstract

We explore two motives in a bank's use of collateral: an ex-ante *stock-of-risk* effect, whereby banks secure observably riskier loans to reduce future losses; an ex-post *flow-of-risk* effect, whereby banks use collateral to lower the probability of reduced borrower effort. Using loan-level data on Irish enterprise lending, we explore these two mechanisms. We confirm the *stock-of-risk* hypothesis while finding no evidence that collateral reduces the ex-post *flow-of-risk*. We also highlight the importance of loan size by showing that banks secure almost all loans in the top quintile of loan size regardless of risk rating, whereas among smaller loans, collateralisation is higher for riskier loans.

Keywords: SME, Collateral, Risk, Moral Hazard

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Non Technical Summary

The theoretical literature offers two opposing views on the purpose of collateral. In the first, banks use collateral to sort risk-opaque borrowers, and low-risk borrowers signal their quality by choosing secured lending. In the second, collateral is seen as a device to mitigate moral hazard, and observably high-risk borrowers will be required to pledge collateral. Our approach disaggregates this second theory into two separate effects. We describe the theoretical and empirical link between observed risk at origination and collateralisation as an ex-ante *"stock-of-risk"* effect. This effect is likely driven by the bank's desire to alleviate the higher probability of default and expected losses of such observably riskier loans. Second, we consider the improved incentives or reduced moral hazard effects of collateral to be an ex-post *"flow-of-risk"* effect. While previous studies show a positive correlation between observed risk and collateralisation, there are very few direct tests of the success of collateral in reducing moral hazard in small-business lending.

The goal of this paper is to isolate these two separate drivers. Using a panel of Irish SME loans, we use the bank's internal ratings at origination as our proxy for the borrower's ex-ante *stock-of-risk*. Similar to many previous studies, we find that the probability of pledging collateral increases with firm risk. We quantify the ex-post performance-improving (moral hazard-reducing) effects of collateral in two ways: first, by tracking changes in a borrower's internal rating through time; second, by exploring a borrower's switch to default. In both cases, we find no evidence that collateral is a successful tool for mitigating against borrower missed payments – securing a loan does not appear to reduce the probability of a rating deterioration or the probability of default. These results are reached after controlling for a firm's ex-ante *stock-of-risk*, either directly in our models, or through separate estimations for each originating rating group. Additionally we contribute to the literature's understanding of the way in which banks secure enterprise loans by showing that, in the top quintile of the loan size distribution there is close to full collateralization of all loans, regardless of risk profile.

While our results show no evidence that collateral improves loan performance, we note that the securing of observably riskier borrowers at origination is likely still rational from a loss-mitigating perspective. Given that ex-ante riskier borrowers are significantly more likely to fall into default ex-post, it makes sense from a bank's perspective to request collateral on these loans in order to lower the Loss Given Default on these higher-PD loans. We further rationalise the higher collateral rates among riskier and larger borrowers through a simple bank capital framework, and show that collateral reduces Expected Losses and Risk-Weighted Assets, both of which improve the bank's capital ratio.

1 Introduction and Motivation

What is the purpose of collateral in commercial lending? Berger et al. (2011) describe two sets of theoretical models with divergent views. In the first (Bester, 1985; Besanko and Thakor, 1987), lenders use collateral as a self-selecting device to screen risk-opaque borrowers at origination. These models show that the incidence of collateral and firm risk are inversely related – when offered a suite of loan contracts, low-risk borrowers will choose higher collateral requirements (with lower interest rates) while high-risk borrowers will choose lower collateral requirements (with higher interest rates). The second set of models describe collateral as an instrument to mitigate "ex-post frictions" (Berger et al., 2011). For example, the model of Boot et al. (1991) shows that collateral can reduce default risk by motivating bad borrowers to increase effort ex-post. This model suggests that observably riskier borrowers at origination are required to pledge more collateral. Along a similar thread, the model of Bester (1994) suggests that collateral reduces the likelihood of ex-post strategic default.

The empirical literature has found some evidence in favour of the first set of theories[1], while a much wider array of papers have found empirical support for the second set of theories, finding that observably riskier firms at origination are more likely to be required to post collateral.[2] Collateral has been found to be more common for borrowers with previous repayment difficulty, higher leverage, low profitability, and financial stress.[3]

A related strand of literature explores the relationship between risk and collateral by regressing loan interest rates upon collateral.[4] Results from these studies are, however, somewhat mixed.[5]

While the model of Boot et al. (1991) suggests that collateral is used to reduce ex-post moral hazard, the literature has rarely tested whether collateral is in fact a successful mitigant of such behaviour. In this paper, we disaggregate the collateral-risk relationship into two separate mechanisms. First, we run a model familiar to the literature to determine whether observably riskier borrowers are more likely to post collateral at origination. We consider this to be an ex-ante *"stock-of-risk"* effect, in

[1] For example, Berger et al. (2011) find that higher unobserved risk (using missed payments at another bank as a proxy) is associated with lower collateral requirements, but only for borrowers with short banking relationships. Similar findings are observed by Jiménez et al. (2006) using borrower age.

[2] See Steijvers and Voordeckers (2009) for a review of the literature prior to 2009.

[3] Specifically, collateral requirements are shown to increase with past repayment problems (Jiménez et al., 2006; Chakraborty and Hu, 2006; Berger et al., 2011) and firm leverage (Berger and Udell, 1995; Ang et al., 1995; Jiménez et al., 2006). Similarly, increased collateral is observed for firms with poor profitability (Ang et al., 1995) and for those having experienced recent financial stress (Harhoff and Körting, 1998). Hanedar et al. (2014) also find a positive effect for firms with higher liquidity risk, past difficulties paying utility bills and for firms located in high crime areas.

[4] Studies generally employ the interest rate risk premium – equal to the interest rate minus a risk-free rate (treasury or prime rate) – as a proxy for borrower risk.

