

# Asset Encumbrance and Bank Risk: Theory and First Evidence from Public Disclosures in Europe

This version: October, 2018

## Abstract

Asset encumbrance refers to the existence of restrictions to a bank's ability to transfer or realize its assets. Asset encumbrance has recently become a much-discussed subject and policymakers have been actively addressing what some consider to be excessive levels of encumbrance. We provide a theoretical model that highlights the implications of asset encumbrance for funding and financial stability. We show that the effect of encumbrance depends on the levels of over-collateralization faced by the banks. With low levels of overcollateralization, asset encumbrance is negatively associated with bank credit risks as secured funding minimizes bank's exposure to liquidity shocks. When overcollateralization levels are high, encumbrance can exacerbate liquidity risks due to structural subordination effect and, hence, can be positively associated with bank credit risk premiums. We use a novel dataset on the levels of asset encumbrance of European banks and provide empirical evidence supporting the predictions of the model. Our empirical results point to the existence of a negative association between CDS premia and asset encumbrance. This relationship is further amplified by liquidity of banks' balance sheets and stability of their funding. Capital and credit quality of bank assets, on the contrary, do not exhibit strong mediation role between asset encumbrance and bank risk.

*Keywords:* asset encumbrance, collateral, bank risk, credit default swaps

*JEL classification:* G01, G21, G28

# 1 Introduction

As of June 2011, Dexia, a Franco-Belgian bank, reported a strong Tier 1 capital ratio of 11.4%.<sup>1</sup> Out of the 91 institutions analysed in the European Banking Authority (EBA) stress tests, Dexia came joint 12th, with a forecast Core Tier 1 capital ratio of 10.4% under the adverse stress scenario.<sup>2</sup> From a liquidity standpoint, the bank had built up a buffer of €88bn in liquid securities, and its short-term ratings had been reaffirmed as investment grade by the main credit rating agencies. But just three months later, in October 2011, Dexia was partly nationalised by the Belgian and French governments. Several commentators highlighted the high levels of “encumbered” assets as the key factor precipitating its move into government arms.<sup>3,4</sup>

Asset encumbrance refers to the existence of bank balance sheet assets being subject to arrangements that restrict the bank’s ability to transfer or realise them. Assets become encumbered when they are used as collateral to raise funding, for example in repurchase agreements (repos) or in other collateralised transactions such as asset-backed securitisations, covered bonds, or derivatives.<sup>5</sup> In the particular case of Dexia, more than €66bn of its €88bn buffer securities were encumbered through different secured funding arrangements, particularly with the European Central Bank (ECB), and were therefore unavailable for obtaining emergency funding.

Policymakers are acting decisively in order to address what some consider to be excessive levels of asset encumbrance. Some jurisdictions have introduced limits on the level of encumbrance (Australia, New Zealand) or ceilings on the amount of secured funding or covered bonds (Canada, US), while others have incorporated encumbrance levels in deposit insurance premiums (Canada). Several authors have proposed linking capital requirements to the banks’ asset encumbrance levels or establishing further limits to asset encumbrance as a back-stop (Juks [2012], IMF [2013], Helberg and Lindset [2014]). As part of the Basel III regulatory package, the Net Stable Funding Ratio (NSFR), which will introduce additional minimum liquidity

---

<sup>1</sup>See Dexia 2Q & 1H 2011 Results and Business Highlights Presentation, 4 August 2011

<sup>2</sup>The Core Tier 1 ratio represents the ratio of very high quality capital (shareholders’ capital and reserves) to risk-weighted assets (RWA). The Tier 1 capital ratio includes, in addition to Core Tier 1 capital, other perpetual capital resources such as subordinated debt instruments with conversion features and is also expressed as a fraction of RWA.

<sup>3</sup>See e.g. Financial Times, “Bank collateral drying up in rush for security”, October 2011.

<sup>4</sup>More recently, in June 2017, Banco Popular was put into resolution by the European Single Supervisory Mechanism (SSM) and was acquired by Banco Santander for a symbolic amount of €1. Yet, as of year-end 2016, the Spanish bank Banco Popular reported a Tier 1 capital ratio of 12.3% and had passed the EBA stress tests undertaken in 2016 with a solid margin. However, nearly 40% of its total balance sheet assets were encumbered as of December 2016.

<sup>5</sup>Collateralisation is a common method of mitigating counterparty credit risk in derivative markets through the provisioning of margin.

requirements, heavily penalises asset encumbrance by requiring substantial amounts of stable funding. In Europe, regulatory reporting and disclosure requirements have been introduced and all institutions are required to incorporate asset encumbrance within their risk management frameworks. The Dutch National Bank has even committed to “keeping encumbrance to a minimum” (De Nederlandsche Bank [2016]).

Such policy actions stem from a negative perception of asset encumbrance. First, increasing asset encumbrance reduces the amount of unencumbered assets that a bank can use to meet sudden liquidity demands and the pool of assets that become available to unsecured creditors under insolvency, an effect coined as “structural subordination”. In the particular case of Dexia, more than €66bn of its €88bn buffer securities were encumbered through different secured funding arrangements, particularly with the European Central Bank (ECB), and were therefore unavailable for obtaining emergency funding and meet creditors’ demands. If unsecured creditors reflect the risks of asset encumbrance into their required returns, institutions would face higher overall funding costs. As stated by Dr Joachim Nigél, a former member of the executive board of the Deutsche Bundesbank in a speech at the 2013 European Supervisor Education Conference on the future of European financial supervision: “Higher asset encumbrance has an impact on unsecured bank creditors. The more bank assets are used for secured funding, the less remain to secure investors in unsecured instruments in the case of insolvency. They will price in a risk premium for this form of bank funding.”

This paper argues that asset encumbrance may also bring in important benefits. Collateral also provides safety, potentially reducing the bank’s overall cost of funds and liquidity risks. We first present a theoretical model exploring the trade-offs of asset encumbrance and their implications for liquidity risk, and banks’ risk premia. In our model, asset encumbrance has two opposing effects on liquidity risk. First, as the level of asset encumbrance increases, the bank will have fewer unencumbered assets available to meet creditors demands in case of stress — this is the *structural subordination* effect of asset encumbrance. On the other hand, as encumbrance increases, the bank has fewer liabilities subject to a run and, hence, lower liquidity risk — this is the *stable funding* effect of asset encumbrance. Overall, which effect dominates depends crucially on the levels of over-collateralization, i.e. on the haircuts, which in turn is determined by the magnitude and likelihood of fire sale discounts.

We show that the stable funding effect dominates the adverse effect of structural subordination when the haircut *just* reflects the market value of the collateral. Indeed, secured funding reduces liquidity risk because secured creditors require a lower return than unsecured creditors. However, when the levels of over-collateralization of secured funding are higher, the bank raise

a smaller amount of secured funding by pledging the same amount of assets, which reduces the stable funding effect. In turn, the bank needs to raise a larger amount of unsecured funding, which increases the adverse structural subordination effect. When haircuts are high relative to the premia for safety, the structural subordination effect dominates the stable financing effect and liquidity risk increases.

This trade-off generates two distinct predictions on the relationship between encumbrance levels and bank risk. In the case of low haircuts, banks increase the level of asset encumbrance as much as possible, as secured funding is not only cheaper but it also reduces liquidity risk. At the same time, unsecured debt holders would require lower premia to compensate for bank's default risk and recovery rates. Thus, as the availability of bank collateral increases, asset encumbrance increase and unsecured funding rates decrease. Instead, in the case of high haircuts, banks face a trade-off, as secured funding is cheaper but it increases liquidity risk. As a result, we may have banks with higher collateral to choose higher levels of asset encumbrance despite having higher liquidity risk. So, the relationship between asset encumbrance and the cost of funding may be positive.

We test these predictions and investigate, in the absence of data on the availability of bank collateral, the association of asset encumbrance and credit risk spreads. We built a novel dataset using information provided in the asset encumbrance disclosures published for the first time throughout 2015 by European banks, following a set of harmonised definitions provided by the EBA (EBA [2014]). In a cross-section of banks, we find that institutions with higher encumbrance levels tend to have lower CDS spreads — i.e. bank risk seems to be negatively associated with asset encumbrance. We also find that some variables play a mediating role in the relationship between asset encumbrance and bank risk. For banks with highly illiquid balance sheets, correlation of asset encumbrance with bank risk is less pronounced and, in extreme cases, is positive. Bank capital and quality of its assets, on the contrary, do not seem to introduce heterogeneity in the encumbrance-risk link. These findings imply that regulators need to be cautious when assessing asset encumbrance levels and leaping to across-the-board conclusions about its effects.

