BANK OF ENGLAND

Staff Working Paper No. 805

Bank funding costs and capital structure

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June 2019

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Abstract

If bail-in is credible, risk premia on bank securities should decrease as funding sources junior to and alongside them in the creditor hierarchy increase. Other things equal, we find that when banks have more equity and less subordinated debt they have lower risk premia on both. When banks have more subordinated and less senior unsecured debt, senior unsecured risk premia are lower. For percentage point changes to an average balance sheet, these reductions would offset about two thirds of the higher cost of equity relative to subordinated debt and one third of the spread between subordinated and senior unsecured debt.

Key words: Funding costs, weighted average cost of capital, capital structure, creditor hierarchy, loss-absorbing capacity, Modigliani–Miller offset, contingent claims analysis.

JEL classification: G21, G32.

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We are especially grateful to Jas Ellis for setting up and steering this project in its initial phases. We thank Bill Francis, Damien Lynch, Kebin Ma, David Miles, Fernando Moreira, Katharine Neiss, Christian Schmidt, Caspar Siegert, Rhiannon Sowerbutts, Matthew Willison, seminar participants at the Bank of England, and conference participants at the 25th Annual Meeting of the German Finance Association, the poster session at the American Economic Association Annual Meeting 2019, and the Royal Economic Society Annual Conference 2019 for helpful comments and suggestions. We also thank Daniel Norris and Philip Massoud for their research assistance. Data sources: S&P Global Market Intelligence, Bloomberg Finance L.P. and OECD. All remaining errors are our own.

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ISSN 1749-9135 (on-line)

1 Introduction

Since the 2007–2008 financial crisis, regulators have required banks to fund themselves with more equity and with debt that can credibly bear losses in resolution. This paper studies the link between banks' funding costs and the proportions of equity capital and different types of debt on their balance sheets. The implications for banks' funding costs of relying more on equity have been studied extensively, whereas the funding cost implications of relying on more loss-absorbing forms of debt have received less attention.[1] To the best of our knowledge, ours is the first paper to study the relationship between the risk premia on banks' equity, subordinated debt and senior unsecured debt and the proportions of these securities on their balance sheets in a unified framework. Doing so allows us to shed light on how sensitive investors in bank securities are to the quantity and composition of banks' loss-absorbing capacity.

On the one hand, switching from a cheaper source of funding, such as senior unsecured debt, to a more expensive one, such as subordinated debt, directly raises a bank's average funding cost because the bank has to pay the higher cost on a larger proportion of its balance sheet. On the other hand, having more junior securities on a bank's balance sheet to absorb losses should reduce the risk premium that the bank's investors demand. The Modigliani–Miller theorem (Modigliani and Miller, 1958) states that, under certain idealised conditions, a firm's weighted average funding cost should be independent of its capital structure because these two effects exactly cancel each other out. This paper contributes to the large literature on the link between banks' solvency and their funding costs (e.g. Babihuga and Spaltro (2014); Aymanns et al. (2016); Dent, Hacioglu Hoke and Panagiotopoulos (2017)), and the extent to which the Modigliani–Miller theorem applies to them (e.g. Miller (1995); King (2009); Kashyap, Stein and Hanson (2010); Baker and Wurgler (2015); Cline (2015); Kisin and Manela (2016); Sundaresan and Wang (2017)). We study the relationship between banks' funding costs and all forms of loss absorbency, including debt as well as equity.

In this paper we show analytically how the effect of changes in a firm's capital structure on its weighted average funding cost can be decomposed into a 'direct' effect and several potential 'Modigliani–Miller offset' terms. We then use contingent claims analysis in the spirit of Black and Cox (1976) to generate four predictions about how risk premia on a bank's securities should respond to changes in its capital structure assuming all else, including the riskiness of the bank's assets, stays fixed. First, the risk premium on a given funding source should not depend on the composition of more senior liabilities. Second, the risk premium on a funding source should fall as that funding source expands at the expense of a more senior one. Third, the risk premium on a funding source should fall

[1] Linn and Stock (2005) study the effect of junior debt issuance by corporations on their senior unsecured debt risk premia. They find that senior unsecured debt risk premia fall if the new junior debt replaces bank debt, which has a higher priority than senior unsecured debt.

as it shrinks and a more junior one expands. Fourth, the risk premium on a funding source should not depend on the composition of more junior ones. These predictions tell us which of our potential Modigliani–Miller offset terms should matter.

We test these predictions using quarterly data on the funding costs and balance sheet characteristics of an unbalanced panel of advanced-economy banks between 2005 and 2017. We run separate panel regressions with the risk premia for equity, junior debt and senior unsecured debt as the dependent variables, each regressed on nested balance sheet ratios and a set of control variables. This allows us to estimate the set of potential Modigliani–Miller offset terms associated with each balance sheet change. Mirroring our theoretical assumption that all else, including asset risk, is equal, we control for other factors that could influence risk premia on bank securities. Our regression specifications include bank and time fixed effects, along with a range of time-varying bank- and country-level characteristics.

Consistent with the first prediction from our contingent claims analysis, we find no statistically significant relationships between the risk premia on a bank's funding sources and the mix of liabilities senior to them. We find that a bank's equity risk premium is not statistically significantly related to either of the relative proportions of junior versus senior unsecured debt, or senior unsecured versus senior secured debt, on its balance sheet. Similarly, we find no statistically significant relationship between a bank's junior debt risk premium and the relative proportions of senior unsecured versus senior secured debt on its balance sheet.

We also find some evidence consistent with the second prediction from our contingent claims analysis, that the risk premium on a funding source should decrease as it funds a greater share of a bank's balance sheet at the expense of the funding source one notch more senior. In our baseline specification, an increase in the amount of equity on a bank's balance sheet by one percentage point of total assets and a corresponding decrease in junior debt is associated with a 24 basis point decrease in the risk premium on the bank's equity. However, we find no statistically significant relationship between the risk premium on a bank's junior debt and the relative proportions of junior and senior unsecured debt on its balance sheet. We also find no statistically significant relationship between a bank's senior unsecured debt risk premium and its relative proportions of senior unsecured and senior secured debt.

Our results are consistent with the third prediction from our contingent claims analysis, that the risk premium on a funding source should decrease as it shrinks and the funding source one notch beneath it in the creditor hierarchy expands by the same amount. In our baseline specification, an increase in equity of one percentage point of total assets and a corresponding decrease in junior debt on a bank's balance sheet is associated with a 154 basis point decrease in the risk premium on the bank's junior debt. We also find that a one percentage point of total assets increase in junior debt at the expense of senior unsecured debt is associated with a 4 basis point decrease in the risk premium on a bank's senior unsecured debt.

Finally, we find no statistically significant relationship between the risk premium on senior unsecured debt and the relative proportions of equity and junior debt on a bank's balance sheet. This is in line with the fourth prediction from our contingent claims analysis, that the risk premium on a funding source should not be affected by the composition of more junior funding sources.

We test the robustness of these baseline results to our choice of specification. In our baseline specification, both our independent and dependent variables enter in levels. In our robustness checks, we also consider level-log, log-level and level-level specifications. Our baseline regressions do not include a lagged dependent variable, so we also consider alternative specifications that do. Our robustness checks also consider specifications with and without our baseline asset-side, liability-side and country-level controls respectively. Combining these different dimensions gives us a total of 64 different specifications. The evidence from these 64 specifications is broadly consistent with our findings from our baseline specification. We also test the robustness of our baseline results to dropping individual firms or individual time periods from our sample, and find very similar results to those using our full sample.

Combining the estimated Modigliani–Miller offset terms from our regressions with balance sheet data for a representative bank allows us to calculate an overall Modigliani–Miller offset for each type of balance sheet change considered. For a typical bank in our sample, with equity, junior and senior unsecured debt at 7.9%, 1.8% and 11.9% of total assets, with funding spreads of 568, 308 and 174 basis points respectively, and facing a 33% corporate tax rate and a risk-free interest rate of 3%, the total Modigliani–Miller offset associated with replacing one percentage point of junior debt with equity on the balance sheet is 64%, of which 18 percentage points is driven by the reduction in the cost of junior debt. Similarly, the Modigliani–Miller offset associated with replacing one percentage point of senior unsecured debt with junior debt on the balance sheet would be 35%.

The rest of this paper is structured as follows. In section 2 we set out formally how changes in a firm's capital structure could affect its overall funding costs. We distinguish between what we call the direct effect of replacing a cheaper source of funding with a more expensive one, and Modigliani–Miller offset terms, which capture the idea that changes in the composition of a firm's balance sheet may affect the riskiness, and therefore the pricing, of its funding sources. In section 3 we set out some contingent claims analysis of the creditor hierarchy and use it to derive four testable implications about the sign of these Modigliani–Miller offset terms. In section 4 we describe the data we use to test these hypotheses along with our baseline empirical specification. Section 5 presents our baseline results. In section 6 we discuss the robustness of these results to different empirical specifications. In section 7 we show how our findings differ across different levels of bank solvency and over time. Section 8 discusses the implications of our results for banks' weighted average cost of capital. Section 9 concludes.

2 The weighted average cost of capital

A firm's weighted average cost of capital (WACC) is the weighted average of what it must pay to fund its assets.[2] For a firm whose total assets A are funded by equity and liabilities listed in ascending order of seniority, with 0 denoting equity, 1 being the most junior liability and N being the most senior, we can define the WACC as:

$$\text{WACC} \equiv \frac{\sum_{i=0}^{N} R_i L_i}{\sum_{i=0}^{N} L_i} = \frac{\sum_{i=0}^{N} R_i L_i}{A},$$

where L_i denotes the total face value of claims of seniority i and R_i denotes the rate of return on those claims.[3]

We are interested in how a firm's WACC depends on the composition of the liabilities side of its balance sheet, holding the size of its balance sheet fixed. We consider the implications of increasing one source of funding m by one percentage point of the balance sheet and reducing another source n by an equivalent amount, leaving the total size of the balance sheet unchanged. We interpret this as a counterfactual thought experiment: what would the WACC be for an otherwise-identical firm that funded itself with one percentage point of total assets more claims of seniority m and one percentage point of total assets fewer claims of seniority n? Letting $\lambda_i \equiv 100 L_i / \sum_{i=0}^{N} L_i$ denote the share of funding source i in percentage points of the balance sheet, and setting $\lambda_n = \tilde{\lambda} - \lambda_m$, where $\tilde{\lambda}$ is an arbitrary constant (so that the interpretation is increasing funding source m and decreasing funding source n by the same amount), we can rewrite the WACC as:

$$\text{WACC} \equiv \sum_{i=0}^{N} R_i \frac{\lambda_i}{100} = R_m \frac{\lambda_m}{100} + R_n \frac{\tilde{\lambda} - \lambda_m}{100} + \sum_{\substack{i=0 \\ i \notin \{m,n\}}}^{N} R_i \frac{\lambda_i}{100}.$$

[2] The word 'capital' in the phrases 'capital structure' and 'weighted average cost of capital' refers to *all* of the liabilities and equity that a firm uses to fund its assets. In this paper we mainly use the term 'funding cost' instead of 'cost of capital' to avoid confusion with the narrower regulatory and accounting definitions of capital. Similarly, we often refer to 'funding sources' rather than 'liabilities' to emphasise that we are considering all types of funding on the balance sheet, including equity.

[3] The cost to a firm of funding its assets through liabilities in creditor class $i \in \{1 \ldots, N\}$ is simply the interest rate on those liabilities. The cost to a firm of funding its assets through equity is the opportunity cost of that equity funding, which is not directly observed. In our empirical work we estimate the cost of equity using a capital asset pricing model (CAPM) approach, under which the required rate of return on an asset depends on the correlation of its value with that of the market portfolio.