[5] A positive relationship between interest rates and collateral is observed in Berger and Udell (1990), Machauer and Weber (1998), Brick and Palia (2007) (for outside collateral only) and Godlewski and Weill (2011) while a negative relationship is observed in Degryse and Van Cayseele (2000), Lehmann and Neuberger (2001), Berger et al. (2011) and Berger et al. (2016) (where the effect is stronger for liquid collateral).

that collateral is used by banks as a reaction to the *at-origination* profile of borrowers. This effect is likely driven by the bank's desire to alleviate the higher probability of default and expected losses of such observably riskier loans and is analogous to the "sorting-by-observed-risk paradigm" described by Berger and Udell (1990). Second, controlling for a borrower's *stock-of-risk*, we explore whether collateralised loans are less likely to experience declines in creditworthiness ex-post, which we consider an ex-post *"flow-of-risk"* effect. Both components of the relationship can in principle be consistent with moral hazard-based theories of collateral: tests of *stock-of-risk* shed light on a bank's intention to mitigate against ex-post non-payment, while tests of the *flow-of-risk* can confirm whether such a strategy is in fact successful. To our knowledge, such a distinction between *stock-of-risk* and *flow-of-risk* has not been made previously in the economics literature on enterprise loan collateralization. In fact, the only paper we are aware of that tests for the role of collateral in explaining ex-post loan performance, while also controlling for ex-ante loan risk, is Berger et al. (2016).

We test our hypotheses on a sample of Small and Medium Enterprise (SME) loans originated by Irish banks between December 2011 and December 2015. Our results provide strong evidence for a *stock-of-risk* effect: using the bank's internal rating at origination to measure a borrower's ex-ante observed riskiness, we find that observably riskier firms are more likely to pledge collateral, with the impact close to monotonically increasing through the rating categories. We also find strong evidence that larger loans are more likely to have collateral posted: unconditionally, loans in the top decile of the drawn originating loan balance distribution have a collateralisation rate of 98-99 per cent, regardless of loan risk. In a multivariate setting, relative to the bottom decile of drawn originated loan balance, loans at the median are 19 percentage points more likely to post collateral, while loans in the 9th and 10th decile are 56 and 65 percentage points more likely, respectively. To our knowledge, ours is the first paper in the literature to show such a stark non-linearity in the collateral-loan size relationship, and the first to have uncovered a quasi "blanket collateralisation" policy at the top end of the loan size distribution.

On the *flow-of-risk*, our empirical tests provide no evidence that collateral successfully acts to mitigate against either ex-post deteriorations in borrower ratings or loan default. If anything, our results, where significant, suggest that collateral is associated with a *higher* probability of ex-post deterioration and default. This result is in line with the default model of Berger et al. (2016), which is the study closest in spirit to ours. In their study (using Bolivian data), they also find that collateral is associated with higher ex-post non-payment, while controlling for prior defaults of the borrowing firm. However, they also differentiate between liquid collateral (such as deposits, guarantees and securities) and illiquid collateral (movable assets, real estate, bonds and vehicles) and find that the former lowers the probability of default, consistent with the moral hazard mitigation expected by the theory. Using a subset of our data, we also explore different types of collateral but do not find heterogeneous effects.

Other studies have also observed a positive association between collateral and ex-post loan default (Jiménez and Saurina, 2004; Jiménez et al., 2006; Berger et al., 2011).[6] In each of these studies, however, ex-ante borrower risk is omitted when observing the collateral-ex-post-performance relationship, meaning that these studies cannot rule out that the finding is driven by the fact that riskier loans at origination are both more likely to post collateral and more likely to default ex-post.

While our results provide no evidence that collateral successfully acts to mitigate against ex-post missed payment, our results should not be interpreted as suggesting that the decision to secure riskier loans is irrational from the bank's perspective. On the contrary, from a bank regulatory capital perspective, our results suggest that banks are rational in the profile of borrowers posting collateral. Firstly, our models show that banks demand collateral from borrowers with the highest ex-ante *stock-of-risk* and that such borrowers are significantly more likely to fall into default ex-post. Secondly, we show that collateral is more likely to be required for larger loans. In Section 4 we discuss in detail how such a targeting of collateral among loans with higher Probability of Default (PD) and Exposure at Default (EAD) can improve the bank's capital ratio both through a lowering of expected losses and provisions through the Loss Given Default (LGD) channel, as well as through the shrinking of the effective size of the balance sheet through lowering of Risk-Weighted Assets.

The rest of the paper is structured as follows: Section 2 introduces our SME loan-level dataset and the empirical methods used; Section 3 presents our results; Section 4 discuss the implication of our findings; Section 5 concludes.

2 Methods and Data

Our analysis uses seven waves of SME loan-level data (LLD) available for three Irish banks comprising roughly two thirds of the SME lending market. These data describe the stock of loans at a point in time, submitted on a six-monthly basis from December 31st 2011 through June 30th 2015. The data base has been collected from the subject banks for stress testing, loan loss forecasting and policy analysis purposes. Loans can be identified by a unique ID and linked across each data drop. The dataset used for empirical analysis in this paper is a subset of the LLD, where unique loan IDs must be observable at least twice, with the two observations being at least two years apart. Further, we focus on term loans rather than on revolving credit facilities. Finally, given that one of the key variables of interest is the riskiness of a borrower at loan origination, and our first data submission is at end-2011, we restrict the sample to loans originated from July 2011 onwards. This significantly reduces the

[6] In Jiménez et al. (2006), the authors have information on default status both ex-ante and ex-post, but use these variables to proxy observable and unobservable measures of borrower riskiness in a model of the determinants of collateral. They do not test for the moral-hazard-mitigating properties of collateral as we propose to do in the current study.

amount of loans included in our empirical models relative to the stock of loans outstanding at a point in time.

We now outline the two hypotheses to be tested empirically in this paper. Motivated by the theoretical foundations of Boot et al. (1991) and the findings of much of the empirical literature, our first hypothesis is as follows:

H1. *At origination, banks are more likely to demand collateral from observably riskier borrowers.*

As mentioned, we consider this to be an ex-ante *stock-of-risk* effect. In this regard, the data set contains an observable, continuous and time-varying measure of borrower risk – the bank's internal rating of the borrower – which describes a firm's business performance and ability to repay. While this rating is not available for the exact date of loan origination (ratings are provided on the date of data submission only), we proxy the originating rating by focussing on loans that originated within six months prior to each respective six-monthly data submission date. For example, for a loan issued in September 2011, we will assign the rating in the December 2011 data submission to be its "origination rating". Empirically, we estimate the following standard logit model:

$$C_{i,t=0} = R_{i,t=0} + \mathbf{X}_{i,t=0} + e_i \tag{1}$$

where $C_{i,t=0}$ is a dummy variable indicating whether borrower i committed collateral at origination ($t = 0$), R is risk, $\mathbf{X}$ is a vector of loan and borrower controls and e is the error term. Our second hypothesis explores the ex-post *flow-of-risk* effects of collateral:

H2. *Post-origination, collateral reduces borrower moral hazard by increasing effort and/or reducing excessive risk-taking.*

We employ two models to test this hypothesis. In the first, we proxy borrower effort by tracking changes in internal ratings through time. In this regard, the following logit model is estimated:

$$Det_{i,t=1} = C_{i,t=0} + R_{i,t=0} + \mathbf{X}_{i,t=0} + e_i \tag{2}$$

where the dependent variable, $Det_{i,t=1}$, is a dummy variable indicating an ex-post rating decline. This variable is created by comparing originating ratings to the latest available wave (using all available wave combinations), but applying an arbitrary two-year minimum gap between waves (we test the robustness of our results to different gaps in the analysis). The restricted sample resulting from this data requirement is employed in all regressions for consistency. **H2** will be validated if a negative and economically and statistically significant coefficient is observed for secured loans. We further explore this hypothesis by estimating the following default model:

$$Def_{i,t=1} = C_{i,t=0} + R_{i,t=0} + \mathbf{X}_{i,t=0} + e_i \tag{3}$$

where $Def_{i,t=1}$ is a dummy variable indicting ex-post default. Again, if collateral improves ex-post loan performance we would expect to observe a negative coefficient. Importantly, in both equations (2) and (3), we control for the observable ex-ante *stock-of-risk* effects by including the borrower's originating rating.

Our analysis focuses on term loans to SMEs and Table 1 presents descriptive statistics for all variables employed (for all borrowers, secured and unsecured loans respectively). Of the 6,607 loans in the data, 53% are secured by collateral. In only 548 cases do we observe more than one loan has been issued to the same borrowing company, indicating that the ratings and collateral data can be thought of as company-level rather than loan-level concepts (in that it is not the case that any results could be driven by between-loan, within-borrower variation in either collateral status or rating).

Our measure of borrower risk is the bank's internal credit rating. Each of these rating categories represents a probability of default bucket as viewed by the bank's loan officers. These ratings vary through time and are reviewed regularly either algorithmically or by internal credit committees (with the level and regularity of scrutiny depending on the size of the borrower). We will show in Table 2 that these rating scales are strong discriminators of subsequent default, with the default rate among loans rated in category 1 being 3.9 per cent, with that among loans in category 6 being 41.3 per cent (and increases in default probability observed for each intermittent move up the rating scale).

While we do not have precise access to the information set used by the lender in assigning these ratings, it is worth dwelling on the possibility that the collateral status of the loan may be used by the lender as an input factor, and what this would mean for our estimates. If a loan officer incorporated information on a loan's collateral status into his/her rating decision, it is likely that the loan officer would assign *lower-risk* ratings to loans with collateral, given that the assumed moral-hazard-reducing effects of collateral form such a strong part of the conventional wisdom in banking, and these ratings relate to the probability of default, rather than the loss given default. The implication in relation to **H1** is that, if we find that higher-risk loans are more likely to be collateralised, this finding would be *above and beyond* a downward bias in the collateral-rating relationship which arises due to the moral hazard assumption forming part of the loan officer's information set. Put another way, if collateral status is factored in by loan officers when assigning ratings (who give lower-risk ratings to loans with collateral, *ceteris paribus*), then our estimates of a positive relationship between riskiness and collateral at origination are in fact a lower bound.

For **H2**, which relates to deterioration in ratings or transitions to default, there is less concern for any bias to be introduced to the estimates. Given that we control for ex-ante originating rating and

look at subsequent changes *within-loan*, any bias resulting from loan officer incorporation of collateral status is already controlled for. Results for **H2** could only be biased if loans were switching from secured to unsecured during the loan's lifetime, with this switch being related to a rating downgrade due to the loan officer's incorporation of a new higher PD owing to to the higher likelihood of reduced borrower effort. If this bias was present, it would favour the uncovering of a negative relationship between collateral and subsequent deterioration in loan performance (i.e. it would favour **H2**). If our results show that there is either no relationship or a positive relationship between collateral and ex-post deterioration, with the possibility of such a bias being present, it suggests that the likelihood of there truly being a negative relationship present in the data (as hypothesised in **H2**) is close to zero. To the best of our knowledge, this type of switch in the collateral status of a loan is not particularly common in Irish banking and is unlikely to be the driver of our results. Loan collateral status switches are extremely uncommon in our data set.

We aggregate the bank's internal rating scale into six evenly sized groups, with between 14% and 19% of loans in each category. Although a very high share of loans experienced an ex-post rating decline (43%), this rate is identical for secured and unsecured borrowers. However, the ex-post default rate of secured borrowers (16%) is slightly higher than unsecured borrowers (14%).

The remaining control variables show a number of differences between secured and unsecured loans. For example, secured loans have higher balances (about six times larger), longer terms (2.3 years longer) and lower interest rates (62 basis points lower). The secured sample also has a higher share of "SME" (versus Micro) loans.[7] We proxy relationship length as the difference between the earliest origination date and latest maturity date across all of a borrower's active loans. The average relationship length is about four years longer for secured loans.

Figure 1 plots the share of collateralised loans by originating loan balance deciles, for less risky and more risky loans (defined as loans in ratings groups 1-3 and 4-6, respectively). Among smaller loans, there is clear evidence of a *stock-of-risk* pattern, where the collateral share is higher among risky loans than less risky loans in each decile. However, as we move to the 8th, 9th and 10th deciles, it appears that Irish banks operate of policy of quasi-blanket collateralisation, with little distinction between less risky and more risky loans. This policy appears so stark that within the top decile, low and high risk loans have collateral rates of 98 and 99 per cent, respectively.

Table 2 examines the relationship between ex-ante risk and the three dependent variables – the share of loans with collateral, the share that experienced a decline in internal ratings and the share that

[7]Loans are located in either the "Micro" or "SME" segment of a bank's business banking portfolio, with Micro loans going to smaller borrowers and SME loans going to larger firms. The delineation within lenders does not follow a precise statistical definition such as that used by national statistical agencies. In all cases, lending in the Corporate Banking divisions of the lenders is excluded, meaning that the study is restricted to the full range of firm sizes within the SME category.

Table 1: Summary statistics of variables employed, regression sample.