There is a small but emerging literature studying asset encumbrance and bank financial instability. In Ahnert et al. [2017], a bank's amount of unsecured debt is fixed and the bank can expand profitable investment through secured funding, which leads to greater asset encumbrance. However, with greater asset encumbrance, fewer unencumbered assets are available to meet unsecured debt withdrawals, thereby exacerbating bank's liquidity risk. As a consequence, Ahnert et al. [2017] predict that bank's asset encumbrance level is positively correlated with the

premium of unsecured debt. In our paper, on the contrary, banks can use secured financing to replace unsecured funding. This generates the stable funding effect of asset encumbrance, which is absent in Ahnert et al. [2017]. Thus, we predict that bank's asset encumbrance level can be negatively correlated with the premium of unsecured debt when the haircut of over-collateralization is low. This result also differs from Matta and Perotti [2015]. In Matta and Perotti [2015], more secured debt results in more liquidity risk. Therefore, unsecured debt bears more risk, requiring a higher promised yield. Gai and Chapman [2017] also study the implications of bank asset encumbrance for financial instability. However, in their model, bank's funding structure is exogenously given rather than endogenously chosen by the bank.

Our paper is related with the literature on secured debt and more generally firms' debt structure choices. Theoretically, the possible explanations of the use of secured debt include mitigating agency conflicts between shareholders and creditors (Smith and Warner [1979], Stulz and Johnson [1985]), addressing the information asymmetries between the lender and borrower (Chan and Thakor [1987], Berger and Udell [1990], Thakor and Udell [1991]). A recent interesting paper by Donaldson et al. [2017] focus on the role that collateral can serve as a commitment device for the firm. In their model, a firm can not commit not to expropriate the unsecured creditors. Creditors thus require collateral for protection against possible expropriation by collateralized debt in the future. However, collateralized borrowing has a cost since it can constrain firm's future borrowing and investment. Unlike these papers, our paper focus on bank's funding structure and emphasizes a different friction of collateralized borrowing: the interaction between collateralized borrowing and bank's unsecured creditors as well as liquidity risk, which is banking specific.

Empirically, Julio et al. [2007] find that the vast majority of public debt issues are unsecured, while Nini et al. [2009] document that 65 percent of a large sample of private credit agreements between 1996 and 2005 were secured. In the context of banking, Di Filippo et al. [2016] find that that banks with higher credit risk are able to offset a reduction of unsecured borrowing with secured loans, consistent with theories of lender moral hazard. Unlike Di Filippo et al. [2016], we find that better banks may use more secured debt. Besides, our paper focuses on the relationship between asset encumbrance level and the premium of unsecured debt holders. Therefore, our paper can explicitly tackle the issue of structural subordination missing in Di Filippo et al. [2016].

The rest of the paper is organized as follows. Sections 2 and 3 describe the model setup and bank liquidity risk. In Section 4 we present the theoretical results for the case when collateral haircuts are low. Section 5 is devoted to the discussion of theoretical implications of high

rates of over-collateralization. In Section 6 we provide empirical evidence supporting model predictions. Section 7 concludes.

## 2 Theoretical Framework

We now present a simple model of a bank to understand banks' optimal choices of asset encumbrance, as well as the resulting implications of these choices on unsecured debt risk premia.

### 2.1 Bank and Investors

A risk-neutral bank has access to a profitable project that needs one unit of cash at  $t = 0$ . The bank's project generates a random return  $\theta \geq 0$  at  $t = 1$  and a fixed return  $k < 1$  at  $t = 2$ . The random return  $\theta$  follows a uniform distribution with  $\theta \sim U[0, \bar{\theta}]$ . For notational simplicity, we sometimes denote the (uniform) cumulative distribution function of  $\theta$  by  $F(\theta)$ . As  $k < 1$  and  $\theta$  can be zero, the bank is subject to insolvency risk. The bank has limited liability.<sup>6</sup>

At  $t = 0$ , the bank has no cash at hand, so it needs to raise funds from a competitive credit market. We assume that the bank issues long-term demandable debt.<sup>7</sup> That is, creditors can withdraw their money at  $t = 1$ , before the debt matures at  $t = 2$ . The bank can use  $\theta$  and the proceeds from selling part of the fixed second-period returns  $k$  prematurely, at a per-unit price of  $\phi < 1$ . Equivalently, at  $t = 1$ , there is a bond market where the bank can sell riskless bonds which promise one unit of cash at  $t = 2$ , at a price  $\phi < 1$ .<sup>8</sup> Since the project's payoff at  $t = 2$  is  $k$ , the bank can sell riskless bonds up to a maximum of  $k$ . The bank fails if the amount withdrawn exceeds its liquid assets at  $t = 1$ . Thus, as in Allen and Gale [1994], the bank is subject to liquidity risk.

Price  $\phi$  depends on the state of the economy: with probability  $q_L$ , the state is bad, in which the price of the collateral is  $\phi_L$ , and with probability  $q_H$ , the state is good, in which the price of the collateral is  $\phi_H$ , with  $\phi_L < \phi_H$  and  $q_H + q_L = 1$ .<sup>9</sup> Denote variability of collateral prices as  $\Delta$ , with  $\Delta \equiv \frac{\phi_H}{\phi_L} - 1 > 0$ . Note, that one can treat  $\Delta$  as a measure of a fire sale discount in a bad

<sup>6</sup>A storage technology allows the bank to transfer cash from one date to the next without cost.

<sup>7</sup>Calomiris and Kahn [1991], Diamond and Dybvig [1983] and Diamond and Rajan [2001] provide micro-foundations for demandable debt. For instance, in Calomiris and Kahn [1991] and Diamond and Rajan [2001], demandable debt act as an instrument to prevent opportunistic behavior by bank managers.

<sup>8</sup>See Freixas and Rochet [2008] for the same setup.

<sup>9</sup>This may reflect the fact that for some collateral, it is more susceptible to the fluctuations of market price. For instance, in Gorton and Metrick (2003), the haircuts should be higher for asset classes that are more prone to be sensitive to adverse selection risk. It may also reflect the fact that for some countries, the liquidity of the financial system is uncertain in the future such that the price of the collateral also becomes volatile.

state relative to the good one.

The bank raises funding by issuing secured and/or unsecured debt funding, so as to maximize the bank's expected profits at  $t = 0$ . There are two types of creditors. Some are risk neutral but demand a minimum expected return of  $1 + \gamma$ , with  $\gamma > 0$ . The others are infinitely risk averse, and willing to lend only if debt is absolutely safe, but they demand a minimum return of just 1.<sup>10</sup> Since infinitely risk averse investors demand a lower expected return, it is optimal for the bank to raise (safe) secured funding from this group of investors, and (risky) unsecured debt from the risk neutral investors. This setup captures a major advantage of secure funding: it is perceived to carry lower roll-over risks and is generally cheaper than equivalent unsecured funding. We assume that the wealth of each group investors is sufficiently large so that the bank's financing decision will not be constrained by each group of investors' wealth.

## 2.2 Asset Encumbrance

Denote by  $s$  the funds raised through (long-term demandable) secured debt to the risk-averse investors. To make they are repaid fully and unconditionally, the bank needs to pledge enough assets. The bank can pledge a fraction of the project's payoff at  $t = 2$ , up to a maximum of  $k$ . The bank's return  $\theta$  at  $t = 1$  cannot be pledged because it is random with the lowest return being equal to 0. Hence, from now on, we refer to  $k$  as the available collateral of the bank. Since secured debt is absolutely safe, the face value per unit of secured debt is equal to 1, which is the minimum return demanded by infinitely risk averse investors.