Differentiating the WACC with respect to the percentage point share of claims of seniority m, λ_m, yields:

$$\begin{aligned}
\frac{d\text{WACC}}{d\lambda_m}|_{\lambda_n=\tilde{\lambda}-\lambda_m} = & \frac{R_m - R_n}{100} + \left(\frac{dR_m}{d\lambda_m}|_{\lambda_n=\tilde{\lambda}-\lambda_m}\right)\frac{\lambda_m}{100} \\
& + \left(\frac{dR_n}{d\lambda_m}|_{\lambda_n=\tilde{\lambda}-\lambda_m}\right)\frac{\tilde{\lambda}-\lambda_m}{100} \\
& + \sum_{\substack{i=0 \\ i\notin\{m,n\}}}^{N} \left(\frac{dR_i}{d\lambda_m}|_{\lambda_n=\tilde{\lambda}-\lambda_m}\right)\frac{\lambda_i}{100} \\
= & \underbrace{\frac{R_m - R_n}{100}}_{\text{direct effect}} + \sum_{i=0}^{N} \underbrace{\left(\frac{dR_i}{d\lambda_m}|_{\lambda_n=\tilde{\lambda}-\lambda_m}\right)}_{\text{potential sources of M–M offset}} \frac{\lambda_i}{100}.
\end{aligned} \tag{1}$$

This equation allows us to decompose the effect on a firm's WACC into two categories: direct effects and Modigliani–Miller offset terms. The direct effect is that replacing one unit of funding from source n with a unit of funding from source m means paying the funding cost differential $R_m - R_n$ on that marginal unit. The Modigliani–Miller offset terms come from the fact that changing the funding mix can have implications for the cost of the different sources of funding. In the long run, these changes in funding costs would affect all the *infra*marginal units of each funding source.

The intuition for why there should be Modigliani–Miller offsets is that more junior liabilities absorb losses ahead of more senior liabilities. For example, if there is more junior debt on the balance sheet, we would expect the risk premium on senior unsecured debt to be lower because it is less likely to bear losses. However, we would not expect there to be Modigliani–Miller offsets for all combinations of liabilities. In the next section we provide some contingent claims analysis of the creditor hierarchy that yields predictions about which of these potential Modigliani–Miller offset terms should matter.

3 Contingent claims analysis of the creditor hierarchy

Consider a firm with total assets A_t and liabilities with face values $\{L_i\}_{i=1}^{N} > 0$ indexed in ascending order of seniority, with 1 being the most junior and N being the most senior. We assume for simplicity that all of the liabilities mature at the same time. On the maturity date T the firm's assets have a value A_T, which we assume is a random variable whose distribution is independent of the firm's capital structure.[4] The assets are sold and the proceeds A_T are paid out according to the creditor hierarchy. Those in the most senior creditor class, N, are paid first. Proceeds cascade down into the next most senior creditor class, i, if and only if creditors in the class above, $i+1$, have received the full face value of their claims. Shareholders are the residual claimants on the firm and have limited liability: they receive the net asset value of the firm if the value of its assets exceeds its liabilities, but are not obliged to make up the difference if there is a shortfall. Shareholders' residual claim on the firm is equivalent to a 'liability' with a seniority index of zero and face value $L_0 \equiv A_t - \sum_{i=1}^{N} L_i$. At the maturity date T, the per-unit payoff of a liability with seniority j is:

$$V_j \equiv \frac{\max\left(A_T - \sum_{i=j+1}^{N} L_i, 0\right) - \max\left(A_T - \sum_{i=j}^{N} L_i, 0\right)}{L_j} \tag{2}$$

$$= \begin{cases} 1 & \text{if } A_T \geq \sum_{i=j}^{N} L_i, \\ \frac{A_T - \sum_{i=j+1}^{N} L_i}{L_j} & \text{if } \sum_{i=j+1}^{N} L_i \leq A_T \leq \sum_{i=j}^{N} L_i, \\ 0 & \text{if } A_T \leq \sum_{i=j+1}^{N} L_i. \end{cases} \tag{3}$$

The two terms in the numerator of expression (2) correspond to the payoffs of two different European call options on the value of the firm's assets with different strike prices. We can think of investors with seniority j as having bought a call option with a strike price equal to the total face value of liabilities senior to them, and having simultaneously sold a call option whose strike price equals the total face value of liabilities senior to and equal (*pari passu*) with them.[5]

3.1 Testable implications

We are interested in how the value of a liability in creditor class j changes when creditor class m is expanded and the creditor class above, $m+1$, shrinks by the same amount.[6] We set $L_{m+1} = \tilde{L} - L_m$, where $\tilde{L}$ is an arbitrary constant, and calculate the derivative of the payoffs and the intervals in (3) with respect to L_m.

Proposition 1. *A change in the composition of more senior liabilities does not affect the value of*

[4] We discuss the implications of alternative theories in which the firm's capital structure can affect its asset risk in section 3.3 below.

[5] This is a generalisation of the well-known result that equity can be thought of as a European call option on the value of a firm's assets with a strike price equal to the total face value of the firm's liabilities (Black and Scholes, 1973).

[6] This is without loss of generality because we can find the effect of expanding creditor class m at the expense of an arbitrary creditor class n by chaining together the effects of substituting creditor class m for $m+1$, $m+1$ for $m+2$ and so on up to substituting $n-1$ for n.

liabilities in creditor class j:

$$dV_j/dL_m|_{L_{m+1}=\tilde{L}-L_m} = 0, \quad \forall m > j.$$

Proof. None of $\sum_{i=j+1}^{N} L_i$, $\sum_{i=j}^{N} L_i$ or L_j change, so none of the payoffs or intervals in (3) change either. □

Proposition 2. *An increase in* pari passu *liabilities with a corresponding decrease in more senior liabilities increases the value of liabilities in creditor class j:*

$$dV_j/dL_m|_{L_{m+1}=\tilde{L}-L_m} > 0, \quad m = j.$$

Proof. An increase in L_j with a corresponding decrease in L_{j+1} means a decrease in $\sum_{i=j+1}^{N} L_i$ and no change in $\sum_{i=j}^{N} L_i$. The lack of change in $\sum_{i=j}^{N} L_i$ means the number of states of the world in which $A_T \geq \sum_{i=j}^{N} L_i$, and the payoff to creditor class j is 1, is unchanged. Taking the derivative of $(A_T - \sum_{i=j+1}^{N} L_i)/L_j$ with respect to L_j, and recalling that $L_{j+1} = \tilde{L} - L_j$, we have $(\sum_{i=j}^{N} L_i - A_T)/(L_j)^2 > 0$, so payoffs are higher in states of the world in which $\sum_{i=j+1}^{N} L_i < A_T < \sum_{i=j}^{N} L_i$. The decrease in $\sum_{i=j+1}^{N} L_i$ increases the number of states of the world in which $\sum_{i=j+1}^{N} L_i < A_T < \sum_{i=j}^{N} L_i$ and the payoff to creditor class j is $(A_T - \sum_{i=j+1}^{N} L_i)/L_j > 0$, with a corresponding decrease in the number of states in which $A_T \leq \sum_{i=j+1}^{N} L_i$ and the payoff is zero. Payoffs to creditor class j are therefore the same or higher for all realisations of the asset value A_T. □

Proposition 3. *An increase in more junior liabilities with a corresponding decrease in* pari passu *liabilities increases the value of liabilities in creditor class j:*

$$dV_j/dL_m|_{L_{m+1}=\tilde{L}-L_m} > 0, \quad m = j-1.$$

Proof. An increase in $L_{j-1}$with a corresponding decrease in L_j means a decrease in $\sum_{i=j}^{N} L_i$ but no change in $\sum_{i=j+1}^{N} L_i$. The decrease in $\sum_{i=j}^{N} L_i$ increases the number of states of the world in which $A_T \geq \sum_{i=j}^{N} L_i$ and the payoff to creditor class j is 1, with a corresponding decrease in the number of states of the world in which $\sum_{i=j+1}^{N} L_i < A_T < \sum_{i=j}^{N} L_i$ and the payoff is $(A_T - \sum_{i=j+1}^{N} L_i)/L_j < 1$. With no change in $\sum_{i=j+1}^{N} L_i$ and a decrease in L_j, this latter payoff is higher than it was before. Finally, with no change in $\sum_{i=j+1}^{N} L_i$ there is no change in the number of states of the world in which $A_T \leq \sum_{i=j+1}^{N} L_i$ and the payoff to creditor class j is zero. Payoffs to creditor class j are therefore the same or higher for all realisations of the asset value A_T. □

Proposition 4. *A change in the composition of more junior liabilities does not affect the value of liabilities in creditor class j:*

$$dV_j/dL_m|_{L_{m+1}=\tilde{L}-L_m} = 0, \quad m < j-1.$$

Proof. None of $\sum_{i=j+1}^{N} L_i$, $\sum_{i=j}^{N} L_i$ or L_j change, so none of the payoffs or intervals in (3) change either. □

When balance-sheet changes increase the value V_j of a funding source in one or more states of the world, as in Propositions 2 and 3 above, investors should demand a lower risk premium for holding that funding source: $dR_j/dV_j < 0$. Where balance-sheet changes have no effect on the value of a funding source in any state of the world, as in Propositions 1 and 4 above, there should be no effect on that funding source's risk premium. This means we can use our Propositions 1–4 to make predictions about potential Modigliani–Miller offset terms as follows:

$$\frac{dR_j}{d\lambda_m}|_{\lambda_{m+1}=\tilde{\lambda}-\lambda_m} \begin{cases} = 0 & \forall m > j \text{ (Proposition 1)} \\ < 0 & m = j \text{ (Proposition 2)} \\ < 0 & m = j-1 \text{ (Proposition 3)} \\ = 0 & m < j-1 \text{ (Proposition 4).} \end{cases}$$

3.2 Application with equity, junior and senior unsecured debt

In our empirical work we test the propositions above using data on banks' funding costs and balance sheets. Although our contingent claims analysis can be applied to an arbitrary number of different liabilities, we only have data on the costs of three funding sources: equity, junior (subordinated) debt and senior unsecured debt. Fortunately, this is just enough to allow us to test all four of our propositions. We use the capital asset pricing model (CAPM) to infer a bank's cost of equity from the covariance of its share price with a global stock market index. To infer the funding costs of banks' junior and senior unsecured debt, we use the associated credit default swap (CDS) spreads.

We estimate the effect of three different thought experiments on each of these three funding costs, for a total of nine potential Modigliani–Miller offsets. In each thought experiment, we consider an otherwise-identical bank that is funded with one percentage point of total assets more of one type of funding source (e.g. equity) and one percentage point of total assets less of the funding source one step higher in the creditor hierarchy (e.g. junior debt), as in Propositions 1–4 above. We run three separate

Table 1: Potential Modigliani–Miller offset terms and predicted signs from contingent claims analysis

	Effect of having one percentage point of total assets more		
	equity	**junior debt**	**senior unsecured debt**
	and one percentage point of total assets less		
	junior debt	senior unsecured debt	senior secured debt
on the risk premium for			
equity	$\beta_{E,E} < 0$	$\beta_{E,J} = 0$	$\beta_{E,S} = 0$
junior debt	$\beta_{J,E} < 0$	$\beta_{J,J} < 0$	$\beta_{J,S} = 0$
senior unsecured debt	$\beta_{S,E} = 0$	$\beta_{S,J} < 0$	$\beta_{S,S} < 0$

regressions, with the funding costs of equity, junior debt and senior unsecured debt respectively as our dependent variables. In each of these three regressions the key independent variables are the same nested balance sheet variables: equity, equity plus junior debt, and equity plus junior debt plus senior unsecured debt (all expressed in percentage points of total assets). The estimated coefficients from our three regressions give us a 3×3 grid of potential Modigliani–Miller offset terms, as shown in Table 1.

We use $\beta_{j,m}$ to denote the estimated effect on the cost of funding source j of increasing funding source m by one percentage point of total assets and decreasing funding source $m+1$ (i.e. one notch more senior) by the same amount. This corresponds to the potential Modigliani–Miller offset term $dR_j/d\lambda_m|_{\lambda_{m+1}=\tilde{\lambda}-\lambda_m}$ from our differentiated WACC equation (1) in section 2 above. For example, the coefficient $\beta_{S,E}$ gives the estimated effect on the cost of senior unsecured debt of increasing the amount of equity on the balance sheet at the expense of an offsetting reduction in the quantity of junior debt.