	All Borrowers		Unsecured Borrowers		Secured Borrowers	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Dependent Variables						
Collateral	52.9%		0.0%		100.0%	
Rating Deterioration	43.4%		43.4%		43.3%	
Default	14.5%		15.6%		13.5%	
Independent Variables						
Originating Rating 1	19.4%		23.0%		16.1%	
Originating Rating 2	16.9%		15.9%		17.7%	
Originating Rating 3	16.4%		17.0%		15.8%	
Originating Rating 4	17.3%		15.3%		19.2%	
Originating Rating 5	14.3%		12.3%		16.2%	
Originating Rating 6	15.7%		16.4%		15.1%	
SME	38.6%		18.9%		56.2%	
Relationship Length	11.5	9.8	9.3	9.0	13.4	10.1
Term	5.472	3.457	4.254	1.937	6.559	4.094
Balance	58173.3	309125.5	15308.3	12809.0	96410.5	421398.3
Interest Rate	4.953	1.166	5.281	1.286	4.662	0.955

Notes: Summary statistics based on a sample of 6,607 term loans from one Irish bank. Although included in the analysis, we have not shown statistics for regional and sectoral variables.

switched to default status (for each originating rating group). For the latter two dependent variables, we further disaggregate by secured and unsecured loans. At this stage, there is some evidence that collateralisation increases with ex-ante risk (column two). However, this relationship is not monotonic, with originating rating group three showing a lower collateral rate than group two, and group six showing a lower rate than group five. Furthermore, there is limited evidence that collateral reduces the likelihood of a rating decline (columns three and four). For example, for loans in originating rating groups one and two (the lowest ex-ante risk), rating declines are *more* prevalent for secured loans. For the remaining originating rating groups, the share of declines are similar for secured and unsecured loans (although secured loans in originating rating group four have a lower share of declines). However, ex-post default increases consistently with ex-ante risk (columns five and six), and there is evidence that secured loans perform better – within each originating rating, secured loans have a lower share of defaults (except group six). The following section explores whether such relationships hold once all firm and loan characteristics are controlled for.

3 Results

Table 3 presents marginal effects from the logit model described in Equation 1. Our core interest is the relationship between a borrower's ex-ante *stock-of-risk* (the borrower's originating rating) and the bank's decision to secure the loan at origination. Results show that all rating groups are statistically and economically significant (Model (1)), and compared to the reference category (rating group one –

Figure 1: Collateral across the distribution of drawn originated loan balance

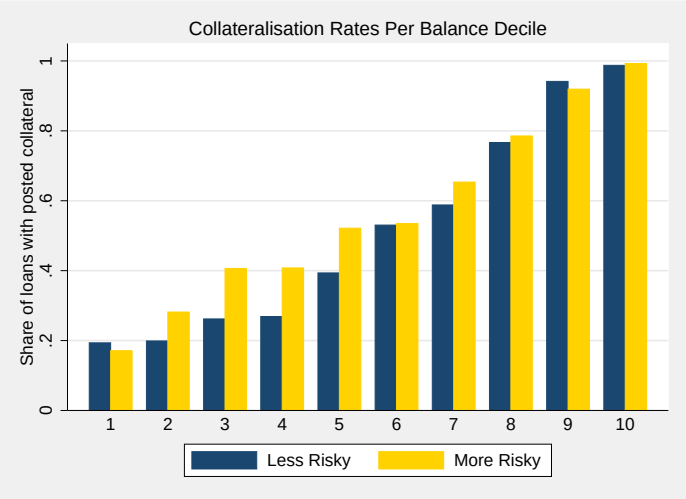

Table 2: Collateral and ex-post performance by originating rating

	Collateral	Rating Deterioration		Default	
	All Borrowers	Unsecured Borrowers	Secured Borrowers	Unsecured Borrowers	Secured Borrowers
Originating Rating 1	44.0%	58.4%	70.0%	3.9%	2.3%
Originating Rating 2	55.4%	43.7%	47.1%	7.4%	2.9%
Originating Rating 3	50.9%	34.5%	34.1%	8.1%	6.2%
Originating Rating 4	58.4%	37.2%	32.1%	14.5%	10.2%
Originating Rating 5	59.6%	41.8%	40.8%	25.8%	19.3%
Originating Rating 6	50.8%	38.6%	37.0%	41.3%	43.5%

Notes: Summary statistics based on a sample of 6,607 term loans from one Irish bank. This table presents the share of loans with collateral, the share that experienced a decline in internal ratings and the share that switched to default status.

the lowest risk loans), the probability of collateralisation increases by 9.6, 8, 15, 16 and 18 percentage points (PPs) for groups two through six respectively. These effects are sizable given the collateral rate of group one (44 per cent) and is evidence in support of Hypothesis **H1** – banks are more likely to demand collateral from borrowers which have a higher ex-ante *stock-of-risk*.

There are a number of additional significant results of interest in Table 3. For example, the size of the loan is particularly important for the bank's decision to secure, confirming the pattern presented in Figure 1. To illustrate the magnitude of this loan-size effect, we re-estimate the model with balance deciles (Model (2) in Table 3). With the exception of the third decile, collateralisation increases consistently with balance. For example, compared to the reference group (first decile, with collateral rate of 18 per cent), the probability of pledging collateral increases by 19 PPs for the fifth decile and by 65 PPs for the tenth decile. Also apparent in Table 3 is that collateralisation increases in loan term. It should be pointed out that, under Basel guidelines relevant in the period under study, a shorter-term

loan carries a lower risk weight. Therefore, it is intuitive that, when terms are longer, risk-weighted assets are greater, so to offset this higher risk-weight, expected losses and provisions can be lowered by requiring collateral (see Section 4 for a more thorough discussion of the role of regulatory capital in explaining our findings).

We also find, surprisingly, that collateral increases in relationship length. It is possible that younger firms are less likely to have experienced the negative effects of the financial crisis and, as a consequence, are considered less risky. Further, older loan relationships are also more likely to have originated at a time before 2008 when large amounts of SME lending in Ireland was linked to the property market (McCann and McIndoe-Calder, 2014), which would also be likely to increase the likelihood of a loan being collateralised. We also observe a negative coefficient for the loan interest rate – collateral and price appear to be substitutes in Irish SME lending.