For each unit of secured funding, the bank needs to pledge  $1 + h$  units of collateral, where  $h$  reflects the haircut. Since secured debt is required to be absolutely safe, the minimum possible level of haircut is determined by the lowest possible price of the collateral in the market, that is,  $h$  is such that  $(1 + h)\phi_L = 1$ . Indeed, if asset price of the collateral at  $t = 1$  turns out to be  $\phi_L$ , which is the worst scenario, the bank can sell the collateral and recover  $(1 + h)\phi_L = 1$  at  $t = 1$  for each unit of secured funding. In other words,  $\Delta$  can be interpreted as a measure of *ex-post* overcollateralization in a good state since  $(1 + h)\phi_H - 1 = \Delta$ .

The assets pledged to secured debt holders as collateral are encumbered, so they cannot be sold at  $t = 1$  to meet unsecured debt holders' withdrawals. In the event of a bank run, secured debt holders can seize the encumbered assets  $(1 + h)s$ . Because of full collateral protection, they have no incentive to withdraw money in the interim period. In case of bank failure, the bank liquidates the unencumbered assets  $k - (1 + h)s$  at a price  $\phi$  ( $\phi_H$  or  $\phi_L$ ), which are shared

---

<sup>10</sup>See Gorton et al. [2012] and Krishnamurthy and Vissing-Jorgensen [2012] for empirical evidence, and Genaioli et al. [2012], Stein [2012] and Caballero and Farhi [2013] for similar modeling assumptions.

by the unsecured investors on a pro-rata basis.

Denote by  $1 - s$  the funds raised through (long-term demandable) unsecured debt to the risk-neutral investors. The face value per unit of unsecured debt,  $D$ , is endogenously determined by  $1 - s$ , via a zero profit condition, taking into account that the risk-neutral investors demand a minimum return of  $1 + \gamma$ .

The timing of the model is illustrated in Figure 1. For simplicity, we assume that the bank's project is profitable even if all the long-term assets are liquidated at  $t = 1$  and the bank finances the project entirely through unsecured debt.

[Figure 1]

### 3 Structural Subordination vs. Stable Funding

This section identifies the two effects of secured funding on liquidity risk, which we name stable funding and structural subordination effects. In this section, we treat the level of secured funding,  $s$ , and the face value of a unit of unsecured debt,  $D$ , as exogenously given. In the following sections, we endogenize  $D$ .

The bank is exposed to insolvency risk. The bank is insolvent if and only if the total value of bank's assets is inferior to the debt obligations:

$$\theta + k < s + (1 - s)D.$$

As  $k < 1$ ,  $\theta$  can be zero, and  $s + (1 - s)D > 1$  (as  $D \geq 1 + \gamma$ ), there exists a critical solvency return  $\theta^{**}$  such that the bank is solvent if and only if:

$$\theta > \theta^{**} \equiv s + (1 - s)D - k. \quad (1)$$

The bank is also exposed to liquidity risk. At  $t = 1$ , unsecured debt holders can decide whether to withdraw the money or not. The bank can use its period-1 proceeds  $\theta$  as well as proceeds from the sale of unencumbered assets,  $k - (1 + h)s$  at a price of  $\phi < 1$  to meet the withdrawal. But, if all the unsecured debt holders choose to withdraw, the bank will fail from a run on the bank at  $t = 1$  if the bank's available liquidity is inferior to the investors' withdrawals.

Since asset price is uncertain at  $t = 1$ , we have two different critical liquidity returns for the two states. If asset price is  $\phi_L$ , the critical liquidity return for the bank  $\theta_L^*$ :

$$\theta_L^* \equiv (1 - s)D - (k - (1 + h)s)\phi_L \quad (2)$$



If asset price is  $\phi$ , the critical liquidity return for the bank  $\theta_H^*$ :

$$\theta_H^* \equiv (1-s)D - (k - (1+h)s)\phi_H \quad (3)$$

From the definitions of  $\Delta$ ,  $\theta_L^*$  and  $\theta_H^*$ , one gets

$$\theta_H^* = \theta_L^* - (k\phi_L - s)\Delta \quad (4)$$

Clearly,  $\theta_H^* < \theta_L^*$ . Given bank's choice of asset encumbrance at  $t = 0$ , the bank is more likely to fail if the price of the collateral at  $t = 1$  is low, since bank's available liquidity through collateral sales is reduced, thus the bank needs a higher  $\theta$  to survive at  $t = 1$ .

As  $\theta_L^* > \theta_H^* > \theta^{**}$ , the range of  $\theta$  can be split into four regions. If  $\theta < \theta^{**}$ , the bank is insolvent. If  $\theta^{**} < \theta < \theta_H^*$ , the bank is solvent but possibly illiquid in both states. If  $\theta_H^* < \theta < \theta_L^*$ , the bank is solvent but possibly illiquid in the bad state, solvent and liquid in the good state. If  $\theta > \theta_L^*$ , the bank is solvent and liquid in both states. The intermediate region  $\theta^{**} < \theta < \theta_H^*$  and  $\theta_H^* < \theta < \theta_L^*$  spans multiple equilibria. In one of them, all unsecured debt holders withdraw and the bank fails. In another equilibrium, all unsecured debt holders choose not to withdraw and the bank survives. For simplicity, we assume that the bad equilibrium prevail, so that the bank always fails if it is solvent but possibly illiquid, because of the unsecured investors' self-fulfilling concern that all the other unsecured debt holders withdraw.<sup>11</sup> As  $\theta \sim F(\theta)$ , the bank fails at  $t = 1$  with probability  $F(\theta_L^*)$  in the bad state and  $F(\theta_H^*)$  in the good state. Clearly, the higher the liquidity cutoff, the higher the bank's liquidity risk.

Notice that an increase in secured funding,  $s$ , has two effects on bank's liquidity risk,  $\theta^*$ . On the one hand, as  $s$  increases  $(1-s)D$  decreases, which implies that the bank needs less liquidity to face a potential liquidity shock at  $t = 1$ . This is the *stable funding effect* of secured financing. On the other hand, as  $s$  increases,  $(1+h)s$  increases, which implies that the amount of unencumbered assets available to the unsecured debt holders is lower. This is the *structural subordination effect* of secured funding.

---

<sup>11</sup>On the contrary, if the good equilibrium is chosen, bank's liquidity risk will disappear. In this case, only solvency risk is relevant for the bank. More generally, we can extend the model to allow for multiple equilibrium. In the more general case, when  $\theta < \theta^*$ , the bank fails from bank run with exogenous probability  $p$ , and survives with probability  $1-p$ . Our results still hold in this more general case. In principle, we could also use the global games approach of Goldstein and Puzner [2005], to select a unique equilibrium. We work with an exogenously chosen equilibrium for tractability.

## 4 Benchmark: No Overcollateralisation

To better illustrate the main intuition of the model, in this section, we study bank's asset encumbrance choice when the price of collateral is certain to be  $\phi = q_L\phi_L + q_H\phi_H$  at  $t = 1$ . In the next section, we will explore the more general case with uncertain price.

Since there is no price uncertainty, the haircut of secured funding  $h$  is such that  $(1+h)\phi = 1$ , which means that there is no overcollateralisation for secured funding. We can define a critical liquidity return for the bank  $\theta^*$ :

$$\theta^* \equiv (1-s)D - (k - (1+h)s)\phi \quad (5)$$

### 4.1 Endogenous Funding Cost without Overcollateralisation

In this subsection, we show how the level of secured funding affects the bank's liquidity risk  $\theta^*$ , taking into account that  $s$  and  $\theta^*$  also affect the face value of unsecured debt  $D$ . Given  $s$ , the break-even condition for unsecured debt holders is indeed given by:

$$\int_0^{\theta^*} [\theta + (k - (1+h)s)\phi]dF(\theta) + \int_{\theta^*}^{\bar{\theta}} (1-s)DdF(\theta) = (1-s)(1+\gamma) \quad (6)$$

The first term in the left hand side is unsecured debt holders' expected return if the bank fails from a run at  $t = 1$ . Unsecured debt holders share  $\theta$ , as well as all the discounted unencumbered collateral,  $(k - (1+h)s)\phi$ , on a pro-rata basis. The second term in the left hand side is unsecured debt holder's expected return if the bank survives from the run. In this case, unsecured debt holders are fully paid at  $t = 2$ . The right hand side is the opportunity cost of unsecured debt holders' funding.