Depending on the prevailing law, there may be several different types of liabilities that have priority over senior unsecured debt in the creditor hierarchy, such as senior secured debt, deposits, unpaid wages and tax liabilities. In our empirical specification we consider an increase in senior unsecured debt and a corresponding decrease in senior secured debt. Our reason for doing so is that senior secured debt has an unambiguously higher priority in the creditor hierarchy than senior unsecured debt. In insolvency, holders of senior secured debt have the first claim on the value of the assets against which their debt was secured. If the assets are worth less than the value of their debt claim, they have a senior unsecured claim for the amount of the shortfall. By contrast, depositor preference and other forms of statutory priority differ across jurisdictions and over time.

Proposition 1 tells us that we should expect to see $\beta_{E,J} = \beta_{E,S} = \beta_{J,S} = 0$, that is, the risk premium on equity should not depend on the composition of debt, nor should the risk premium on junior debt depend on whether senior debt is secured or unsecured. From Proposition 2 we should expect to see negative coefficients on the main diagonal of Table 1: $\beta_{E,E} < 0$, $\beta_{J,J} < 0$ and $\beta_{S,S} < 0$. That is, the risk premia on equity, junior debt and senior unsecured debt should each decrease as those securities fund a greater proportion of a bank's balance sheet at the expense of liabilities one notch more senior in the creditor hierarchy. Similarly, from Proposition 3 we should expect to see $\beta_{J,E} < 0$ and $\beta_{S,J} < 0$, meaning the risk premium on junior debt should decrease as equity funds a greater proportion of a bank's balance sheet at the expense of junior debt, and the risk premium on senior unsecured debt should decrease as junior debt increases at the expense of senior unsecured debt. Finally, Proposition 4 tells us that we should not expect $\beta_{S,E}$ to be significantly different from zero, because in our contingent claims analysis of the creditor hierarchy the risk premium on senior unsecured debt should only depend on the *total* of equity and junior debt and not on their *relative* magnitudes.

3.3 Implications of alternative theories in which capital structure affects asset risk

A key assumption of our contingent claims analysis is that the value of a bank's assets is a random variable whose distribution is unaffected by the composition of the bank's funding sources. There are two main channels through which this assumption might be violated in practice: a market influence channel and a cost-of-failure channel. In our empirical work we include several controls for asset risk to mitigate against the possibility that our coefficient estimates are driven by these channels, rather than by the Modigliani–Miller offset channels that we are primarily interested in. Nevertheless, to the extent that we are unable to perfectly control for asset risk, these alternative channels would imply different predictions for the signs of some of our coefficients of interest in Table 1.

The first channel through which a bank's capital structure could affect its asset risk is a market influence channel, whereby investors who are more exposed to losses exert greater pressure on the bank's management to avoid taking excessive risks.[7] If an increase in a more junior funding source, m, at the expense of the funding source one notch more senior in the creditor hierarchy, $m+1$, led to a reduction in the bank's asset risk through such a market influence channel, then we would expect to see a reduction in the risk premium on *all* of a bank's loss-absorbing funding sources, not just on funding sources m and $m+1$ as Propositions 2 and 3 from our contingent claims analysis would predict. If higher equity at the expense of junior debt means shareholders have more 'skin in the game' and induce the bank's management to take less asset risk (e.g. Furlong and Keeley (1989);

[7] Bliss and Flannery (2002) distinguish between two stages of market discipline: market *monitoring* refers to the extent to which investors are aware of risks and charge commensurate risk premia, whereas market *influence* refers to the feedback from investors' risk sensitivity to a firm's decision-making.

Calem and Rob (1999)), then we would expect senior unsecured debt investors to charge a lower risk premium even though the total amount of loss-absorbing capacity junior to them has not changed. We would therefore expect to see $\beta_{S,E} < 0$ in our regressions. Similarly, if junior debtholders exert a stronger disciplining influence on bank risk-taking than senior unsecured debtholders, then the risk premium on equity should also reflect the reduction in asset risk and we should expect to see $\beta_{E,J} < 0$. Finally, if senior unsecured debtholders exert a stronger influence than senior secured debtholders, any reduction in asset risk should also be reflected in the risk premia on equity and junior debt: $\beta_{E,S} < 0$ and $\beta_{J,S} < 0$.[8]

The second main channel through which the value of a bank's assets could depend on its capital structure is bankruptcy costs. Our contingent claims analysis takes the value of the bank's assets as given, and so does not allow for the possibility that failure would lead to a further deterioration in the value of the bank's assets. In practice, the full going-concern value of a firm's assets may not be recoverable if it fails, due to a loss of franchise value and the administrative costs of insolvency or resolution Ang, Chua and McConnell (1982). If investors were concerned about this potential for the failure of a bank to endogenously reduce the value of its assets, then in contrast to our Proposition 4, the composition of more junior funding sources *would* matter in the case of replacing junior debt with equity. If this were the case, then investors in senior unsecured debt should charge a lower risk premium when there is equity rather than junior debt to protect them from losses, because equity can absorb losses while the bank is a going concern and thereby reduce the risk of failure. In terms of our coefficient estimates, this implies that we should expect to find $\beta_{S,E} < 0$ if this cost-of-failure channel is important.

4 Empirical analysis

4.1 Data

We test our four propositions using a panel of advanced-economy banks which we gather from S&P Capital IQ, a commercial database compiled from published accounts. We use data on all firms designated as 'banks' or 'investment banks and brokers' within the database that have total assets greater than £15 billion.[9] We also include a small number of banks not categorised under these

[8] Consistent with a market influence channel for risk-sensitive debt, Danisewicz et al. (2018) find that subordinating non-depositor claims is associated with a reduction in asset risk, and Francis et al. (2019) find that banks reduce their risk exposure after issuing senior debt to other banks.

[9] The Bank of England has said that bail-in is likely to be its resolution strategy for banks with balance sheets larger than an indicative threshold of £15 billion–£25 billion. See 'The Bank of England's approach to resolution', October 2017, available at https://www.bankofengland.co.uk/-/media/boe/files/news/2017/october/the-bank-of-england-approach-to-resolution.

headings within S&P Capital IQ that have been designated as systemically important, either globally or domestically, by regulatory authorities.[10]

We use data on balance sheet structures and measures of funding costs for these banks at a quarterly frequency. In all cases, our measures of funding costs and balance sheet structures correspond to the same legal entity.

Bank balance sheet data: We use data on banks' asset and liability structures at a quarterly frequency over the period 2005 Q1 to 2017 Q4. This covers accounting measures of balance sheet quantities as well as some regulatory measures. All data are converted to pounds sterling (GBP) by the S&P Capital IQ database.

Risk premia on debt funding: We use daily data between 2005 Q2 and 2018 Q1 on 5-year junior and senior unsecured CDS premia from Capital IQ to proxy for marginal funding costs in excess of the risk-free rate on junior and senior unsecured debt and take averages of these risk premia over quarterly intervals. The 5-year maturity is generally considered to be the most liquid maturity for CDS.

Risk premium on equity: We estimate the risk premium on equity (cost of equity in excess of the risk-free rate) using a capital asset pricing model (CAPM) approach. We calculate quarterly CAPM betas for each bank by regressing daily excess stock returns (sourced from S&P Capital IQ) on excess returns for the MSCI World Index (our proxy for the market portfolio, sourced from Bloomberg) over distinct three-month periods between 2005 Q2 and 2017 Q1 and use the yield on US 10-year government bonds to proxy for the risk-free rate (also sourced from Bloomberg). These quarterly CAPM betas are then multiplied through by the annualised average market risk premium over the sample period, which we estimate to be around 5.4%.[11]

We also use time-varying country-level data on sovereign CDS premia and GDP growth at a quarterly frequency from Capital IQ and the OECD respectively.

[10]The lists we consulted include: the Financial Stability Board's list of global systemically important banks as of 21 November 2016, other systemically important institutions notified to the European Banking Authority as of 25 April 2016, US bank holding companies subject to the Federal Reserve's annual Comprehensive Capital Analysis and Review as of March 2014, and banks designated as systemically important by the Swiss National Bank, the Australian Prudential Regulatory Authority, or the Canadian Office of the Superintendent of Financial Institutions. Our final sample includes banks from the following countries: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, the United States and the United Kingdom.

[11]This is somewhat lower than the consensus forecast of financial economists collated by Welch (2000), which places the arithmetic average equity risk premium between 6% and 7%.

4.2 Regression specification

Our aim is to estimate the relationship between changes in a bank's funding structure and the risk premia that investors subsequently charge on its funding sources. By doing so we can gather evidence to test the four hypotheses we have derived analytically. We use our quarterly frequency panel dataset to estimate separate regressions for the average cost of different funding sources against a common set of lagged balance sheet quantities and controls:

$$R^E_{i,t} = \beta_{E,E}\left(\frac{E}{A}\right)_{i,t-1} + \beta_{E,J}\left(\frac{E+J}{A}\right)_{i,t-1} + \beta_{E,S}\left(\frac{E+J+S}{A}\right)_{i,t-1} + \alpha^E_i + \gamma^E_t + \mathbf{Z}'\delta^E + \varepsilon^E_{i,t}$$

$$R^J_{i,t} = \beta_{J,E}\left(\frac{E}{A}\right)_{i,t-1} + \beta_{J,J}\left(\frac{E+J}{A}\right)_{i,t-1} + \beta_{J,S}\left(\frac{E+J+S}{A}\right)_{i,t-1} + \alpha^J_i + \gamma^J_t + \mathbf{Z}'\delta^J + \varepsilon^J_{i,t}$$

$$R^S_{i,t} = \beta_{S,E}\left(\frac{E}{A}\right)_{i,t-1} + \beta_{S,J}\left(\frac{E+J}{A}\right)_{i,t-1} + \beta_{S,S}\left(\frac{E+J+S}{A}\right)_{i,t-1} + \alpha^S_i + \gamma^S_t + \mathbf{Z}'\delta^S + \varepsilon^S_{i,t}$$

Our baseline specification includes the following explanatory variables: lagged balance sheet quantities of equity E, junior debt J and senior unsecured debt S scaled by total assets A and expressed in percentage points; bank-specific fixed effects α_i;[12] quarterly time dummies γ_t; and a set of time-varying bank and country-level controls $\mathbf{Z}$. The *ceteris paribus* assumptions underpinning our contingent claims analysis mean that the resulting hypotheses relate exclusively to Modigliani–Miller offset effects. Our choice of baseline specification is motivated by trying to approximate these conditions as closely as possible so that we can compare the estimated values of our regression coefficients directly against these hypotheses.

We do so in the following ways. We include our variables of interest (the lagged balance sheet ratios) in a nested fashion. This makes explicit that a one percentage point of assets increase of a given funding source is entirely at the expense of the funding source one notch more senior.[13] For example,

[12] We tested fixed effects against random effects in our panel specification. Hausman (1978) test statistic results favoured incorporating fixed effects.

[13] Identical results can be obtained using linear combinations of non-nested ratios. The p-values associated with the t-statistics from our regressions with nested balance sheet ratios are the same as those associated with the F-statistics from an equivalent regression using non-nested ratios.

the coefficient $\beta_{S,E}$ measures the relationship between a one percentage point of assets replacement of junior debt with equity and the average cost of senior unsecured debt over the next quarter. We regress our measures of funding costs on balance sheet information from the previous quarter, because our interest is in the effect of capital structure on funding costs rather than the reverse.

We also include the following variables in $\mathbf{Z}$ as controls:

Liability-side controls

- The lagged senior secured debt-to-assets ratio, entering as $\left(\frac{E+J+S+S^{Sec}}{A}\right)_{i,t-1}$, to enable clearer interpretation of the coefficients on $\left(\frac{E+J+S}{A}\right)_{i,t-1}$. Including this ratio in our regressions means the coefficients $\beta_{E,S}$, $\beta_{J,S}$ and $\beta_{S,S}$ capture the relationship between increases in senior unsecured debt at the expense of senior secured debt and the risk premia on equity, junior and senior unsecured debt respectively.
- The lagged short-term debt-to-assets ratio, as a liquidity risk control. Controlling for liquidity risk is important if increased loss-absorption through subordination in the creditor hierarchy comes at the expense of reduced funding maturity. We control for this as best we can by aggregating together total debt funding with a maturity of one year or less at origination and long-term debt funding with residual maturity of one year or less. Unfortunately our data allows us to either examine creditor maturity or creditor hierarchy but not both simultaneously (e.g. we do not know the proportion of senior unsecured debt that is short term).
- The lagged deposit-to-assets ratio, both as a liquidity risk control and as a control for business model heterogeneity.
- Regulatory adjustments to equity (as a percentage of total assets) to ensure that changes in our balance sheet equity variable reflect changes in regulatory capital.[14]

Asset-side controls

- Lagged total assets, as a control for bank size.[15] This also ensures that our coefficients of interest relate to changes in the *composition* of the liability side of a bank's balance sheet of a *given* size, rather than to balance sheet expansions or contractions funded with a changing mix of securities.