Our second hypothesis describes collateral as a device which reduces a borrower's ex-post *flow-of-risk*. We test this using two models: in the first, we explore the relationship between collateral and ex-post rating deteriorations (Table 4); in the second, we explore the effects of collateral on ex-post default (Table 6). In both tables we include results with and without originating ratings to explore whether controlling for the *stock-of-risk* affects the role of collateral. Results from Table 4 show that larger loans, loans with longer terms and loans with higher interest rates are more likely to experience a rating decline. However, contrary to the expectations of Hypothesis **H2**, we find no evidence that collateral improves ex-post performance. In Model (1) (originating ratings excluded), the collateral coefficient is not significant, while in Model (2) (ratings included), the sign is contrary to expectations – collateralised loans are *more* likely to experience an ex-post decline in internal rating (probability of a decline increases by 4.4 PPs relative to an overall mean of 43 per cent). As in the descriptive analysis of Table 2, it is apparent that borrowers with the lowest originating risk (rating group one – the reference group) are the most likely to experience a rating decline. However, a consistent pattern between originating ratings and deteriorations is not apparent. We further explore this relationship by estimating separate models for each of the six originating ratings (represented by Models (1) through (6) in Table 5, respectively). We again find no evidence that collateral improves ex-post loan performance, with only a marginally significant and, again, *positive* coefficient observed within originating rating group one.

Table 6 presents results from the ex-post default model described in Equation (3). Consistent with Table 4, we find that larger loans, loans with shorter terms and loans with higher interest rates are more likely to underperform (switch to default) ex-post. Table 6 also shows that borrowers with longer relationships are less likely to default. While collateral is positive and significant in Model (1) (without originating ratings), this variable becomes insignificant once we control for a borrower's ex-ante *stock-of-risk* (Model (2)). Therefore, as with our first ex-post model, we again find no evidence

Table 3: Relationship between ex-ante risk and collateral – logit model marginal effects

	(1)	(2)
Originating Rating 2	0.0963***	0.0939***
	(0.0156)	(0.0153)
Originating Rating 3	0.0799***	0.0798***
	(0.0157)	(0.0156)
Originating Rating 4	0.149***	0.150***
	(0.0156)	(0.0154)
Originating Rating 5	0.163***	0.161***
	(0.0170)	(0.0170)
Originating Rating 6	0.176***	0.167***
	(0.0169)	(0.0171)
SME	0.152***	0.153***
	(0.0106)	(0.0104)
Relationship Length	0.00434***	0.00451***
	(0.000540)	(0.000535)
Term	0.0190***	0.0169***
	(0.00202)	(0.00213)
Interest Rate	-0.0707***	-0.0689***
	(0.00562)	(0.00579)
Log of Balance	0.162***	
	(0.00607)	
Balance Decile 2		0.0522**
		(0.0249)
Balance Decile 3		0.108***
		(0.0251)
Balance Decile 4		0.0923***
		(0.0245)
Balance Decile 5		0.185***
		(0.0241)
Balance Decile 6		0.230***
		(0.0267)
Balance Decile 7		0.293***
		(0.0272)
Balance Decile 8		0.391***
		(0.0264)
Balance Decile 9		0.564***
		(0.0267)
Balance Decile 10		0.649***
		(0.0247)
Sector Dummies	Yes	Yes
Region Dummies	Yes	Yes
N	6607	6607

Notes: The dependent variable is a dummy indicating whether collateral was committed. Standard errors (clustered by borrower) in parentheses. Statistical significance denoted by $^{*}(p < 0.1)$,$^{**}(p < 0.05)$,$^{***}(p < 0.01)$.

that collateral improves loan performance.

From Table 6 it is evident that a borrower's *stock-of-risk* is a strong and significant predictor of ex-post default. For example, compared to the reference group (originating rating one – lowest risk), firms in group four are 8.1 PPs more likely to switch to default while firms in group six are 24 PPs more likely. These effects are large relative to the mean default rate (15 per cent). Similar to the analysis of Table 4, we further attempt to remove stock effects by estimating the model for each rating group

Table 4: Relationship between collateral and ex-post rating deterioration – logit model marginal effects

	(1)	(2)
Secured	0.00471	0.0437***
	(0.0148)	(0.0145)
Originating Rating 2		-0.184***
		(0.0204)
Originating Rating 3		-0.305***
		(0.0201)
Originating Rating 4		-0.317***
		(0.0199)
Originating Rating 5		-0.277***
		(0.0211)
Originating Rating 6		-0.328***
		(0.0199)
SME	0.0312**	0.0136
	(0.0149)	(0.0145)
Relationship Length	0.00106	0.000464
	(0.000675)	(0.000654)
Term	-0.0234***	-0.0263***
	(0.00247)	(0.00240)
Log of Balance	0.0419***	0.0417***
	(0.00749)	(0.00723)
Interest Rate	0.0266***	0.0327***
	(0.00555)	(0.00572)
Sector Dummies	Yes	Yes
Region Dummies	Yes	Yes
Time Dummies	Yes	Yes
N	6607	6607

Notes: The dependent variable is a dummy indicating whether the borrower's internal rating deteriorated post origination. Standard errors (clustered by borrower) in parentheses. Statistical significance denoted by *($p < 0.1$),** ($p < 0.05$),*** ($p < 0.01$).

(Table 7). Again, there are few significant results for the collateral dummy, and where significant, are not of the expected sign – within originating groups one and three, secured loans are *more* likely to switch to default.

For loans in the "SME" segment, we are able to identify whether the borrower posted "inside" or "outside" collateral. Inside collateral includes commercial property, residential property, land and other business assets, while outside collateral includes personal guarantees. To incorporate this added level of granularity, we analyse Hypothesis **H1** using a multinomial logit model with the dependent variable taking one of four values: no collateral (the reference group), outside collateral only, inside collateral only and outside and inside collateral combined. Results from this model are displayed in Table 8 where marginal effects for the latter three categories are displayed. In terms of a borrower's *stock-of-risk*, it appears the results are only significant for the combined collateral category – as originating risk increases, banks tend to demand both inside *and* outside collateral, but neither in isolation. Similar results are observed for loan balance, with a significant positive effect for the combined category only.