As shown in (6), the face of value of unsecured debt  $D$  depends on the bank's liquidity risk  $\theta^*$  and the level of secured funding  $s$ . In turn, the bank's liquidity risk  $\theta^*$  defined in (5) depends on  $D$  and  $s$ . The following proposition characterizes the effect of secured funding on the bank's liquidity risk.<sup>12</sup>

**Proposition 1** *If there is no overcollateralisation of secured funding, bank's liquidity risk  $\theta^*$  is strictly decreasing in the level of secured funding  $s$ .*

This result is quite intuitive: since  $1 + \gamma$  is high, i.e.  $(1+h)\phi = 1 < 1 + \gamma$ , the bank needs to promise high amount of debt payments when raising unsecured funding, in order to make

---

<sup>12</sup>The proofs of all results are in the Appendix A.

unsecured debt holders break even. High debt obligations imply high liquidity risk. If the bank can replace unsecured funding with secured funding, since secured debt holders require a lower rate of return, the bank's total debt obligations decrease, which reduces bank's liquidity risk.

## 4.2 Optimal Asset Encumbrance and Bank Risk without Overcollateralisation

In this subsection, we determine the bank's optimal level of secured funding, as well as the resulting unsecured funding costs. Our analysis unfolds in three steps. First, we study how the level of secured funding  $s$  affects bank's expected profits. Second, we determine the bank's optimal level of secured funding,  $s^*$ , and the level of unsecured debt value, as a function of the available collateral  $k$ . Third, we make predictions on the relationship between asset encumbrance and unsecured interest in a cross-section of banks with different levels of available collateral  $k$ , which are empirically unobservable.

The expected profits of the bank at  $t = 0$  is given by:

$$\Pi = \int_{\theta^*}^{\bar{\theta}} [\theta + k - s - (1 - s)D] dF(\theta). \quad (7)$$

When  $\theta < \theta^*$ , the bank fails at  $t = 1$  and shareholders receive 0. When  $\theta > \theta^*$ , the bank survives and the payoff of the bank's assets is  $\theta + k$ . At  $t = 2$  the bank pays  $s$  to secured debt holders and  $(1 - s)D$  to unsecured investors. Clearly,  $\Pi$  is a function of  $\theta^*$ ,  $D$  and  $s$ . As we have shown before, both  $\theta^*$  and  $D$  are determined by  $s$ . Therefore,  $\Pi$  is determined by  $s$ .

Secured funding affects bank's expected profit in two ways. First, since secured funding is a cheaper source of finance, higher asset encumbrance reduces bank's overall funding cost: conditional on success, the bank receives larger residual payoffs. Second, in the case of  $(1 + h)\phi = 1$ , asset encumbrance reduces bank risk,  $\theta^*$ . Both effects are positive.

**Proposition 2** *If there is no overcollateralisation of secured funding, the bank's profits are strictly increasing in the level of secured funding  $s$ , which implies that the optimal level of secured funding for the bank is  $s^* = k/(1 + h)$ .*

Thus, the bank should set the level of secured funding as high as possible. We now determine the optimal level of secured funding, as well as the resulting face value of unsecured debt  $D$  and the bank's liquidity risk  $\theta^*$ .

**Proposition 3** *If there is no overcollateralisation of secured funding, as the amount of available collateral  $k$  increases (i) the level of secured funding,  $s^*$ , increases. whereas (ii) the unsecured funding cost,  $D$ , decreases.*

The intuition of Proposition (3) is as follows. A bank with more available collateral is able to raise more secured funding. As we have shown before, secured funding reduces bank's liquidity risk. Therefore, the liquidity risk of bank failure decreases in asset encumbrance, and unsecured debt holders demand a lower interest rate to compensate for the risk of bank failure.

In our model, bank's asset has two components:  $\theta$  and  $k$ . Even though the amount of total assets may be observable, in reality, it is difficult to separate  $\theta$  from the collateral available  $k$ . To test the predictions of our model, we can find the relationship between bank's unsecured funding cost and bank's level of asset encumbrance. From the model, we have the following hypothesis.

**Hypothesis 1** *In a cross-section of banks with an endogenously chosen level of asset encumbrance, bank's unsecured funding cost  $D$  is negatively correlated with bank's level of asset encumbrance  $s$ .*

As an example, Panel a, b, c of Figure 2 plots the optimal level of asset encumbrance as well as the resulting face value of unsecured debt as a function of the level of available collateral  $k$ , as well as the relationship between the level of asset encumbrance and the face value of unsecured debt, for the case of  $\bar{\theta} = 1, \phi = 0.9, \gamma = 0.05$  and  $h = 0.11$ .

[Figure 2]

## 5 General Case

In this section, we consider the case that the price of the collateral at  $t = 1$  may be uncertain, and investigate its implications for the haircut of secured funding, bank's liquidity risk and asset encumbrance choice.

### 5.1 Endogenous Funding Cost under General Case

Given  $s$ , the break-even condition for unsecured debt holders is given by:

$$\begin{aligned}
& q_L \left[ \int_0^{\theta_L^*} (\theta + (k - (1 + h)s)\phi_L) dF + \int_{\theta_L^*}^{\bar{\theta}} (1 - s) D dF \right] \\
& + q_H \left[ \int_0^{\theta_H^*} (\theta + (k - (1 + h)s)\phi) dF + \int_{\theta_H^*}^{\bar{\theta}} (1 - s) D dF \right] = (1 - s)(1 + \gamma) \quad (8)
\end{aligned}$$

The first term in the left hand side is unsecured debt holders' expected return if the state is bad. In the bad state, unsecured debt holders are fully paid with probability at  $1 - \theta_L^*$ . The second term in the right hand side is unsecured debt holder's expected return if the state is good. In the good state, unsecured debt holders are fully paid with probability at  $1 - \theta_H^*$ . The right hand side is the opportunity cost of unsecured debt holders' funding.

**Proposition 4** *For a given  $s$ , there exist  $\Delta_L, \Delta_H$  with  $\Delta_L < \Delta_H$  such that*

- (i) *for  $\Delta > \Delta_H$ , both  $\theta_L^*$  and  $\theta_H^*$  are strictly increasing in the level of secured funding  $s$ .*
- (ii) *for  $\Delta_L < \Delta < \Delta_H$ ,  $\theta_L^*$  is strictly decreasing in, whereas  $\theta_H^*$  is strictly increasing in the level of secured funding  $s$ ,*
- (iii) *for  $\Delta < \Delta_L$ , both  $\theta_L^*$  and  $\theta_H^*$  are strictly decreasing in the level of secured funding  $s$ ,*

As before, asset encumbrance has two opposing effects on bank's liquidity risk: stable funding effect and structural subordination effect. However, the structural subordination effect is different in the two states. When the price of the collateral at  $t = 1$  turns out to be  $\phi_L$ , *ex-post* the bank pledges just enough collateral for the secured debt to be safe. On the contrary, when the price of the collateral at  $t = 1$  turns out to be  $\phi_H$ , *ex-post* the bank pledges more collateral than what secured debt creditors would have required at  $t = 0$  if they can perfectly knew the collateral price is  $\phi_H$ . Moreover, the higher the fire sale discount  $\Delta$ , the greater the *ex-post* overcollateralization in the good state. As a result, the bank has less available liquidity to meet unsecured creditors' liquidity needs at  $t = 1$  in the good state due to *ex-post* overcollateralization. This exposes the bank to more liquidity risk, compared to the case without asset price uncertainty.

Hence, asset encumbrance  $s$  may have different effects on the liquidity risk in the two states. Case 1 happens when the fire sale discount is sufficiently high which leads to higher haircut and stronger structural subordination effect. Therefore, in this case structural subordination effect dominates stable funding effect. Case 3 happens when the fire sale discount is sufficiently low. Low variability of prices leads to lower haircut and weaker structural subordination effect. Therefore, structural subordination effect is dominated by stable funding effect. Case 2 lies in

between: stable funding effect outweighs the structural subordination effect in the bad state, however, due to *ex-post* overcollateralization, structural subordination effect in the good state is sufficiently large such it outweighs the stable funding effect.