[14] Regulatory measures of balance sheet equity can differ from accounting measures for a number of reasons. Regulators make deductions to the accounting value of equity to account for assets they do not expect to hold their value during periods of financial difficulty for the firm (e.g. goodwill). Specific requirements must also be met for funding to be eligible to count towards regulatory definitions. We would therefore expect regulatory definitions of banks' equity, such as Core Tier 1 and Tier 1 capital, to be more credible measures of available going-concern loss absorbency on the balance sheet than accounting measures.

[15] Babihuga and Spaltro (2014) and Ahmed, Anderson and Zarutskie (2015) find that larger firms tend to face lower borrowing costs.

- The lagged loan-to-assets ratio, as a control for business model heterogeneity.
- Three different lagged controls for asset riskiness: the non-performing assets to total assets ratio, a Sharpe ratio[16] and a regulatory measure of the average risk weight. Asset riskiness could be a particularly important source of endogeneity for our analysis. On the one hand, banks with more capital or risk-sensitive liabilities might choose to take less asset risk due to increased 'skin in the game' or monitoring effects. This reduction in asset risk may drive lower funding spreads and lead us to overestimate any reduction in funding costs that is due to Modigliani–Miller offset effects if we do not control for this. On the other hand, banks with greater asset riskiness could be required to fund themselves with more capital (e.g. through increases in average risk weights mechanically increasing regulatory capital requirements) and also have higher funding spreads. This could lead us to underestimate the Modigliani–Miller effects of changes in the creditor hierarchy if we failed to control for asset risk.

Country-level controls

Changes in macroeconomic conditions also affect banks' capital positions and risk premia on their funding sources, possibly leading us to overestimate Modigliani–Miller effects. So we include:

- Lagged quarter-on-quarter GDP growth, to control for external shocks that could simultaneously drive changes in capitalisation and funding spreads.
- Contemporaneous sovereign CDS premia, as an additional control for external shocks, as well as for the health of the sovereign, which may matter for investors' perceptions of the strength of implicit guarantees.

4.3 Regression sample and stylised facts

As we run separate regressions for each of our three funding cost measures, we make use of three different subsamples of our data. Junior debt CDS spreads are the most limited in terms of data availability. Although data are only available for publicly listed banks at the highest level of consolidation, our cost

[16]A commonly used control for risk in the banking literature is the Z-score, measured as $\frac{R\bar{O}A+\frac{E}{A}}{\sigma_{ROA}}$ (e.g. (Laeven and Levine, 2009; Lepetit and Strobel, 2013)). As we already include the equity-to-assets ratio $\frac{E}{A}$ as a separate explanatory variable in our regressions, we instead include a Sharpe ratio (Sharpe, 1966) measured at the bank level as $\frac{R\bar{O}A}{\sigma_{ROA}}$ as our alternative control for bank asset risk. Means and standard deviations of the return on assets for this measure are calculated over a backward-looking two-year rolling window.

of equity regression has the greatest data availability, particularly over time. Senior unsecured CDS spreads also have good availability and are quoted for non-listed firms as well as subsidiaries that issue debt.

Summary statistics across our variables are shown in Table A1 in the Appendix. These are calculated on the basis of a pooled sample that contains complete data across our explanatory variables of interest and our controls, as well as at least one of our funding cost measures. Our summary statistics therefore capture the diversity of the banks that enter our regressions.

Our three funding cost measures follow the expected rank order on average. The average risk premium on equity is greater than the average junior CDS spread, which in turn is greater than the average senior unsecured CDS spread. The risk premium on equity is estimated as negative for some banks in some time periods. This occurs because we estimate the CAPM betas over short intervals of three months. It is reasonable to expect that from time to time stock returns for some banks will move in the opposite direction to the overall market, driving the estimated negative values. But the average risk premium on equity for each bank is positive over the sample period.

The average risk premium on equity over time ranges between 177 and 996 basis points (Appendix Figure A1) but displays no obvious trend over the sample period. Both the junior and senior unsecured CDS spreads were very low prior to 2008 (Appendix Figures A2 and A3).

The equity-to-assets ratio in our sample is 7.9% on average, with considerable variation around the mean. The histogram (Appendix Figure A4) indicates that the distribution of the equity-to-assets ratio is twin peaked, with a considerable mass of the distribution located between 5% and 6%, and another mass of the distribution located between 10% and 11%. Though they exist in our original dataset, we exclude bank-time observations for insolvent banks (i.e. those with a negative equity-to-assets ratio) from our regressions.

The average junior debt-to-assets ratio in the sample is much lower, at around 1.8%. But the distribution is skewed and ranges between 0% and 25%, with some firms in our sample choosing not to issue any junior debt at all (Appendix Figure A5). The same is true for the senior unsecured debt-to-assets ratio. The mean is higher, at around 11.9%. The ratio ranges between 0% and 68%, reflecting the fact that some firms do not issue this form of debt at all while others are highly reliant on it (Appendix Figure A6). This is true of the senior secured debt-to-assets ratio, the deposits-to-assets ratio and the short-term debt-to-assets ratio as well. So banks in our sample exhibit a considerable range of diversity in their choice of liability structure.

Our asset-side controls also highlight a considerable level of business model diversity across the banks in our sample. Bank size ranges from £15 billion (reflecting our chosen cutoff) to over £2 trillion, with a mean of around £300 billion. The loans-to-assets ratio ranges from as low as 3% to as high as 95%, reflecting the presence of commercial, universal and investment banks in our sample. Asset riskiness, as measured by the non-performing assets ratio and the Sharpe ratio, also exhibit variation both across banks and over time. Average risk weights are the most stable of our risk measures, trending slightly downwards over time but with considerable cross-firm variation.

5 Baseline results

We present our baseline results in Table 2 using the empirical specification set out in section 4.2. This linear specification in levels, making use of nested balance sheet ratios, enables a straightforward interpretation of our coefficients of interest as a one percentage point of balance sheet swap of one funding source for another. The regressions are all estimated using standard errors that are clustered at the bank level.

The three coefficients in the upper-right corner of Table 2 relate to Proposition 1 from our contingent claims analysis of the creditor hierarchy, that the risk premium on a source of funding should not depend on the composition of more senior liabilities. In line with this proposition, we find no statistically significant relationship between a bank's risk premium for equity and the relative proportions of junior debt versus senior unsecured debt, or senior unsecured versus senior secured debt, on its balance sheet. Similarly, we find no statistically significant relationship between a bank's junior CDS spread and its relative proportions of senior unsecured and senior secured debt.

Turning now to the coefficients on the main diagonal in Table 2, we find limited evidence consistent with our Proposition 2, that the risk premium on a source of funding should be lower when there is more loss-absorbing capacity *pari passu* with it and less senior to it. More equity and less junior debt is associated with a 24 basis point reduction in the risk premium for equity (statistically significant at the 5% level). More junior debt and less senior unsecured debt is associated with a 5 basis points lower junior CDS spread, but this is not statistically significant. More senior unsecured debt and less senior secured debt is associated with a 0.4 basis points lower CDS spread on senior unsecured debt, which is also statistically insignificant.

Consistent with Proposition 3, that the risk premium on a funding source should be lower when there is more loss-absorbing capacity junior to it and less *pari passu* with it, we find that one percentage point of total assets more junior debt and less senior unsecured debt is associated with a 4 basis points lower senior unsecured CDS spread (statistically significant at the 10% level). We also find that one percentage point of total assets more equity and less junior debt is associated with a 154 basis point reduction in the junior CDS spread (statistically significant at the 1% level).

Table 2: Estimated Modigliani–Miller offset coefficients from baseline specification

	Effect of having one percentage point of total assets more		
	equity	**junior debt**	**senior unsecured debt**
	and one percentage point of total assets less		
	junior debt	senior unsecured debt	senior secured debt
on the risk premium for			
equity	-24.0**	-3.6	1.3
	(0.030)	(0.499)	(0.404)
junior debt	-153.6***	-5.2	0.0
	(0.001)	(0.472)	(1.000)
senior unsecured debt	-7.8	-4.4*	-0.4
	(0.642)	(0.051)	(0.796)

Finally, in line with Proposition 4, that the risk premium on a funding source should not depend on the composition of liabilities junior to it, we find no statistically significant relationship between a bank's senior unsecured CDS spread and the relative proportions of equity and junior debt on its balance sheet.

As discussed above, the predictions of our contingent claims analysis are derived under the assumption that a bank's asset risk is unaffected by changes in its capital structure. If our inclusion of bank fixed effects and time-varying measures of asset risk did not adequately control for banks' true asset risk, then the market influence and cost-of-failure channels discussed in section 3.3 above would affect our coefficients of interest. We cannot definitively rule out the possibility that our results are driven in part by these alternative channels. However, if the cost-of-failure channel were important, we would expect to see a statistically significant negative relationship between the risk premium on a bank's senior unsecured debt and its relative proportions of equity and junior debt, which we do not. Similarly, if the market influence channel were important then we would expect to find statistically significant negative relationships between increases in loss-absorbing capacity and the risk premia on *all* funding sources, whereas in fact we do not find statistically significant relationships for coefficients where our contingent claims analysis would predict no relationship.

6 Robustness

We test the robustness of our baseline results across a number of different dimensions. In our baseline regressions, our dependent variables and our key independent variables are both in levels. We test the robustness of our results to alternative specifications in which either the dependent variables, or the key independent variables, or both, are entered in log form. In our robustness checks we also include specifications with lagged dependent variables, which are not included in our baseline regressions. Finally, we include specifications that omit one or more of the following sets of controls that are included in our baseline regressions: liability-side controls, asset-side controls and country-level controls. Combining these different dimensions – dependent variables in levels or logs, key independent variables in levels or logs, lagged dependent variables omitted or included, liability-side controls included or omitted, asset-side controls included or omitted, and country-level controls included or omitted – yields $2^6 = 64$ different specifications. Table 3 summarises the signs of our nine key coefficients of interest under these 64 different specifications, and also shows the robustness of statistical inference on the resulting coefficients to clustering at the firm, country and quarter levels respectively.

Where our baseline specification finds no statistically significant Modigliani–Miller offset, we find no statistically significant effects that are robust across the 64 different specifications. As in our baseline specification, we do not find robust statistically significant relationships between the risk premia on a bank's funding sources and the composition of more senior liabilities. This is consistent with the first prediction of our contingent claims analysis. Consistent with the fourth prediction of our contingent claims analysis, we do not find a robust statistically significant relationship between a bank's senior unsecured debt risk premium and the relative proportions of equity and junior debt on its balance sheet.

Our most robust results are for the coefficients $\beta_{E,E}$ and $\beta_{J,E}$, showing how the risk premia on equity and junior debt respectively relate to the proportion of equity relative to junior debt on a bank's balance sheet. Both of these coefficients are negative and statistically significant at the 10% level in the majority of the specifications we tested. This suggests that banks benefit from lower risk premia on their equity and junior debt when they have more equity and less junior debt on their balance sheets. The coefficient $\beta_{S,J}$, showing the relationship between the risk premium on senior unsecured debt and the proportion of junior debt relative to senior unsecured debt, has the expected negative sign in all 64 different specifications. Around half of these 64 coefficient estimates are statistically significant at the 10% level when clustering at the firm or quarter levels, but only 9 out of the 64 are statistically significant when clustering at the country level. The coefficient showing the relationship between the proportion of junior relative to senior unsecured debt and the risk premium on junior debt, $\beta_{J,J}$, is estimated with the expected negative sign in 61 out of the 64 specifications, and is statistically significant at the 10% level in specifications where the balance sheet ratios are measured in logs.