Table 5: Relationship between collateral and ex-post rating deterioration, by originating rating groups – logit model marginal effects

	(1)	(2)	(3)	(4)	(5)	(6)
Secured	0.0640*	0.0296	0.0136	-0.00280	0.0460	0.0184
	(0.0354)	(0.0375)	(0.0354)	(0.0335)	(0.0359)	(0.0228)
SME	0.0997***	0.0804**	0.0256	-0.0364	-0.0952***	0.0697**
	(0.0324)	(0.0360)	(0.0347)	(0.0337)	(0.0368)	(0.0324)
Relationship Length	0.00407***	0.00462***	-0.00320*	-0.000787	-0.000572	-0.00459**
	(0.00136)	(0.00147)	(0.00164)	(0.00165)	(0.00173)	(0.00183)
Term	0.0167***	-0.0103*	-0.00738	-0.0310***	-0.0471***	-0.101***
	(0.00495)	(0.00532)	(0.00572)	(0.00691)	(0.00810)	(0.00555)
Log of Balance	-0.0240	0.0194	0.0372**	0.0261	0.0829***	0.0511***
	(0.0155)	(0.0190)	(0.0177)	(0.0168)	(0.0172)	(0.0147)
Interest Rate	0.0332***	0.0386***	0.0516***	0.0166	0.0223	0.0256
	(0.0111)	(0.0121)	(0.0135)	(0.0156)	(0.0141)	(0.0187)
Sector Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Region Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Time Dummies	Yes	Yes	Yes	Yes	Yes	Yes
N	1280	1115	1082	1145	947	1038

Notes: The dependent variable is a dummy indicating whether the borrower's internal rating deteriorated post origination. Models (1) through (6) are seperate regressions for each of the six originating rating groups. Standard errors (clustered by borrower) in parentheses. Statistical significance denoted by $^{*}(p < 0.1)$,$^{**}(p < 0.05)$,$^{***}(p < 0.01)$.

The results suggest that when targeting collateral requirements towards ex-ante riskier and larger loans, it appears that banks require inside and outside collateral together in a bundle than in isolation.

Using this same collateral classification, we also explore the effects of collateral type in our *flow-of-risk* models (Table 9). For the rating deterioration model (models (1) and (2)), we again find no evidence in support of Hypothesis **H2**, with collateralised loans more likely to experience declining performance (significant for inside collateral and the combined category when originating ratings are included). Similarly, for the default model (models (3) and (4)), the combined collateral dummy is also positive (but only when originating ratings are excluded). Overall, therefore, the disaggregation of collateral into inside and outside does not affect our conclusions and we find no evidence that collateral improves loan performance.

We test the robustness of our *flow-of-risk* results in Table A1 (Appendix). In Model (1), we narrow the definition of a rating deterioration so that a loan must move by at least two notches in order to be deemed to have deteriorated. In Model (2) we extend this narrowing to a minimum of three notches. In both cases, the coefficient on collateral is positive and significant, counter to the expectations of Hypothesis **H2**. The SME dummy, term, balance and interest rate variables all retain the sign found in the models of Table 4: SME loans and longer-term loans are less likely, while larger loans and loans with a higher interest rate are more likely to experience a rating deterioration. In models (3) and (4), we test the robustness of the arbitrary two-year post-origination gap to one and three years respectively. The pattern of results is close to unchanged relative to that in models (1) and (2).

Table 6: Relationship between collateral and ex-post default – logit model marginal effects

	(1)	(2)
Secured	0.0253***	0.00323
	(0.00694)	(0.00687)
Originating Rating 2		0.0231**
		(0.00981)
Originating Rating 3		0.0409***
		(0.00999)
Originating Rating 4		0.0755***
		(0.0101)
Originating Rating 5		0.125***
		(0.0124)
Originating Rating 6		0.219***
		(0.0171)
SME	-0.0402***	-0.0188**
	(0.00788)	(0.00761)
Relationship Length	-0.00162***	-0.00138***
	(0.000399)	(0.000405)
Term	-0.0697***	-0.0560***
	(0.00331)	(0.00314)
Log of Balance	0.0415***	0.0382***
	(0.00428)	(0.00383)
Interest Rate	0.0196***	0.0151***
	(0.00268)	(0.00246)
Sector Dummies	Yes	Yes
Region Dummies	Yes	Yes
Time Dummies	Yes	Yes
N	6607	6607

Notes: The dependent variable is a dummy indicating whether the borrower has switched to default post origination. Standard errors (clustered by borrower) in parentheses. Statistical significance denoted by $^{*}(p < 0.1)$,** $(p < 0.05)$,*** $(p < 0.01)$.

Table 7: Relationship between collateral and ex-post default, by originating rating groups – logit model marginal effects

	(1)	(2)	(3)	(4)	(5)	(6)
Secured	0.0200*	0.00109	0.0442***	-0.00290	-0.0293	0.000521
	(0.0107)	(0.0113)	(0.0146)	(0.0163)	(0.0214)	(0.0243)
SME	-0.0178	-0.0360***	-0.0615***	-0.0421**	-0.0503**	0.0991***
	(0.0131)	(0.0128)	(0.0151)	(0.0180)	(0.0231)	(0.0328)
Relationship Length	0.000245	-0.000559	-0.00375***	-0.000928	-0.00182	-0.00375**
	(0.000435)	(0.000527)	(0.00114)	(0.000944)	(0.00123)	(0.00182)
Term	-0.0206**	-0.0452***	-0.0313***	-0.0701***	-0.0808***	-0.0995***
	(0.00984)	(0.00988)	(0.00984)	(0.00850)	(0.00970)	(0.00536)
Log of Balance	0.00605	0.0171***	0.00936	0.0399***	0.0732***	0.0875***
	(0.00413)	(0.00637)	(0.00806)	(0.00755)	(0.0127)	(0.0159)
Interest Rate	0.0106***	0.00591*	0.0205***	0.0111	0.00828	0.0106
	(0.00365)	(0.00328)	(0.00570)	(0.00759)	(0.00756)	(0.0170)
Sector Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Region Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Time Dummies	Yes	Yes	Yes	Yes	Yes	Yes
N	1263	1048	1082	1145	947	1038

Notes: The dependent variable is a dummy indicating whether the borrower has switched to default post origination. Models (1) through (6) are seperate regressions for each of the six originating rating groups. Standard errors (clustered by borrower) in parentheses. Statistical significance denoted by *($p < 0.1$),** ($p < 0.05$),*** ($p < 0.01$).