Note here  $\theta_L^*$  is not always decreasing in  $s$ , even if there is no *ex-post* overcollateralization in the case in which the realized asset price is low, because  $\theta_H^*$  and  $\theta_L^*$  are linked through the *ex-ante* funding costs. If  $\theta_H^*$  is higher, investors will demand a higher interest rate, which increases bank's liquidity risk in the low state, even if there is no *ex-post* overcollateralization.

## 5.2 Optimal Asset Encumbrance and Bank Risk under General Case

The expected profits of the bank at  $t = 0$  is given by:

$$\Pi = q_L \int_{\theta_L^*}^{\bar{\theta}} [\theta + k - s - (1 - s)D] dF(\theta) + q_H \int_{\theta_H^*}^{\bar{\theta}} [\theta + k - s - (1 - s)D] dF(\theta) \quad (9)$$

**Proposition 5** *For given  $q$  and  $\gamma$ , there exists  $\Delta^*$  such that*

- (i) *for  $\Delta < \Delta^*$ , bank's expected profit  $\Pi$  is strictly increasing in the level of secured funding  $s$ ,*
- (ii) *for  $\Delta > \Delta^*$ , there exists  $\hat{s} \in [0, k/(1 + h)]$  such that for  $s < \hat{s}$ , bank's expected profit  $\Pi$  is strictly increasing in the level of secured funding  $s$ , and for  $s > \hat{s}$ ,  $\Pi$  is strictly decreasing in the level of secured funding  $s$ .*

The result of case 1 is similar as before. In this case, asset encumbrance reduces bank's liquidity risk in both states. Coupled with the fact that secured funding is cheaper, asset encumbrance is always beneficial to the bank. The result of case 2 differs from that in Proposition 3, where bank's optimal level of secured funding is always a corner solution. The difference arises from the level of the haircut  $h$ , which in turn is determined by  $\phi_L$ . When variability of prices is high and thus the haircut is high, the bank faces a trade-off when choosing the optimal level of secured funding. On the one hand, secured funding is cheaper than unsecured funding. On the other hand, as is shown in Proposition (4), a higher level of secured funding may increase bank's liquidity risk in the good state, and unsecured debt holders may demand a higher interest rate.

**Proposition 6** *If the overcollateralisation of secured funding is sufficiently high, there exist  $k_h$  and  $k_l$  with  $k_h > k_l$  such that (i) the optimal level of secured funding is higher for  $k_h$  than for  $k_l$  and (ii) the interest rate for unsecured debt holders is higher for  $k_h$  than for  $k_l$ .*

It is possible that in a cross-section of banks asset encumbrance is positively associated with the premium of unsecured debt.  $k$  can affect bank's liquidity risk in two ways. First, through

the direct effect on  $k\phi$ , when  $k$  is larger, the bank's liquidity risk is lower in both states. This is intuitive, since a bank with more collateral is less likely to fail from bank run. Second, banks' choice of  $s$  may depend on  $k$ , which has an indirect effect on bank's liquidity risk. If a bank with larger  $k$  chooses higher  $s$ , then the indirect effect would be negative, which may lead to higher liquidity risk.

The implications of the above analysis for observable data can be summarized as follows:

**Hypothesis 2** *If the overcollateralisation of secured funding is sufficiently high, in a cross section of banks with endogenously chosen asset encumbrance level, it is possible that bank's unsecured funding cost  $D$  is positively correlated with bank's level of asset encumbrance  $s$ .*

We illustrate this result in the following numerical example.

[Figure 3]

We now turn to empirical evidence on the relationship between asset encumbrance and credit risk premiums of banks.

## 6 Empirical evidence

In this section, we provide empirical evidence supporting the theoretical model described above. Namely, we run a set of regressions aimed to capture the association between the observable levels of asset encumbrance and bank credit risk. We further analyze heterogeneity of this relationship related to bank characteristics.

### 6.1 Data and Descriptive Statistics

To implement the regression analysis, we extract data from the risk disclosures of banks, including information on encumbered assets, unencumbered assets, off-balance sheet (OBS) collateral received and available for encumbrance, OBS collateral received and re-used and matching liabilities (the liabilities or obligations that give rise to encumbered assets). The baseline cross-sectional analysis is performed on the bank data as of year-end 2014. We complement the disclosure data with data on total assets and equity extracted from Bankscope to compute the asset encumbrance ratios for each institution.

Our main dependent variable in the multivariate regressions is a measure of bank risk represented by banks' average (log of) daily CDS spreads in 2015. CDS spreads are widely considered to be a good indicator of bank risk and can be a proxy for bank unsecured funding costs

(see Babihuga and Spaltro [2014]; Beau et al. [2014 Q4]). We use implied rather than market-based spreads because only the largest global institutions are involved in CDS issuance. For most banks, Fitch Solutions determines the implied spreads on a daily basis using a proprietary model that includes, as inputs, banks' financial fundamental information, distance-to-default information derived from the equity market, and other market variables. In line with the existing literature, we focus on five-year senior spreads since these contracts account for 85% of the market and are highly liquid. The data on implied CDS levels in 2015 is provided by Fitch Solutions and extracted from Bankscope. We keep only those banks in the sample that have at least 20 daily observations of CDS spreads in 2015.

Computing asset encumbrance measures at the bank level is not straightforward since accounting data provides limited information to infer the amount of banks' encumbered assets, unencumbered assets and matching liabilities. Accounting statements are accompanied by disclosures which try to shed light on the amount of assets that are collateralising transactions but, as noted by the EBA: "existing disclosures in International Financial Reporting Standards (IFRS) may convey certain situations of encumbrance but fail to provide a comprehensive view on the phenomenon" (EBA [2014]). For this reason, the EBA introduced new guidelines in 2014 proposing the requirement to disclose asset encumbrance reporting templates. EBA guidelines do not constitute a regulatory requirement and, although most did, not all of the European institutions disclosed such information.

Furthermore, there is currently no consensus as to how asset encumbrance shall be measured and different measures have been proposed. We focus on the value of encumbered assets normalized by bank's total assets as our main measure of asset encumbrance. We also use other key ratios employed by policymakers in the analysis of encumbrance. Hence, the asset encumbrance ratios capture the amount of encumbered assets as a proportion of total assets:

- The ratio of *encumbered assets to total assets*, which captures the overall proportion of balance sheet assets that have been encumbered. This ratio has been used by the Bank of England and the European Systemic Risk Board (ESRB) to undertake analysis of the UK and European banking sectors respectively (ESRB [2013], Beau et al. [2014 Q4]). We denote it as AE.
- The ratio of *encumbered assets and other collateral received and re-used to total assets and total collateral received*, which captures the overall proportion of encumbered balance sheet assets as well as off-balance sheet collateral. This ratio is used by the EBA to undertake their risk assessment of the European banking system and to apply more



comprehensive regulatory reporting requirements (EBA [2016]). We denote this ratio as  $AE^+$ .

The third ratio focuses instead on unencumbered assets:

- The ratio of *unsecured liabilities to unencumbered assets* (ULUA), which captures the unsecured creditor's claims as a proportion of assets which are not subject to collateral agreements. This ratio was highlighted by the Bank of International Settlements' Committee on the Global Financial System (CGFS [2013]) as the preferred measure of asset encumbrance.

We report all the encumbrance measures in percentage points. The computation of each ratio is illustrated in figure 4.

[Figure 4]

A significant part of banks discloses composition of encumbered assets, in particular, in the part of encumbrance of debt securities and other assets. In a few cases when the sum of encumbered assets exceeds the corresponding total values, we treat the former as an absolute measure of encumbered assets. Similarly, when the sum of the components of unencumbered assets exceeds the reported total, we set the latter to be equal to the corresponding sum. The vast majority of such cases seem to be driven by rounding errors rather than systematic under-reporting.

Reporting of matching liabilities used in the calculation of ULUA is of lower quality. That is, about 14% of banks in our sample do not disclose the value of matching liabilities. For these banks we impute the values of matching liabilities normalized by the total liabilities from the corresponding median values of banks of similar business model and size category (as defined in Table 2). We further winsorize the ULUA ratio at the 97.5% level. It is important to keep in mind that a relatively weaker performance of the ULUA measure discussed below may stem, at least, partially from the data quality problems.