Table 3: Robustness of results under alternative specifications

Notes: This table summarises the estimates of our nine coefficients of interest under 64 different specifications. For each of the nine coefficients, the first row shows how many of the 64 point estimates for that coefficient were negative or positive, and the subsequent three rows show how many of those point estimates are statistically significant at the 10% level, with clustering at the firm, country and quarter levels respectively.

		Effect of having one percentage point of total assets more					
		equity		**junior debt**		**senior unsecured debt**	
		and one percentage point of total assets less					
		junior debt		**senior unsecured debt**		**senior secured debt**	
on the risk premium for...		<0	>0	<0	>0	<0	>0
equity							
Point estimates		64	0	33	31	8	56
$p < 10\%$, clustered by:	firm	38	0	0	0	0	0
	country	45	0	16	4	0	0
	quarter	37	0	0	0	0	0
junior debt							
Point estimates		64	0	61	3	27	37
$p < 10\%$, clustered by:	firm	44	0	14	0	0	0
	country	39	0	24	0	0	0
	quarter	39	0	12	0	0	0
senior unsecured debt							
Point estimates		44	20	64	0	42	22
$p < 10\%$, clustered by:	firm	6	0	37	0	0	0
	country	4	0	9	0	0	0
	quarter	5	0	28	0	6	1

In addition to checking our choice of specification, we also check whether the results of our baseline specification are robust to dropping individual time periods or individual firms. We do not find systematic differences from our baseline results when carrying out these checks (see Figures A7 and A8 in the Appendix).

7 Further considerations

7.1 Below- versus above-median Tier 1 capital

One potential source of non-linearity in the relationships we are trying to estimate is that the effects could be markedly different for thinly capitalised relative to well-capitalised banks. Dent, Hacioglu Hoke and Panagiotopoulos (2017) find that a one percentage point reduction in a bank's market-based leverage ratio (MBLR) is associated with a 29 basis point increase in the CDS premium on its senior unsecured debt when the MBLR is below 2.4%, compared with just a 6 basis point increase when the MBLR is above 2.4%. We examine the potential for non-linearity by interacting our coefficients of interest in the baseline specification with a dummy variable set equal to zero if the bank's realised Tier 1 capital-to-assets ratio in a given time period is less than the sample median (6.0%), and one if greater. The estimated overall effects are presented in Tables 4 and 5, and the complete regression results are available in Table A3 in the Appendix.

Table 4: Estimated Modigliani–Miller offset coefficients with below-median Tier 1 capital

	Effect of having one percentage point of total assets more:		
	equity	**junior debt**	**senior unsecured debt**
	and one percentage point of total assets less:		
	junior debt	senior unsecured debt	senior secured debt
on the risk premium for:			
equity	-44.9**	3.4	-0.1
	(0.014)	(0.565)	(0.963)
junior debt	-184.3***	-4.5	0.2
	(0.002)	(0.565)	(0.962)
senior unsecured debt	-7.2	-3.9	-1.6
	(0.750)	(0.135)	(0.359)

Table 5: Estimated Modigliani–Miller offset coefficients with above-median Tier 1 capital

	Effect of having one percentage point of total assets more:		
	equity	**junior debt**	**senior unsecured debt**
	and one percentage point of total assets less:		
	junior debt	senior unsecured debt	senior secured debt
on the risk premium for:			
equity	-15.5	-13.0	2.5
	(0.266)	(0.153)	(0.162)
junior debt	-143.4***	-2.4	0.1
	(0.004)	(0.847)	(0.987)
senior unsecured debt	-1.8	-3.0	1.3
	(0.908)	(0.471)	(0.341)

As can be seen from Tables 4 and 5, we find that the risk premia on both equity and junior debt are more sensitive to a bank's solvency when its Tier 1 capital ratio is below the median. For banks with Tier 1 capital ratios above the median, we find no statistically significant reduction in the risk premium on equity associated with increasing equity and reducing junior debt on their balance sheets.

7.2 Pre- versus post-crisis reforms

Our sample period from 2005 to 2017 includes the global financial crisis and the euro area sovereign debt crisis. In the aftermath of these crises, policymakers have introduced reforms to bank capital regulation and resolution frameworks aimed at preventing future crises and ending the 'too big to fail' problem. To the extent that these reforms have reduced implicit subsidies for bank debt by reducing the probability of government bailouts, we would expect risk premia on bank debt to have increased. We would also expect risk premia on bank debt to have become more sensitive to the amount and type of loss-absorbing capacity on banks' balance sheets. By contrast, since bank equity (unlike bank debt) absorbed losses even during the crisis, we would not expect to see similar changes in the relationship between banks' equity risk premia and their capital structures.

About half of the bank-time observations in our regression sample are from 2014 onwards. By this time the acute phase of the sovereign debt crisis was over and the euro area had returned to positive GDP growth. Although the post-crisis reforms to bank capital and resolution were not yet complete in 2014, their broad outline – including the principle that bank debt would be 'bailed in' instead of bailed out – was clear. The Dodd–Frank Wall Street Reform and Consumer Protection Act had been passed into US law in July 2010. The Financial Stability Board had released the first version of its Key Attributes of Effective Resolution Regimes for Financial Institutions in October 2011, including a bail-in power. By December 2013, the European Council and European Parliament had agreed on a draft of the EU Bank Recovery and Resolution Directive, and the Financial Services (Banking Reform) Act had equipped the UK resolution regime with a bail-in power.

Table 6: Estimated Modigliani–Miller offset coefficients pre-2014

	Effect of having one percentage point of total assets more:		
	equity	**junior debt**	**senior unsecured debt**
	and one percentage point of total assets less:		
	junior debt	senior unsecured debt	senior secured debt
on the risk premium for:			
equity	-31.4***	0.5	0.6
	(0.003)	(0.937)	(0.667)
junior debt	-168.3***	-2.9	0.1
	(0.003)	(0.664)	(0.972)
senior unsecured debt	-7.5	-3.5*	-0.4
	(0.665)	(0.089)	(0.799)

Table 7: Estimated Modigliani–Miller offset coefficients 2014 onwards

	Effect of having one percentage point of total assets more:		
	equity	**junior debt**	**senior unsecured debt**
	and one percentage point of total assets less:		
	junior debt	senior unsecured debt	senior secured debt
on the risk premium for:			
equity	-2.5	-5.1	-0.4
	(0.869)	(0.624)	(0.816)
junior debt	-134.7***	-23.9	4.6
	(0.004)	(0.477)	(0.495)
senior unsecured debt	4.4	-17.2**	-0.5
	(0.783)	(0.032)	(0.803)

Tables 6 and 7 show that when we interact a 2014-onwards dummy with the coefficients of interest in our regression specification, we find that the risk premium on banks' equity has become less sensitive to their solvency (full regression results are available in Table A4 in the Appendix). The risk premium on junior debt also appears to be somewhat less sensitive to banks' solvency from 2014 onwards, but the coefficient is still both economically and statistically significant. For equity and junior debt, we find no evidence therefore that post-crisis reforms have increased investors' sensitivity to banks' solvency. Our findings would be more consistent with the idea that investors in bank equity and junior debt pay closer attention to banks' solvency in crisis times. On the other hand, we do find that from 2014 onwards investors in senior unsecured debt are more sensitive to the relative quantities of junior and senior unsecured debt on banks' balance sheets. This would be consistent with senior unsecured debt having become more risk-sensitive since the introduction of the post-crisis reforms.

8 Implications for the weighted average cost of capital

By mapping the logic set out in section 2 to our empirical approach, we can calculate the WACC implications for each of our three balance sheet thought experiments in the following manner:

$$\begin{aligned}
\frac{E}{A}\uparrow 1\text{pp}, \frac{J}{A}\downarrow 1\text{pp}: \quad \triangle\text{WACC} &= \underbrace{\frac{1}{100}\left(R^E-(1-\tau)R^J\right)}_{\text{direct effect}}+ \\
&\quad \underbrace{\underbrace{\triangle R^E}_{\beta_{E,E}}\left(\frac{E}{A}+1\%\right)+(1-\tau)\underbrace{\triangle R^J}_{\beta_{J,E}}\left(\frac{J}{A}-1\%\right)+(1-\tau)\underbrace{\triangle R^S}_{\beta_{S,E}}\left(\frac{S}{A}\right)}_{\text{M–M offsets}} \\
\frac{J}{A}\uparrow 1\text{pp}, \frac{S}{A}\downarrow 1\text{pp}: \quad \triangle\text{WACC} &= \underbrace{\frac{1}{100}(1-\tau)\left(R^J-R^S\right)}_{\text{direct effect}}+ \\
&\quad \underbrace{\underbrace{\triangle R^E}_{\beta_{E,J}}\left(\frac{E}{A}\right)+(1-\tau)\underbrace{\triangle R^J}_{\beta_{J,J}}\left(\frac{J}{A}+1\%\right)+(1-\tau)\underbrace{\triangle R^S}_{\beta_{S,J}}\left(\frac{S}{A}-1\%\right)}_{\text{M–M offsets}} \\
\frac{S}{A}\uparrow 1\text{pp}, \frac{S^{Sec}}{A}\downarrow 1\text{pp}: \quad \triangle\text{WACC} &= \underbrace{\frac{1}{100}(1-\tau)\left(R^S-R_f\right)}_{\text{direct effect}}+ \\
&\quad \underbrace{\underbrace{\triangle R^E}_{\beta_{E,S}}\left(\frac{E}{A}\right)+(1-\tau)\underbrace{\triangle R^J}_{\beta_{J,S}}\left(\frac{J}{A}\right)+(1-\tau)\underbrace{\triangle R^S}_{\beta_{S,S}}\left(\frac{S}{A}+1\%\right)}_{\text{M–M offsets}}
\end{aligned}$$

Firms are able to service the risk premia that investors demand for holding debt out of their pre-tax rather than post-tax income. We therefore account for the differential in tax treatment between equity and debt funding by scaling the risk premia for junior debt, R^J, and for senior unsecured debt, R^S, using the average corporate tax rate τ in our sample (33%) to place these on an even post-tax footing with equity. The offset terms that we estimate for changes in investors' risk premia for debt must also be scaled down accordingly, as these are also worth less to the bank in post-tax terms.

Table 8 presents the WACC implications for each of the three thought experiments. The effects are calculated using the average values of funding costs and balance sheet quantities in our sample as per Table A1 in the Appendix.[17] We assume that all funding sources other than equity, junior debt and senior unsecured debt are remunerated at the average risk-free rate R_f over our sample period of 3%. We do not factor in Modigliani–Miller offset coefficients that are not statistically significant in our baseline regression.[18] Finally, we calculate the combined size of the offsets for each thought experiment as a percentage of the direct effect. If all of the conditions of the Modigliani–Miller theorem applied, we would expect the combined offsets for each thought experiment to equal 100% of the direct effect. Market frictions, not least the differential tax treatment of equity and debt, would lead us to expect offsets that are considerably lower.

Table 8: WACC effects of percentage point balance sheet changes in capital structure

Thought experiment	$\frac{E}{A} \uparrow 1\text{pp}, \frac{J}{A} \downarrow 1\text{pp}$	$\frac{J}{A} \uparrow 1\text{pp}, \frac{S}{A} \downarrow 1\text{pp}$	$\frac{S}{A} \uparrow 1\text{pp}, \frac{S^{Sec}}{A} \downarrow 1\text{pp}$
Direct effect	4.61	0.90	1.16
$\triangle R^E \left(\frac{E+\triangle E}{A}\right)$	-2.14	0	0
$(1-\tau)\triangle R^J \left(\frac{J+\triangle J}{A}\right)$	-0.82	0	0
$(1-\tau)\triangle R^S \left(\frac{S+\triangle S}{A}\right)$	0	-0.32	0
Overall change in WACC	1.65	0.58	1.16
M–M offset %	**64%**	**35%**	**0%**

Of the three thought experiments, increasing equity at the expense of junior debt has by far the largest direct effect on the weighted average funding cost. The average cost of equity is 260 basis points higher than that of junior debt, and the latter benefits from a 33% tax shield. Factoring in a risk-free rate of 300 basis points, the direct cost of increasing equity by one percentage point at the

[17] It is important to note that these estimates of the WACC implications are sensitive to both the initial funding structure that we use and the magnitude of the balance sheet change that we consider, and so would be materially different if we deviated from the averages.