Table 8: Relationship between ex-ante risk and collateral type – multinomial logit model marginal effects

	Outside Collateral Only		Inside Collateral Only		Outside and Inside Collateral	
	(1)	(2)	(3)	(4)	(5)	
Originating Rating 2	0.0141	0.0129	-0.00955	-0.00797	0.0816***	0.0807***
	(0.0256)	(0.0255)	(0.0225)	(0.0224)	(0.0297)	(0.0297)
Originating Rating 3	0.0125	0.0120	-0.00470	-0.000162	0.0696**	0.0651**
	(0.0255)	(0.0256)	(0.0245)	(0.0248)	(0.0299)	(0.0302)
Originating Rating 4	0.0248	0.0235	-0.0314	-0.0282	0.138***	0.135***
	(0.0255)	(0.0256)	(0.0246)	(0.0248)	(0.0303)	(0.0308)
Originating Rating 5	-0.000593	-0.00151	-0.0450*	-0.0440*	0.148***	0.145***
	(0.0263)	(0.0263)	(0.0259)	(0.0259)	(0.0318)	(0.0323)
Originating Rating 6	-0.0907***	-0.0908***	-0.0196	-0.0238	0.213***	0.213***
	(0.0252)	(0.0254)	(0.0285)	(0.0283)	(0.0359)	(0.0357)
Relationship Length	-0.00410***	-0.00423***	-0.000107	-0.000198	0.00891***	0.00913***
	(0.000877)	(0.000878)	(0.000790)	(0.000784)	(0.000959)	(0.000958)
Term	-0.0101***	-0.0100***	0.00594***	0.00465**	0.00878***	0.00853***
	(0.00269)	(0.00279)	(0.00196)	(0.00199)	(0.00270)	(0.00276)
Interest Rate	0.00000866	0.00100	-0.00687	-0.00510	-0.00721	-0.0103
	(0.00569)	(0.00574)	(0.00684)	(0.00673)	(0.00880)	(0.00863)
Log of Balance	-0.0165**		0.00600		0.0956***	
	(0.00769)		(0.00745)		(0.00935)	
Balance Decile 2		0.0354		-0.00874		0.0328
		(0.0498)		(0.0572)		(0.0704)
Balance Decile 3		0.0263		-0.0569		-0.0149
		(0.0457)		(0.0483)		(0.0651)
Balance Decile 4		-0.00154		-0.0205		0.0746
		(0.0414)		(0.0493)		(0.0630)
Balance Decile 5		0.0803*		0.0263		0.0333
		(0.0426)		(0.0478)		(0.0617)
Balance Decile 6		0.0513		-0.00263		0.118*
		(0.0431)		(0.0497)		(0.0635)
Balance Decile 7		0.0510		0.0131		0.133**
		(0.0429)		(0.0487)		(0.0632)
Balance Decile 8		0.0579		-0.000981		0.179***
		(0.0404)		(0.0460)		(0.0606)
Balance Decile 9		-0.0204		0.0491		0.234***
		(0.0412)		(0.0475)		(0.0619)
Balance Decile 10		-0.0538		0.0179		0.325***
		(0.0405)		(0.0478)		(0.0622)
Sector Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Region Dummies	Yes	Yes	Yes	Yes	Yes	Yes
N	2552	2552	2552	2552	2552	2552

Notes: The categorical dependent variable indicates whether the loan has outside collateral only (Model (1) and (2)), inside collateral only (Model (3) and (4)) and both outside and inside collateral (Model (5) and (6)). Standard errors (clustered by borrower) in parentheses. Statistical significance denoted by $^{*}(p < 0.1)$,** $(p < 0.05)$,*** $(p < 0.01)$.

Table 9: Relationship between collateral and ex-post performance – logit model marginal effects

	Rating Deterioration		Default	
	(1)	(2)	(3)	(4)
Outside Collateral Only	-0.0529	-0.0150	-0.0118	-0.0117
	(0.0334)	(0.0322)	(0.0156)	(0.0169)
Inside Collateral Only	0.0418	0.0860**	0.0328	0.0115
	(0.0372)	(0.0358)	(0.0210)	(0.0199)
Outside and Inside Collateral	0.00165	0.0720**	0.0595***	0.0238
	(0.0320)	(0.0305)	(0.0175)	(0.0167)
Originating Rating 2		-0.202***		0.00250
		(0.0308)		(0.0121)
Originating Rating 3		-0.354***		0.0161
		(0.0315)		(0.0133)
Originating Rating 4		-0.402***		0.0618***
		(0.0311)		(0.0154)
Originating Rating 5		-0.380***		0.119***
		(0.0326)		(0.0181)
Originating Rating 6		-0.406***		0.327***
		(0.0341)		(0.0288)
Relationship Lenght	0.00367***	0.00175*	-0.00165***	-0.000904
	(0.00106)	(0.00104)	(0.000631)	(0.000596)
Term	-0.00924***	-0.0121***	-0.0235***	-0.0171***
	(0.00309)	(0.00302)	(0.00377)	(0.00287)
Log of Balance	0.0284***	0.0297***	0.0434***	0.0329***
	(0.0104)	(0.0102)	(0.00544)	(0.00472)
Interest Rate	0.0237***	0.0271***	0.0226***	0.0157***
	(0.00842)	(0.00819)	(0.00384)	(0.00463)
Sector Dummies	Yes	Yes	Yes	Yes
Region Dummies	Yes	Yes	Yes	Yes
Time Dummies	Yes	Yes	Yes	Yes
N	2552	2552	2552	2552

Notes: The dependent variable in Model (1) and (2) is a dummy indicating whether the borrower's internal rating deteriorated post origination. The dependent variable in Model (3) and (4) is a dummy indicating whether the borrower has switched to default post origination. Standard errors (clustered by borrower) in parentheses. Statistical significance denoted by $^{*}(p < 0.1)$,** $(p < 0.05)$,*** $(p < 0.01)$.

4 Discussion

Our findings can be summarised as confirming that banks are more likely to require collateral from ex-ante riskier borrowers and for larger loans (confirming $H1$), but that collateral does not appear to be successful in its assumed aim of mitigating against ex-post deteriorations in loan performance (rejecting $H2$). We do not believe however that our findings suggest that the bank's application of collateral is irrational from a loss-mitigating perspective.

Rather, we believe that our findings are in fact easily rationalised through the lens of banks' regulatory capital ratios. Consider a bank with a regulatory capital ratio $R_C = \frac{CET1}{RWA}$. The targeting of collateral requirements towards the riskier portion of the loan book can in fact improve R_C both through the numerator (the capital level, $CET1$) and the denominator (Risk-Weighted Assets (RWA)).