Explanatory variables include, in addition to the asset encumbrance measures, CAMEL and control variables. We use the following CAMEL variables:

- The Tier 1 capital ratio, which represents the ratio of high-quality capital (shareholders' capital, reserves and other perpetual capital resources such as subordinated debt), divided by risk-weighted assets (RWA).

- The ratio of unreserved impaired loans to equity, which is another indicator of the quality of the loan portfolio but expressed relative to common equity. It is also known as the “capital impairment ratio”.
- The return on assets ratio (ROA), which is an indicator of the return on a firm’s investments and is calculated by dividing the bank’s net income over its total assets.
- The net loans to deposits and short-term funding ratio, which is a measure of structural liquidity. A lower value of the ratio means the bank relies to a greater extent on more stable deposit funding, as opposed to wholesale funding, to finance its loan book.
- The liquid assets to total assets ratio, which measures the amount of liquid assets that the bank holds and that could be converted into cash to withstand a liquidity stress event.

In our robustness exercise we extend this set of CAMEL variables to include other characteristics of bank operations as in Chiaramonte and Casu [2013], in particular, bank’s leverage ratio, the ratio of loan-loss reserve to gross loans, which measures the quality of the loan portfolio by indicating the proportion of reserves for losses relative to the banks’ loan portfolio, and the return on equity ratio (ROE). Due to potential multicollinearity issues, we treat as baseline the set of CAMEL variables listed above rather than the extended one. As in the case of missing matching liabilities, we impute the few missing CAMEL variable from the median values of the corresponding variables of banks belonging to similar size group and business type.

Control variables include bank size (measured by the natural logarithm of total assets) and central bank exposure to total liabilities. We include dummy variables to differentiate the business model of the institution using three categories: “Commercial banks and Bank holding companies (BHC)”, “cooperative and savings banks” and “other banks”. We also include dummy variables indicating banks incorporated in Eurozone and banks from the GIIPS countries. Furthermore, we include a dummy variable to identify which banks are investment grade. We use implied ratings in order to avoid compromising the sample size, in a similar fashion to CDS spreads. Implied ratings are provided by Fitch Solutions and derived from proprietary fundamental data. These provide a forward-looking assessment of the stand-alone financial strength of a bank and are categorized according to a 10-point rating scale from A to F where A denotes the maximum creditworthiness, with four interim scores (A/B, B/C, C/D and D/E).

Our final data sample includes institutions with total assets above €1bn for which CDS spreads, asset encumbrance, CAMEL and control variables are available, resulting in 534 banks from 21 countries.

Table 1 presents the summary statistics of the variables of study. The mean values of AE, AE<sup>+</sup> and ULUA are 12.8%, 13.2% and 0.92 respectively.<sup>13</sup> Note that there is a wide disparity across banks in our sample. AE and AE<sup>+</sup> present standard deviations of 9.1% and 9.3% respectively, while the coefficient of variation of ULUA is significantly lower. One should also mention that the AE and AE<sup>+</sup> measures are highly correlated (coefficient of correlation 0.98), while ULUA is correlated only moderately with the other encumbrance measures (0.49 and 0.47 with AE and AE<sup>+</sup> correspondingly).

[Table 1]

Table 2 shows the mean levels of the asset encumbrance ratios across rating categories. If anything, banks within the most extreme categories, A/B and E/F, present the lowest mean AE and AE<sup>+</sup> ratios of all categories. For ULUA, the pattern of means conditional on credit rating is even less obvious.

[Table 2]

As shown in the same table, mean encumbrance levels tend to increase with bank size, measured in terms of total assets, across all ratios. This can be related to the fact that securitisation — an important source of encumbrance — involves substantial costs, mostly of a fixed nature, which could be particularly important to issue for smaller banks (Adrian and Shin [2010], Panetta and Pozzolo [2010], Carbó-Valverde et al. [2012]). Table 2 also reports the mean ratio levels by type of institution. We distinguish between “commercial banks and bank holding companies (BHC)”, “cooperative banks”, “savings banks” and “other banks”, including mortgage banks and pure investment banks. Savings banks tend to have lower levels for both AE(+) and ULUA.

Summary statistics of variables used in the baseline cross-sectional estimation is presented in Table 3. In our regression analysis, we use log transformations of encumbrance ratios as it seems reasonable to assume that the effect of encumbrance is not linear. We also report the summary statistics of off- and on-balance sheet ratios, in particular, (log of) encumbered assets on- and off- balance sheet to on-balance encumbrance ( $\ln AE^{\text{On+Off}} / AE^{\text{On}}$ ), as well as the log ratio of on-balance assets to total — on- and off-balance — assets ( $\ln TA^{\text{On}} / TA^{\text{On+Off}}$ ). We do this to compare the statistical relationship between AE, AE<sup>+</sup> and CDS: as AE<sup>+</sup> can be related to AE via simple adjustments through on- and off-balance encumbrance and total assets, one can

---

<sup>13</sup>These average encumbrance measures are somewhat lower than the ones estimated by EBA. This is likely to be driven by the fact that EBA collects information mostly from larger banks. See also the comments to Table 2.

analyze the exact source of statistical association between  $AE^+$  and bank credit risk. Similarly, for low levels of AE, log of ULUA can be approximated as on-balance sheet encumbrance adjusted for the log of the share of total assets financed with unsecured liabilities ( $\ln UL / TA$ ). We report the latter as well to support further discussion of the relevance of different metrics of encumbrance.

[Table 3]

## 6.2 Regression analysis

Table 4 reports the results of the baseline regressions. To account for the potential correlation of the errors among the banks belonging to the same business category in a given country, we apply country-business model clustering in all our regression models. The latter restricts the inference to rather conservative conclusions in which, for example, German saving banks are effectively treated as one observation when assessing the statistical importance of the effects. Column 1 reports the association of encumbrance and CDS premiums without conditioning on bank or country characteristics. Column 2 adds observables; column three eliminates between-country variation and conditions on bank business model.

[Table 4]

A negative and significant association between banks' implied CDS spreads and asset encumbrance emerges across all models. That is, higher levels of on-balance sheet encumbrance are associated with *lower* levels of credit risk premiums, although, quantitatively the relationship is rather moderate. This result is robust to conditioning on observable characteristics, as well as to accounting for unobservable determinants of CDS and asset encumbrance at the levels of country and business model. Thus, our initial evidence suggests a net positive perception of creditors towards asset encumbrance. As suggested in the theoretical discussion, higher collateralisation could lead to a lower probability of default due to diminished liquidity risks and, hence, reduce credit risk premiums.

Table 5 reports similar results with  $AE^+$  as the explanatory variable.<sup>14</sup> Given high correlation of the simple on-balance sheet encumbrance AE and its off-balance sheet augmented version  $AE^+$ , the robustness of our previous conclusions is not surprising. What is more interesting is the separate role of off-balance sheet encumbrance in this relationship. Intuitively,

---

<sup>14</sup>We do not report coefficients on the control variables to preserve space — full outputs can be obtained from authors on request.

the difference between AE and its augmented version  $AE^+$  is driven by the total-to-on-balance encumbrance ratio  $AE^{On+Off} / AE^{On}$ , and the share of on-balance activities in the total balance sheet of a bank  $TA^{On} / TA^{On+Off}$ . Hence, lower panel of Table 5 reports the estimates where  $\ln AE^+$  is replaced with a linear combination of the above three components. It shows that much of the relationship between  $AE^+$  and CDS can be attributed to the co-movement of on-balance encumbrance AE with bank credit risk while the other two components play a smaller role. Thus, the ratio of total encumbrance to on-balance sheet collateral appears to be positively related to CDS, however, this result is robust only when conditioning on other observable characteristics. Given that 81% of banks in our sample do not have off-balance encumbrance, this result should be taken with caution. The general off-balance sheet activities, in their turn, do not exhibit any statistical association with the levels of bank credit risk.

[Table 5]

Table 6 presents the results of a similar exercise with ULUA. In general when measured as the ratio of unsecured liabilities to unencumbered assets, the negative relationship between encumbrance and bank credit risk is somewhat weaker statistically. This could be related to the problems of reporting of matching liabilities discussed above, or to the fact that ULUA captures both the encumbrance composition of the asset side of banks' balance sheets as well as their shares of unsecured funding. When these two factors are included in the regression separately (lower panel of Table 6), only the asset side encumbrance ratio AE remains statistically relevant.