[18] We show in section 6 that the coefficients we do include here are robust across different specifications.

expense of junior debt amounts to 4.61 basis points. This increase in cost is reduced somewhat through partially offsetting reductions in the costs of equity and junior debt. Taken together, this results in an overall offset of around 64% of the direct cost, of which 18 percentage points is accounted for by the reduction in the cost of junior debt. Increasing junior debt at the expense of senior unsecured debt generates the smallest direct cost of the three experiments, as both of these funding sources benefit from the 33% tax shield on debt and the average spread between them is 134 basis points, yielding a direct cost of just 0.90 basis points. The reduction in the risk premium on senior unsecured debt offsets 35% of this direct cost. Finally, increasing senior unsecured debt at the expense of senior secured debt results in no statistically significant offset.

The level of the risk-free rate matters for the size of the direct cost of increasing equity at the expense of junior debt. This is because the tax shield applies to the risk-free portion of banks' funding costs as well as to the risk premium. Relative to our baseline risk-free rate of 3%, a higher risk-free rate of 5% would increase the direct cost of increasing equity at the expense of junior debt to 5.27 basis points, whereas the offsets in Table 8 would be unchanged, meaning a smaller percentage offset of 56%. If instead the risk-free rate were 0%, the direct cost of higher equity would fall to 3.62 basis points and the overall offset percentage would rise to 82%.

To gain a rough sense of the importance of differing tax treatment for the size of the combined offset, we re-estimate the WACC implications of the three thought experiments without scaling our risk premia on debt or their offsets in Table 9. This has two effects. First, it reduces the estimated direct cost of increasing equity at the expense of junior debt, and increases the direct costs of the other two thought experiments. However, it also allows for larger offsets to the risk premia for junior and senior unsecured debt, which results in a substantially higher estimated offset for increasing equity and reducing junior debt by the same amount (129% when tax implications are neglected, versus 64% when they are taken into account). However, the Modigliani–Miller offset percentages for thought experiments involving replacing one kind of debt with another are unchanged by neglecting the differing tax treatments of debt and equity.

Table 9: WACC effects of percentage point balance sheet changes in liability structure (assuming no difference in tax treatment)

Thought experiment	$\frac{E}{A}\uparrow$ 1pp, $\frac{J}{A}\downarrow$ 1pp	$\frac{J}{A}\uparrow$ 1pp, $\frac{S}{A}\downarrow$ 1pp	$\frac{S}{A}\uparrow$ 1pp, $\frac{S^{Sec}}{A}\downarrow$ 1pp
Direct effect	2.60	1.34	1.74
$\triangle R^E\left(\frac{E+\triangle E}{A}\right)$	-2.14	0	0
$\triangle R^J\left(\frac{J+\triangle J}{A}\right)$	-1.23	0	0
$\triangle R^S\left(\frac{S+\triangle S}{A}\right)$	0	-0.48	0
Overall change in WACC	-0.76	0.87	1.74
M–M offset %	**129%**	**35%**	**0%**

9 Conclusion

Funding sources that have a lower position in the creditor hierarchy, such as equity and junior debt, should attract a higher risk premium than more senior liabilities because they are at a greater risk of bearing losses. However, the presence of these funding sources on a bank's balance sheet should make funding sources *pari passu* or senior to them less risky and thereby reduce the risk premium that their investors demand. Using data from 2005 to 2017, we have found robust evidence that the risk premia on equity and junior debt are lower when banks have more equity and less junior debt on their balance sheets; and that the risk premium on senior unsecured debt is lower when banks have more junior debt and less senior unsecured debt.

The methodology we adopt in this paper differs from that of several past studies of the Modigliani–Miller offset associated with higher bank equity. Since we are interested in the loss-absorbing properties of junior and senior unsecured debt as well as equity, we include nested balance sheet ratios as independent variables in our regressions. By doing so, we are able to consider the effect on funding costs of increasing equity at the expense of junior debt in particular, rather than at the expense of all liabilities on the balance sheet. Our results suggest that the effect of higher equity capital on banks' funding costs depends on which other funding sources it replaces. Moreover, we allow the cost of debt as well as the cost of equity to vary with banks' capital structures, whereas several previous studies have assumed that all bank debt is risk-insensitive, and focused on the relationship between bank leverage and the risk premium on equity alone. Our results suggest that reductions in the cost of junior debt are an important and robust source of Modigliani–Miller offset, accounting for 18 percentage points in our baseline specification. The overall Modigliani–Miller offset of 64% that we find for replacing junior debt with equity is towards the upper end of the range of past estimates for reducing leverage, which is between about 40% and 70% (European Central Bank, 2011; Junge and Kugler, 2013; Miles, Yang and Marcheggiano, 2013; Brooke et al., 2015; Cline, 2015; Toader, 2015; Clark, Jones and Malmquist, 2018; Junge and Kugler, 2018).

One of our main findings is that more junior debt and less senior unsecured debt on a bank's balance sheet is associated with a lower risk premium on its senior unsecured debt. Our Modigliani–Miller offset estimate of 35% for replacing senior unsecured debt with junior debt suggests that this could be a relatively cost-effective way for banks to increase their loss-absorbing capacity.

Since the 2007–2008 financial crisis there have been several attempts by regulators and academics to determine the optimal level of bank capital requirements (Basel Committee on Banking Supervision, 2010; Macroeconomic Assessment Group, 2010; Admati et al., 2013; Miles, Yang and Marcheggiano, 2013; Brooke et al., 2015; Cline, 2016; Firestone, Lorenc and Ranish, 2017; Barth and Miller, 2018). Higher capital requirements should reduce the probability and cost of banking crises, but they may increase banks' funding costs and thereby reduce the supply of credit to the real economy.

Another focus of the regulatory response to the crisis has been the development of resolution regimes designed to minimise the cost of bank failures. Systemically important banks that would need to be recapitalised in resolution will now be subject to minimum requirements on their total loss-absorbing capacity ('TLAC'). This is comprised of regulatory capital and debt that can credibly be written down or converted into equity ('bailed in').[19] To the extent that TLAC-eligible debt imposes market discipline on banks and facilitates their effective resolution, it can act as a substitute for equity capital in reducing the probability and cost of banking crises. For example, the Bank of England's Financial Policy Committee judged that effective resolution arrangements would reduce the optimal capital requirement by about 5 percentage points of risk-weighted assets (Bank of England, 2015).

We would expect the funding costs of loss-absorbing debt to be lower than those of equity but higher than those of liabilities such as deposits that cannot credibly absorb losses. Some previous studies of optimal capital requirements have assumed that all bank debt is risk-insensitive. The presence of risk-sensitive bank debt implies that we should also consider the effect of higher equity on the cost of that debt when calculating the effect on banks' funding costs. Moreover, this implies that TLAC requirements will also have implications for banks' overall funding costs that policymakers should consider when choosing the optimal combination of equity and loss-absorbing debt requirements.

[19] Although the Financial Stability Board's TLAC standard only applies to globally systemically important banks (G-SIBs), the debt of other banks is also subject to bail-in. In the European Union, all banks are required to meet a minimum requirement on own funds and eligibile liabilities ('MREL'), which is similar in spirit to the FSB TLAC requirement.

There are some important caveats to bear in mind when interpreting our results. First, as discussed above, the overall Modigliani–Miller offset percentages are sensitive to the starting balance sheet composition, the size of the change considered, the risk-free interest rate and the corporate tax rate. Second, our data comes from published balance sheets rather than regulatory returns, and our measures of equity, junior debt and senior unsecured debt do not map neatly onto regulatory definitions. Third, we study the relationship between banks' funding costs and their *actual* capital structures rather than the regulatory requirements that apply to them. Changes in banks' capital structures that are attributable to changes in regulatory requirements may have different implications for their funding costs than changes made for other reasons. Since banks typically maintain voluntary 'management' buffers above their regulatory requirements, there may not be a one-for-one relationship between changes in regulatory requirements and changes in resources on banks' balance sheets, although Bridges et al. (2014) and de-Ramon, Francis and Harris (2016) find evidence consistent with changes in requirements passing through fully to banks' capital resources in the long run.