A bank's $CET1$ is always healthier when loan loss provisions are lower. Such provisions are mechanically linked to the Expected Loss (EL) on a loan book, which is generally calculated in loan loss forecasting exercises as the product of probability of default, exposure at default and loss given default ($PD \times EAD \times LGD$). Given this identity, it follows that the impact of an increase in the riskiness of loans (PD) or the size of possible losses (loan balance, EAD) on portfolio EL can be mitigated simply by lowering the LGD on the riskiest and largest loans. The simplest and lowest-cost method for lowering LGD on a group of loans is to instigate a policy whereby all such loans must be collateralised, preferably with Loan to Value ratios (LTVs) as low as possible. With such a policy in place, the impact of default events on loan loss provisions is greatly reduced.

The above feature of collateral can act to allow for large expansions in both balance sheet size and riskiness without a commensurate impact on loan loss provisions. The advantages of collateral from a bank's perspective are not, however, limited to the numerator of R_C. The size of the balance sheet for regulatory purposes allows for assets to be risk-weighted, with less risky loans allowing the bank more capital relief via a lower risk weight. Recent public consultation from the Basel Committee on Banking Supervision provides clear insights into the way in which stronger collateralisation can act to reduce risk weights.[8] The Committee has proposed a risk-weighting regime that gives capital relief in the form of lower risk weights to loans that are secured against property. For loans secured against residential property, the risk weighting can be as low as 25 per cent for loans with particularly low LTV. For loans secured against commercial property, low-LTV lending can lead to a reduction in the loan's risk weight from that of the counterparty borrower to 60 per cent, provided the LTV is sufficiently low. Such risk-weighting treatment on the part of regulators again provides a clear incentive to banks: for loans to the riskiest borrowers (high PD) or for the largest amounts (high EAD), a requirement for

[8] Basel Committee on Banking Supervision; Consultative Document; Standards; Revisions to the Standardised Approach for credit risk. Available here

collateral will have the greatest impact in reducing the size of the overall effective balance sheet for regulatory capital purposes. Such decreases in RWA will mechanically lead to improvements in R_C.

These features of collateral, acting to allow banks to issue higher PD and EAD loans without proportionate knock-on impacts for capital ratios, suggest that banks' targeting of collateral at such loans can be easily explained even where there is no evidence that collateral is successful in dissuading higher-risk borrowers from eventual default.

5 Conclusions

The model of Boot et al. (1991) shows that collateral can reduce default risk by motivating bad borrowers to increase effort ex-post. A large literature has subsequently confirmed this hypothesis by showing that higher-risk borrowers are more likely to post collateral. Our approach disaggregates this finding into two separate effects. We describe the theoretical and empirical link between observed risk at origination and collateralisation as an ex-ante *"stock-of-risk"* effect. This effect is likely driven by the bank's desire to alleviate the higher probability of default and expected losses of such observably riskier loans. Second, we consider the improved incentives or reduced moral hazard effects of collateral to be an ex-post *"flow-of-risk"* effect. In this paper, we try to isolate these two separate drivers.

We use the bank's internal ratings at origination as our proxy for the borrower's ex-ante *stock-of-risk*. Similar to many previous studies, we find that the probability of pledging collateral increases with firm risk. This relationship is both robust and economically significant – the probability of pledging collateral for the highest-risk firms is around 18 percentage points higher than the lowest-risk firms. Collateral requirements are also higher for larger loans, longer terms and for borrowers with longer relationships.

We attempt to identify the ex-post performance-improving (moral hazard-reducing) effects of collateral in two ways: first, by tracking changes in a borrower's internal rating through time; and, second, by exploring a borrower's switch to default. In both models, our results are not in line with our hypothesised expectations – securing a loan does not appear to reduce the probability of a rating deterioration or the probability of default. These results are reached after controlling for a firm's ex-ante *stock-of-risk*, either directly in our models, or through separate estimations for each rating group. In fact, where results are statistically significant, we do not find the expected sign – secured loans are *more* likely to under-perform. The literature has generally interpreted results similar to our *stock-of-risk* models as evidence that banks have moral-hazard-reducing effects of collateral in mind when originating risky loans. However, direct tests of whether collateral is successful in this stated aim are extremely rare, and have never been framed in this way before. Our *flow-of-risk* models fill this gap in the literature.

The final question that must be posed is, if collateral is shown to be unsuccessful in its aim of improving ex-post effort and reducing subsequent missed payments, why do banks require collateral of ex-ante observably riskier borrowers? Using a simple bank capital framework, we show that securing ex-ante riskier and larger loans will reduce Expected Loss and Risk Weighted Assets, both of which will improve the bank's capital ratio. Given that ex-ante riskier and larger loans do indeed appear in our models to be most likely to enter default ex-post, it is rational for a bank to require security on these them, even when it cannot be confirmed that collateral is successful in achieving its aim of reducing ex-post defaults.

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Table A1: Robustness checks – Relationship between collateral and ex-post rating deterioration (logit model marginal effects)

	(1)	(2)	(3)	(4)
Secured	0.0437***	0.0337**	0.0406***	0.0448**
	(0.0132)	(0.0132)	(0.0103)	(0.0212)
SME	-0.0381***	-0.0412***	-0.000695	0.00191
	(0.0133)	(0.0128)	(0.0105)	(0.0210)
Relationship Length	0.0000912	0.000338	-0.0000259	0.000467
	(0.000592)	(0.000564)	(0.000459)	(0.000967)
Term	-0.0307***	-0.0214***	-0.0183***	-0.0330***
	(0.00280)	(0.00293)	(0.00163)	(0.00339)
Log of Balance	0.0401***	0.0333***	0.0322***	0.0483***
	(0.00663)	(0.00678)	(0.00501)	(0.0105)
Interest Rate	0.0312***	0.0264***	0.0316***	0.0217***
	(0.00521)	(0.00463)	(0.00456)	(0.00806)
Sector Dummies	Yes	Yes	Yes	Yes
Region Dummies	Yes	Yes	Yes	Yes
Time Dummies	Yes	Yes	Yes	Yes
Originating Rating Dummies	Yes	Yes	Yes	Yes
N	6607	5569	12599	3243

Notes: The dependent variable is a dummy indicating whether the borrower's internal rating deteriorated post origination. In Models (1) and (2), a deterioration is defined as a minimum of two and three places respectively (previously a minimum of one place). In Models (3) and (4), the gap between loan origination and ex-post is one year and three years respectively (previously two years). Standard errors (clustered by borrower) in parentheses. Statistical significance denoted by $^{*}(p < 0.1)$,$^{**}(p < 0.05)$,$^{***}(p < 0.01)$.

Appendix Tables