[Table 6]

We next perform a series of robustness checks of the above mentioned results. First, following Chiamonte and Casu [2013] we include other CAMEL variables to account for other factors that may drive encumbrance and CDS premiums. The results are reported in Table 7. On-balance encumbrance ratio AE remains negatively associated with bank credit risk at conventional levels of statistical significance.

[Table 7]

Next, we include past levels of credit risk (average of daily  $\ln$  CDS in 2014) as an additional control (Table 8, upper panel). All the specifications — including the ones with ULUA — demonstrate the established negative relationship between encumbrance ratios and credit risk levels in 2015. We further rerun our baseline specifications using weighted estimators where weight of each observation is proportional to bank total assets. By doing this we aim to test

the sensitivity of our conclusions to imposing lower weights of observations corresponding to smaller banks — especially saving and cooperative banks in Germany and Italy — that dominate our sample. The lower panel of Table 8 demonstrates that, if anything, the estimated relationship becomes more sizable economically.

[Table 8]

In our next round of robustness checks we extend the sample in time and include encumbrance data from the years 2016 and 2017. This, however, drastically affects the sample size. First, the implied CDS spreads are no longer provided by Fitch Solutions for the later years of the sample. Hence, we opt for implied CDS provided by Bloomberg, and the latter has a lower coverage. Secondly, many banks do not keep the older reports on their web sites and disclose only current financial data which makes it difficult to obtain encumbrance ratios for the interim period. The rest of the variables are obtained and constructed in the way similar to the cross-sectional data set. The matched sample of extended encumbrance measures and implied CDS contains 99 banks.<sup>15</sup> The summary statistics of variables used in panel estimation is reported in Table 9.

[Table 9]

Table 10 presents the panel estimates. We run regression specifications both in levels and in differences to verify the stability of the baseline result. Column 1 and 2 report specifications in levels with the latter presenting the estimates of the relationship between asset encumbrance and bank risk using only within bank variation. Columns 3 and 4 instead present estimates obtained in first differences — without and with control variables, correspondingly. In addition to the standard controls, in each regression we condition on the year indicators. The results confirm our baseline conclusion that higher on-balance encumbrance ratio is associated with lower credit risk. Given that between-bank variation is the predominant source of variation of encumbrance ratios, we find these results particularly important.

[Table 10]

### **6.3 Heterogeneity of the relationship between asset encumbrance and bank credit risk**

While the results of the previous section conform well with the predictions of the theoretical model in part of average co-relation of encumbrance levels and bank credit risk, its conclusions

---

<sup>15</sup>Matching encumbrance with market CDS would result in a sample that is more than three times smaller.

are silent about the heterogeneity of this relationship and its sources. In this section, we fill in this gap.

We perform the analysis of effect heterogeneity with the baseline cross-sectional data of encumbrance ratios in 2015. Furthermore, rather than following the traditional approach of interacting encumbrance ratios with all potential bank characteristics to study the dimensions of heterogeneity, we opt for grouping CAMEL variables into a smaller number of factors that underlie bank financial ratios. This allows for a clearer separation of the forces that drive encumbrance-risk heterogeneity, and at the same time minimizes the issues of multicollinearity that could arise when several interaction variables have strong common components.

In particular, we perform a simple Principal Component Analysis of the correlation matrix of bank CAMEL variables included as control variables in the previous section, i.e. The Tier 1 capital ratio, The ratio of unreserved impaired loans to equity, The return on assets ratio, The net loans to deposits and short-term funding ratio, and The liquid assets to total assets ratio.<sup>16</sup> We choose two principal components that explain approximately 60% of total variance. The resulting factor loadings are reported in Table 11.

[Table 11]

The table indicates that the first factor loads positively on bank capital and profitability and negatively on low quality of loans as measured by the ratio of unreserved impaired loans to equity. At the same time, it has close to zero relevance to liquidity variables. Hence, we call the first component “Capital”: it reflects profitability of the assets as well as risks associated with their quality and leverage structure. Higher Capital scores are assigned to well capitalized banks with profitable assets and high quality of credit portfolios. The second component, on the contrary, loads positively on loans to deposits ratio and negatively on the share of liquid assets in total assets of a bank. Since in the case of the second component the loadings on capital-related ratios are substantially smaller in magnitude, we call it “Liquidity” factor. Hence, higher values of the predicted scores for the Liquidity factor indicate *lower* liquidity of bank’s balance sheet or more fragile funding structure.

We next proceed by running baseline regressions similar to the ones of Table 4 but with AE ratio interacted with the Capital and Liquidity scores of each bank obtained from PCA. The results are presented in Table 12, where both scores are demeaned and standardized to have unit standard deviation. Columns 1 and 2 introduce interaction of AE with the Capital score: unconditionally as well as with the full set of controls and country fixed effects estimator. The capital

---

<sup>16</sup>We also performed factor analysis of the correlation matrix of these variables and obtained conceptually very similar results.

score is negatively associated with the credit risk. Also, similarly to the results of the previous section, a bank with an average capital score demonstrates negative relationship between encumbrance and credit risk. However, the association of encumbrance and CDS premium does not seem to depend much on the capital score of the bank: the estimated coefficients on the interaction of AE and capital score are close to zero and estimated very imprecisely.

[Table 12]

Bank's liquidity, on the contrary, seems to be more relevant for the relationship between its encumbrance and credit risk. Thus, the coefficient on double interaction of AE and bank liquidity is positive and statistically significant at conventional levels. Moreover, liquidity seems to have a strong economic significance for the estimated relationship between encumbrance and credit risk: the interaction coefficient is of the same magnitude as the non-interacted AE: an increase of one standard deviation in liquidity score can offset the negative relationship between encumbrance and credit risk. Put differently, for banks with sufficiently illiquid balance sheets, higher encumbrance ratio correlates positively with CDS premiums — contrary to the conclusions of the previous section. At the same time, the negative relationship between AE and credit risk that was established earlier characterizes banks with the average liquidity scores; the negative relationship is quantitatively more pronounced for banks with abnormally high liquidity in their balance sheets.

## 7 Conclusion

Asset encumbrance has been a much-discussed subject in recent literature and policymakers have been actively addressing what some regulators consider to be excessive levels of asset encumbrance. In this paper, we provide a theoretical model that captures the relationship between asset encumbrance and bank liquidity risk. According to this model, secured funding serves as a mechanism that change bank's exposure to liquidity risks. When the degree of over-collateralization is not high, a bank can fully exploit the stability of secured financing and reduce its liquidity risks associated with the unsecured debt holders. Hence, asset encumbrance and risk premiums would have a negative relationship.

In an alternative situation when a bank faces high rates of over-collateralization, asset encumbrance can have an opposite effect on bank's liquidity risk. In this case, as collateralization requires relatively large amount of pledgeable assets, the negative structural subordination effect dominates the positive impact of asset encumbrance. Hence, the relationship between



encumbrance and bank risk premiums can be positive when a bank faces adverse conditions of collateralization.

We next provide empirical analysis that supports the theoretical predictions. We show that asset encumbrance is, on average, negatively associated with bank risk across different asset encumbrance measures. We also show that liquidity of bank plays a mediating role in the relationship between asset encumbrance and bank risk. Thus, for banks with less liquid balance sheets, higher encumbrance ratios are likely to signal higher credit risks. On the contrary, banks with more liquid assets or more stable funding exhibit stronger negative relationship between asset encumbrance and CDS premiums. These results suggest that regulators need to be cautious before leaping to all-encompassing conclusions when assessing the effects of asset encumbrance levels.