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Appendix

Figure A1: Variation in the risk premium for equity over time

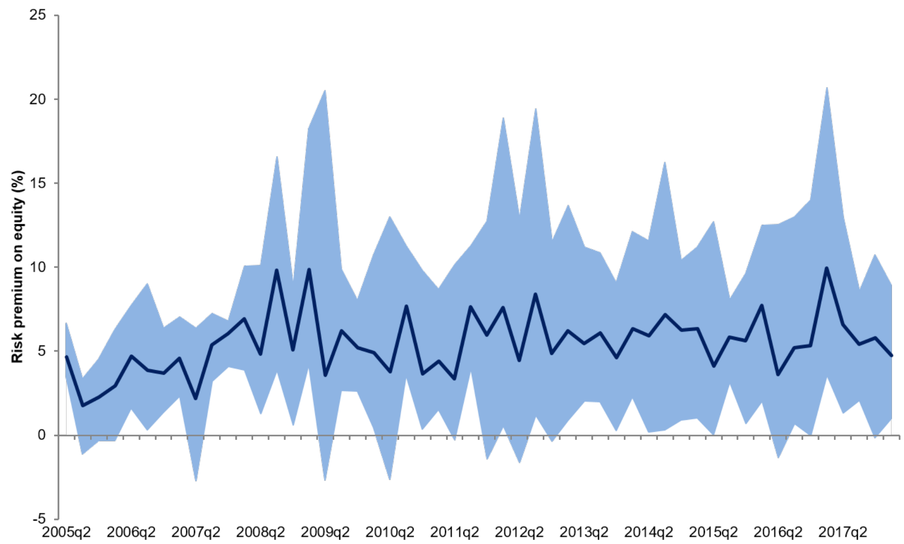


Figure A2: Variation in the junior CDS spread over time

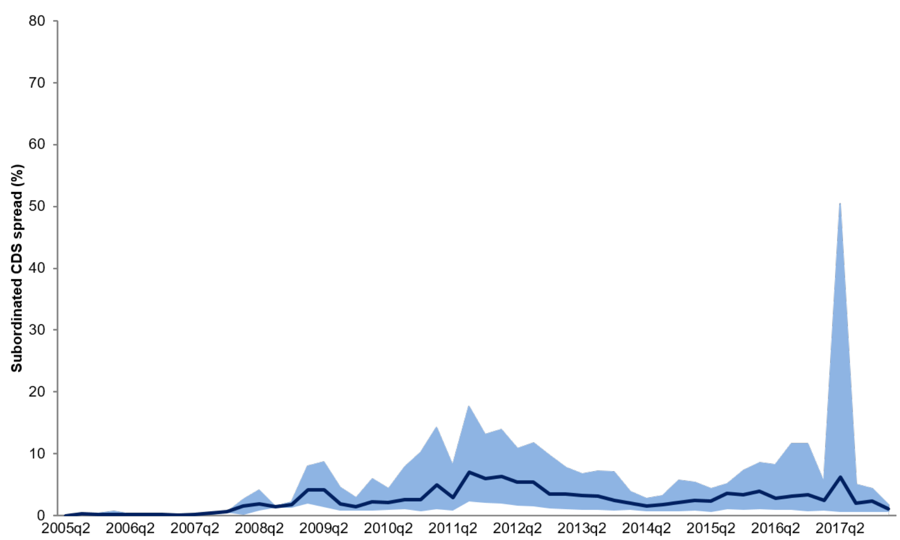


Figure A3: Variation in the senior unsecured CDS spread over time

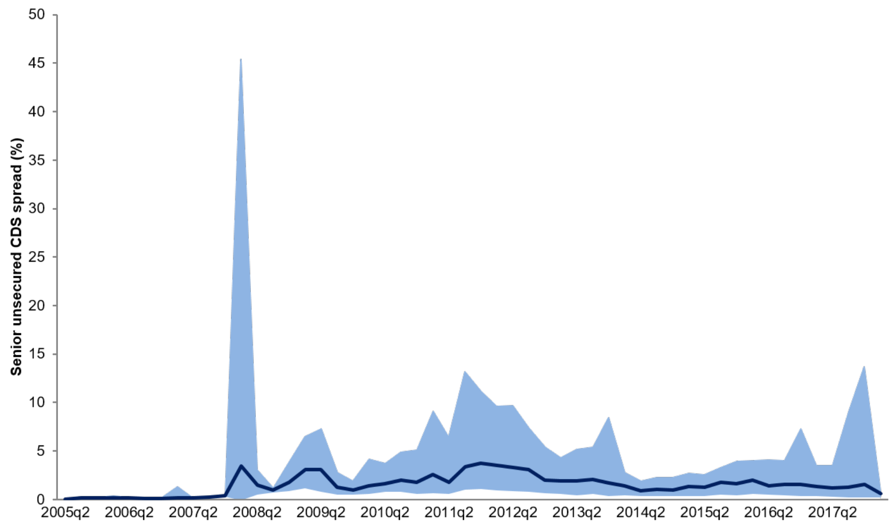


Figure A4: Distribution of equity-to-assets ratio

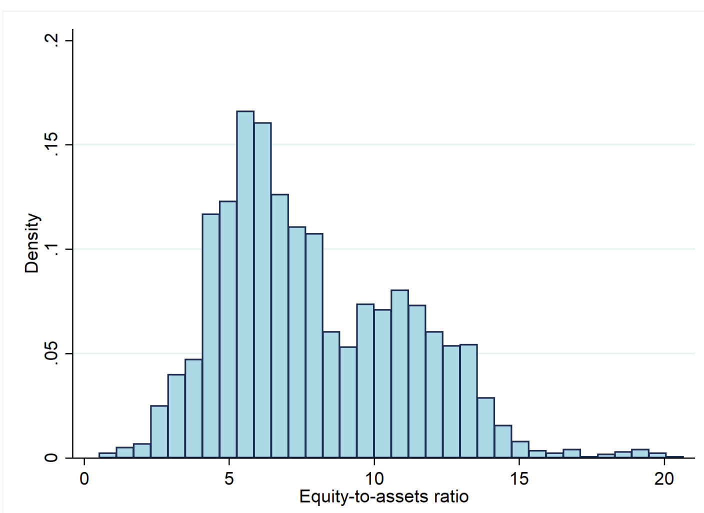


Figure A5: Distribution of junior debt-to-assets ratio

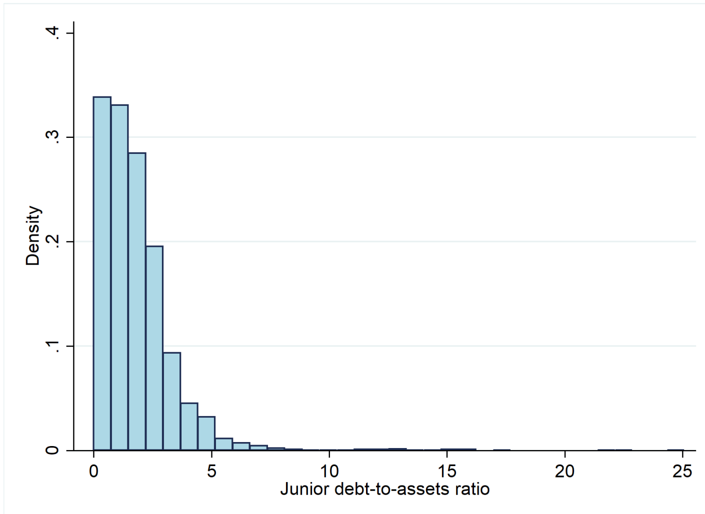


Figure A6: Distribution of senior unsecured debt-to-assets ratio

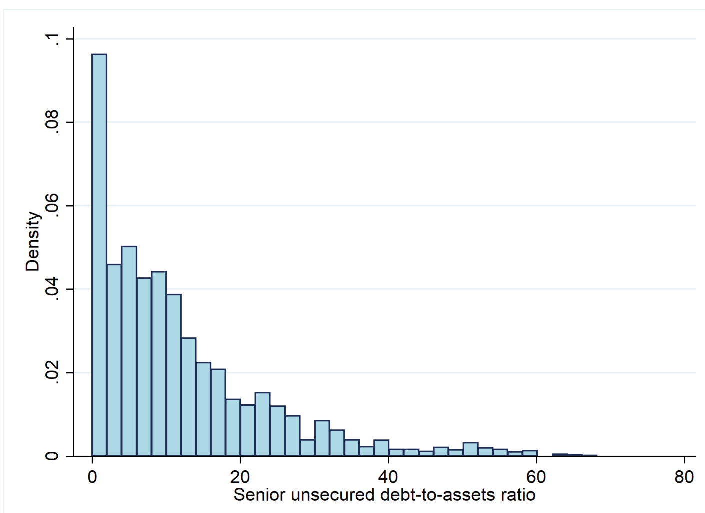
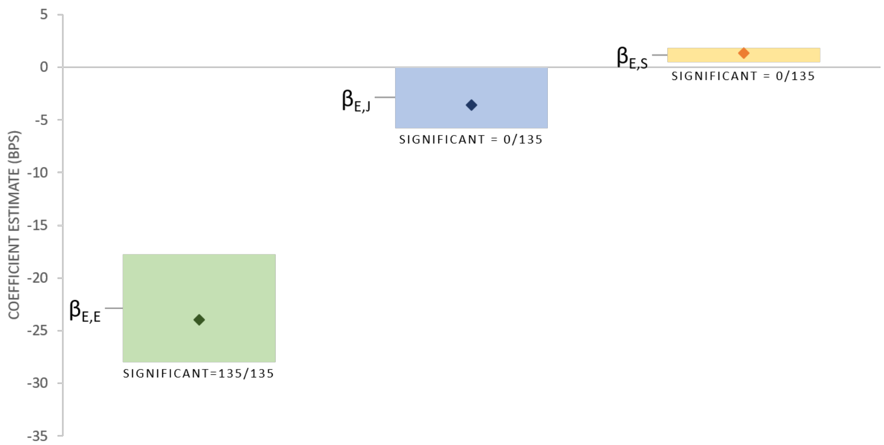
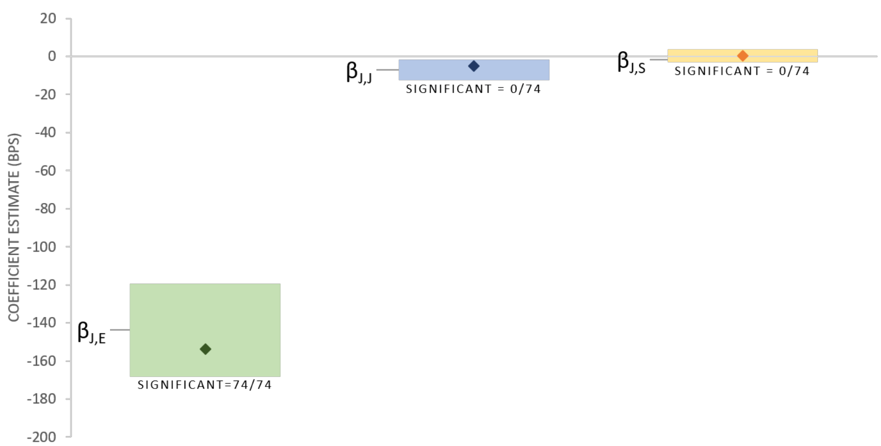


Figure A7: Robustness of coefficient estimates to dropping individual firms from the sample

(a) Cost of equity regression



(b) Cost of subordinated debt regression



(c) Cost of senior unsecured debt regression

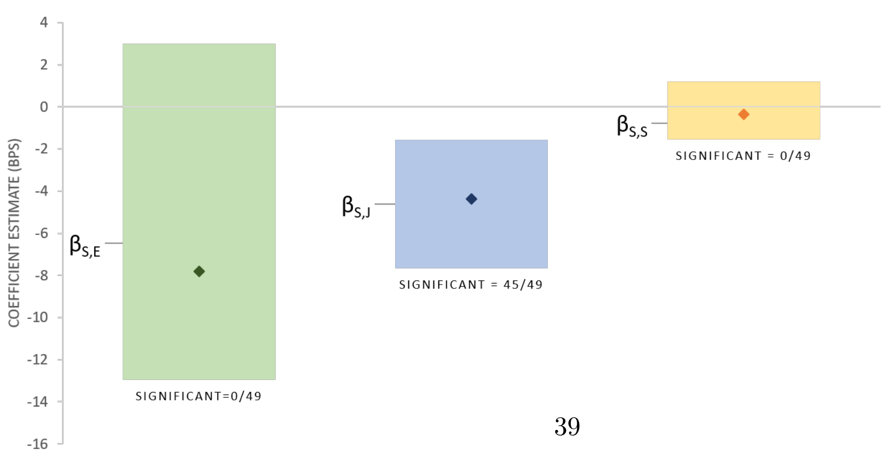
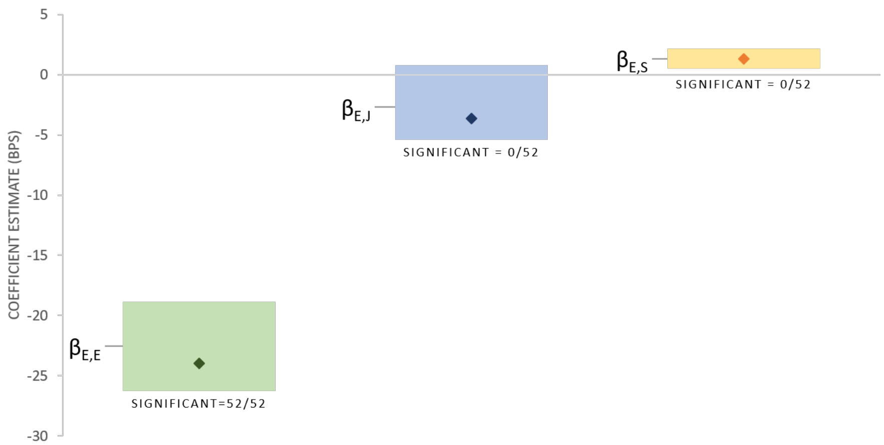
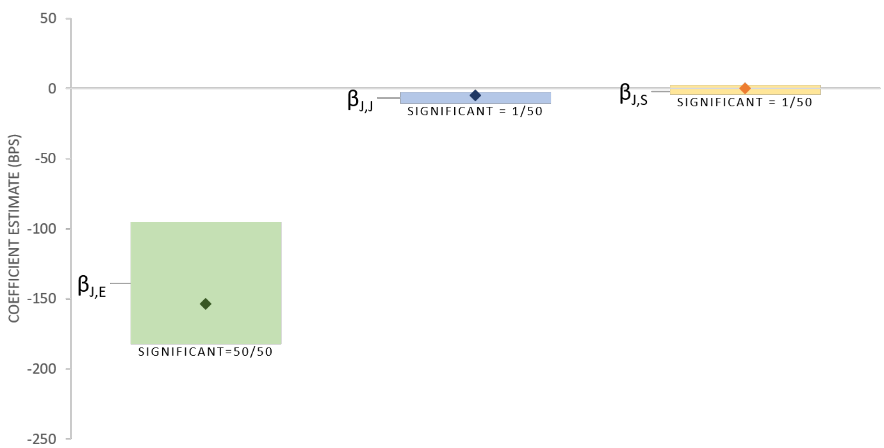


Figure A8: Robustness of coefficient estimates to dropping individual time periods from the sample

(a) Cost of equity regression



(b) Cost of subordinated debt regression



(c) Cost of senior unsecured debt regression

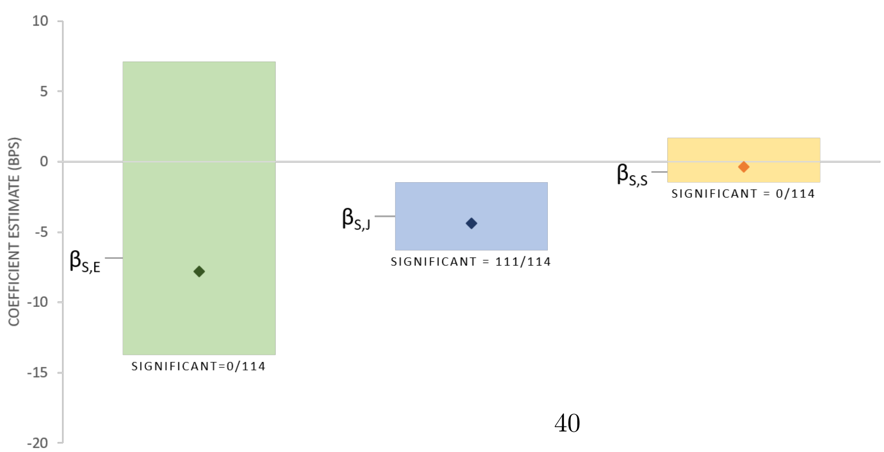


Table A1: Summary statistics

	Obs	Mean	SD	Min	5th %	Median	95th %	Max
Funding costs (basis points)								
Equity risk premium	2602	568.0	394.6	-870.8	-8.0	541.6	1250.2	3233.4
Junior CDS spread	1166	307.9	476.7	7.0	59.3	189.5	842.8	8635.4
Senior unsecured CDS spread	1606	173.5	260.6	1.0	27.7	100.0	513.6	4535.3
Liability structure (percentage points)								
Equity-to-assets ratio	3051	7.9	3.2	0.5	3.6	7.2	13.4	20.7
Junior debt-to-assets ratio	3051	1.8	1.7	0.0	0.0	1.5	4.4	25.1
Senior unsecured debt-to-assets ratio	3051	11.9	11.8	0.0	0.3	8.6	35.7	68.2
Liability-side controls (percentage points)								
Senior secured debt-to-assets ratio	3051	9.1	9.2	0.0	0.3	6.4	27.8	73.1
Deposits-to-assets ratio	3051	58.2	20.1	0.0	22.1	61.8	87.2	93.8
Short-term debt-to-assets ratio	3051	10.4	10.2	0.0	0.4	7.1	32.2	68.4
Asset-side controls								
Total assets (£ billion)	3051	323.8	425.0	15.1	21.3	119.3	1351.3	2226.9
Loans-to-assets ratio (percentage points)	3051	56.9	17.4	2.8	23.6	61.7	79.3	95.0
Regulatory adjustments (percentage points)	3051	1.3	1.5	-6.2	-0.6	1.0	4.0	10.3
Non-performing assets ratio (percentage points)	3051	2.7	4.5	0.0	0.1	1.1	11.3	36.1
Average risk weight (percentage points)	3051	55.0	21.3	5.0	23.0	52.4	88.3	121.5
Sharpe ratio	3051	3.7	5.6	-3.4	-0.5	1.8	13.8	71.2
Country-level controls								
Sovereign CDS spread (basis points)	3051	77.3	246.1	1.1	3.3	39.1	256.2	11091.5
GDP growth (percentage points)	3051	0.4	0.9	-4.9	-1.1	0.5	1.3	6.8

Table A2: Baseline regression results

Risk premium on...	equity	junior debt	snr unsec debt
$\frac{E}{Assets}_{i,t-1}$	-23.996**	-153.616***	-7.805
	(0.030)	(0.001)	(0.642)
$\frac{E+J}{Assets}_{i,t-1}$	-3.637	-5.237	-4.400*
	(0.499)	(0.472)	(0.051)
$\frac{E+J+S^{unsec}}{Assets}_{i,t-1}$	1.291	0.001	-0.384
	(0.404)	(1.000)	(0.796)
$\frac{E+J+S^{unsec}+S^{Sec}}{Assets}_{i,t-1}$	-3.674	4.193*	0.960
	(0.130)	(0.097)	(0.568)
$Total\,assets_{i,t-1}$ (£bn)	0.013	-0.178	-0.087*
	(0.835)	(0.160)	(0.092)
$\frac{Deposits}{Assets}_{i,t-1}$	-5.199*	-8.364	-3.466*
	(0.056)	(0.107)	(0.087)
$\frac{Short-term\,debt}{Assets}_{i,t-1}$	1.196	-2.187	-0.448
	(0.479)	(0.458)	(0.774)
$\frac{Reg\,adjustments}{Assets}_{i,t-1}$	8.690	159.174***	12.268
	(0.548)	(0.003)	(0.567)
$Sharpe\,ratio_{i,t-1}$	-0.772	-0.479	1.180
	(0.682)	(0.868)	(0.400)
$\frac{NPA}{Assets}_{i,t-1}$	17.620***	44.722***	11.948**
	(0.000)	(0.000)	(0.025)
$\frac{Loans}{Assets}_{i,t-1}$	-4.767**	2.331	-0.007
	(0.021)	(0.473)	(0.997)
$Avg\,risk-weight_{i,t-1}$	4.750***	10.848***	2.805
	(0.004)	(0.010)	(0.118)
$Sovereign\,CDS\,yield_{i,t}$	0.058	0.285***	0.173***
	(0.281)	(0.000)	(0.003)
$GDP\,growth_{i,t-1}$	-7.645	-21.585*	-25.829***
	(0.570)	(0.096)	(0.000)
Constant	1,123.4***	805.4**	264.2**
	(0.000)	(0.036)	(0.013)
Firm dummies	Yes	Yes	Yes
Time dummies	Yes	Yes	Yes
Observations	2,596	1,159	1,596
Clusters (firms)	138	77	117
R-squared (within)	0.032	0.212	0.156

*** p<0.01, ** p<0.05, * p<0.1

Table A3: Regression results for below- and above-median Tier 1-to-assets ratio

Risk premium on...	equity	junior debt	snr unsec debt
$\frac{E}{Assets}_{i,t-1}[D=0]$	-44.943**	-184.298***	-7.226
	(0.014)	(0.002)	(0.750)
$\frac{E}{Assets}_{i,t-1}[D=1]$	-15.529	-143.356***	-1.831
	(0.266)	(0.004)	(0.908)
$\frac{E+J}{Assets}_{i,t-1}[D=0]$	3.389	-4.521	-3.945
	(0.565)	(0.565)	(0.135)
$\frac{E+J}{Assets}_{i,t-1}[D=1]$	-12.991	-2.446	-3.042
	(0.153)	(0.847)	(0.471)
$\frac{E+J+S^{unsec}}{Assets}_{i,t-1}[D=0]$	-0.091	0.204	-1.590
	(0.963)	(0.962)	(0.359)
$\frac{E+J+S^{unsec}}{Assets}_{i,t-1}[D=1]$	2.473	0.062	1.344
	(0.162)	(0.987)	(0.341)
$\frac{E+J+S^{unsec}+S^{Sec}}{Assets}_{i,t-1}$	-3.270	3.815	1.164
	(0.174)	(0.122)	(0.461)
$Total\,assets_{i,t-1}\,(£bn)$	0.008	-0.206	-0.093*
	(0.899)	(0.112)	(0.051)
$\frac{Deposits}{Assets}_{i,t-1}$	-5.054*	-8.367	-3.099
	(0.058)	(0.116)	(0.113)
$\frac{Short-term\,debt}{Assets}_{i,t-1}$	1.082	-2.244	-0.414
	(0.519)	(0.447)	(0.787)
$\frac{Reg\,adjustments}{Assets}_{i,t-1}$	13.367	164.764***	6.586
	(0.379)	(0.002)	(0.752)
$Sharpe\,ratio_{i,t-1}$	-0.956	-0.964	0.846
	(0.612)	(0.746)	(0.555)
$\frac{NPA}{Assets}_{i,t-1}$	17.611***	43.199***	11.569**
	(0.000)	(0.000)	(0.030)
$\frac{Loans}{Assets}_{i,t-1}$	-4.390**	3.330	0.130
	(0.028)	(0.310)	(0.946)
$Avg\,risk-weight_{i,t-1}$	4.607***	10.179**	2.955
	(0.005)	(0.016)	(0.111)
$Sovereign\,CDS\,yield_{i,t}$	0.059	0.295***	0.175***
	(0.265)	(0.000)	(0.001)
$GDP\,growth_{i,t-1}$	-6.686	-21.258	-23.628***
	(0.619)	(0.111)	(0.001)
$D=1\left[\left(\frac{Tier\,1}{Assets}\right)_{i,t-1} > \left(\frac{\bar{Tier\,1}}{Assets}\right)\right]$	-107.654	-299.588	-159.947
	(0.361)	(0.205)	(0.138)
Constant	1,188.515***	975.601**	264.270**
	(0.000)	(0.016)	(0.027)
Firm dummies	Yes	Yes	Yes
Time dummies	Yes	Yes	Yes
Observations	2,596	1,159	1,596
Clusters	138	77	117
R-squared (within)	0.035	0.215	0.167

*** p<0.01, ** p<0.05, * p<0.1

Table A4: Regression results pre- and post-2014

Risk premium on...	equity	junior debt	snr unsec debt
$\frac{E}{Assets}_{i,t-1}\,[\gamma=0]$	-31.402***	-168.289***	-7.451
	(0.003)	(0.003)	(0.665)
$\frac{E}{Assets}_{i,t-1}\,[\gamma=1]$	-2.545	-134.709***	4.442
	(0.869)	(0.004)	(0.783)
$\frac{E+J}{Assets}_{i,t-1}\,[\gamma=0]$	0.490	-2.944	-3.487*
	(0.937)	(0.664)	(0.089)
$\frac{E+J}{Assets}_{i,t-1}\,[\gamma=1]$	-5.064	-23.888	-17.182**
	(0.624)	(0.477)	(0.032)
$\frac{E+J+S^{unsec}}{Assets}_{i,t-1}\,[\gamma=0]$	0.642	0.131	-0.369
	(0.667)	(0.972)	(0.799)
$\frac{E+J+S^{unsec}}{Assets}_{i,t-1}\,[\gamma=1]$	-0.444	4.643	-0.471
	(0.816)	(0.495)	(0.803)
$\frac{E+J+S^{unsec}+S^{Sec}}{Assets}_{i,t-1}$	-2.280	3.455	0.903
	(0.341)	(0.190)	(0.598)
$Total\,assets_{i,t-1}\,(£bn)$	-0.006	-0.208	-0.085*
	(0.914)	(0.151)	(0.073)
$\frac{Deposits}{Assets}_{i,t-1}$	-5.447**	-8.595	-3.543*
	(0.045)	(0.103)	(0.076)
$\frac{Short-term\,debt}{Assets}_{i,t-1}$	0.853	-2.161	-0.472
	(0.588)	(0.455)	(0.761)
$\frac{Reg\,adjustments}{Assets}_{i,t-1}$	6.684	165.361***	10.425
	(0.632)	(0.003)	(0.622)
$Sharpe\,ratio_{i,t-1}$	-1.602	-1.211	1.249
	(0.387)	(0.676)	(0.363)
$\frac{NPA}{Assets}_{i,t-1}$	18.087***	43.397***	12.017**
	(0.000)	(0.000)	(0.020)
$\frac{Loans}{Assets}_{i,t-1}$	-3.685*	2.910	-0.184
	(0.073)	(0.355)	(0.920)
$Avg\,risk-weight_{i,t-1}$	2.723	10.771***	2.969
	(0.103)	(0.003)	(0.107)
$Sovereign\,CDS\,yield_{i,t}$	0.051	0.278***	0.173***
	(0.294)	(0.000)	(0.002)
$GDP\,growth_{i,t-1}$	-4.685	-20.229	-25.955***
	(0.731)	(0.105)	(0.000)
$\gamma=1\,[t>2013]$	Effect absorbed by time dummies		
Constant	1,122.658***	831.259**	279.931**
	(0.000)	(0.031)	(0.012)
Firm dummies	Yes	Yes	Yes
Time dummies	Yes	Yes	Yes
Observations	2,596	1,159	1,596
Clusters	138	77	117
R-squared (within)	0.045	0.217	0.159

*** p<0.01, ** p<0.05, * p<0.1