## References

- Tobias Adrian and Hyun Song Shin. Liquidity and leverage. *Journal of financial intermediation*, 19(3):418–437, 2010.
- Toni Ahnert, James Chapman, et al. Asset encumbrance, bank funding and fragility. Technical report, European Systemic Risk Board, 2017.
- Franklin Allen and Douglas Gale. Limited market participation and volatility of asset prices. *The American Economic Review*, pages 933–955, 1994.
- Rita Babihuga and Marco Spaltro. *Bank funding costs for international banks*. Number 14-71. International Monetary Fund, 2014.
- BCBS. Basel iii: The liquidity coverage ratio and liquidity risk monitoring tools. *Basel Committee on Banking Supervision, BIS*, 2013.
- Emily Beau, John Hill, Tanveer Hussain, and Dan Nixon. Bank funding costs: what are they, what determines them and why do they matter? *Bank of England Quarterly Bulletin*, 2014 Q4.
- Allen N Berger and Gregory F Udell. Collateral, loan quality and bank risk. *Journal of Monetary Economics*, 25(1):21–42, 1990.
- Markus Brunnermeier and Arvind Krishnamurthy. Liquidity mismatch. In *Risk Topography: Systemic Risk and Macro Modeling*. University of Chicago Press, 2014.
- Ricardo J Caballero and Emmanuel Farhi. A model of the safe asset mechanism (sam): Safety traps and economic policy. Technical report, National Bureau of Economic Research, 2013.
- Charles W Calomiris and Charles M Kahn. The role of demandable debt in structuring optimal banking arrangements. *The American Economic Review*, pages 497–513, 1991.
- Santiago Carbó-Valverde, David Marques-Ibanez, and Francisco Rodríguez-Fernández. Securitization, risk-transferring and financial instability: The case of Spain. *Journal of International Money and Finance*, 31(1):80–101, 2012.
- CGFS. Asset encumbrance, financial reform and the demand for collateral assets. *Committee on the Global Financial System, BIS*, 49, 2013.

- Yuk-Shee Chan and Anjan V Thakor. Collateral and competitive equilibria with moral hazard and private information. *The Journal of finance*, 42(2):345–363, 1987.
- Laura Chiaramonte and Barbara Casu. The determinants of bank cds spreads: evidence from the financial crisis. *The European Journal of Finance*, 19(9):861–887, 2013.
- De Nederlandsche Bank. Keeping encumbrance to a minimum. *Bank Newsletter, April 2016*, 2016.
- Mario Di Filippo, Angelo Ranaldo, and Jan Wrampelmeyer. Unsecured and secured funding. 2016.
- Douglas W Diamond and Philip H Dybvig. Bank runs, deposit insurance, and liquidity. *Journal of political economy*, 91(3):401–419, 1983.
- Douglas W Diamond and Raghuram G Rajan. Liquidity risk, liquidity creation, and financial fragility: A theory of banking. *Journal of political Economy*, 109(2):287–327, 2001.
- Jason Roderick Donaldson, Denis Gromb, and Giorgia Piacentino. The paradox of pledgeability. 2017.
- EBA. Guidelines on disclosure of encumbered and unencumbered assets. *European Banking Authority/GL/2014/03*, 2014.
- EBA. Eba report on asset encumbrance. *European Banking Authority reports*, 2016.
- ESRB. Recommendations of the european systemic risk board of 20 december 2012 on funding of credit institutions. *ESRB reports*, 2013.
- European Commission. Commission implementing regulation (eu) 2015/79 of 18 december 2014. *Commission Implementing Regulation*, 2015.
- Xavier Freixas and Jean-Charles Rochet. *Microeconomics of banking*. MIT press, 2008.
- Toni Ahnert Kartik Anand Prasanna Gai and James Chapman. Asset encumbrance, bank funding and fragility. 2017.
- Nicola Gennaioli, Andrei Shleifer, and Robert Vishny. Neglected risks, financial innovation, and financial fragility. *Journal of Financial Economics*, 104(3):452–468, 2012.

- Itay Goldstein and Ady Pauzner. Demand–deposit contracts and the probability of bank runs. *the Journal of Finance*, 60(3):1293–1327, 2005.
- Gary Gorton, Stefan Lewellen, and Andrew Metrick. The safe-asset share. *The American Economic Review*, 102(3):101–106, 2012.
- Stig Helberg and Snorre Lindset. How do asset encumbrance and debt regulations affect bank capital and bond risk? *Journal of Banking & Finance*, 44:39–54, 2014.
- IMF. Changes in bank funding patterns and financial stability risks. *IMF Global Financial Stability Report*, 2013.
- ISDA. Isda margin survey 2015. *International Swaps and Derivatives Association*, 2015.
- Reimo Juks. Asset encumbrance and its relevance for financial stability. *Sveriges Riksbank Economic Review*, page 3, 2012.
- Brandon Julio, Woojin Kim, and Michael Weisbach. What determines the structure of corporate debt issues? Technical report, National Bureau of Economic Research, 2007.
- Arvind Krishnamurthy and Annette Vissing-Jorgensen. The aggregate demand for treasury debt. *Journal of Political Economy*, 120(2):233–267, 2012.
- Rafael Matta and Enrico C Perotti. Insecure debt. *CEPR Discussion Papers*, 2015.
- Greg Nini, David C Smith, and Amir Sufi. Creditor control rights and firm investment policy. *Journal of Financial Economics*, 92(3):400–420, 2009.
- Fabio Panetta and Alberto F Pozzolo. Why do banks securitize their assets? bank-level evidence from over one hundred countries. *Working paper*, 2010.
- Manmohan Singh. Collateral, netting and systemic risk in the otc derivatives market. *IMF Working Paper WP/10/99*, 2010.
- Clifford W Smith and Jerold B Warner. On financial contracting: An analysis of bond covenants. *Journal of financial economics*, 7(2):117–161, 1979.
- Jeremy C Stein. Monetary policy as financial stability regulation. *The Quarterly Journal of Economics*, 127(1):57–95, 2012.

René M Stulz and Herb Johnson. An analysis of secured debt. *Journal of financial Economics*, 14(4):501–521, 1985.

Anjan V Thakor and Gregory F Udell. Secured lending and default risk: equilibrium analysis, policy implications and empirical results. *The Economic Journal*, 101(406):458–472, 1991.

Adrian ARJM Van Rixtel and Gabriele Gasperini. Financial crises and bank funding: recent experience in the euro area. *BIS Working Papers 406*, 2013.

## A Appendix: Proofs

### Proof of proposition 1

From equation (5), we have

$$(1-s)D = \theta^* + k\phi - (1+h)\phi s$$

Substituting  $(1-s)D$  into the participation constraint (6), we get:

$$k\phi - (1+h)\phi s + \int_0^{\theta^*} \theta dF(\theta) + \int_{\theta^*}^{\bar{\theta}} \theta^* dF(\theta) = (1-s)(1+\gamma)$$

Differentiating this equation with respect to  $s$ , one gets:

$$\frac{\partial \theta^*}{\partial s} = \frac{(1+h)\phi - (1+\gamma)}{1 - F(\theta^*)}$$

Clearly,  $\partial \theta^* / \partial s < 0$  if  $(1+h)\phi = 1$ .

Q.E.D.

### Proof of proposition 2

We just need to show that the derivative of  $\Pi$  with respect to  $s$  is positive. Coupled with the participation constraint (6), the bank expected profit can be rewritten as:

$$\begin{aligned} \Pi = & \int_0^{\bar{\theta}} \theta dF(\theta) - s \int_{\theta^*}^{\bar{\theta}} dF(\theta) - (1+h)\phi s \int_0^{\theta^*} dF(\theta) \\ & + k \int_{\theta^*}^{\bar{\theta}} dF(\theta) + k\phi \int_0^{\theta^*} dF(\theta) - (1-s)(1+\gamma). \end{aligned}$$

By differentiating this equation with respect to  $s$  one gets:

$$\begin{aligned}
\frac{\partial \Pi}{\partial s} &= - \int_{\theta^*}^{\bar{\theta}} dF(\theta) - (1+h)\phi \int_0^{\theta^*} dF(\theta) + 1 + \gamma \\
&+ s \frac{\partial \theta^*}{\partial s} f(\theta^*) - (1+h)\phi s \frac{\partial \theta^*}{\partial s} f(\theta^*) \\
&- k \frac{\partial \theta^*}{\partial s} f(\theta^*) + k\phi \frac{\partial \theta^*}{\partial s} f(\theta^*) \\
&= (1 + \gamma - (1+h)\phi)F(\theta^*) + \gamma(1 - F(\theta^*)) \\
&+ s(1 - (1+h)\phi) \frac{\partial \theta^*}{\partial s} f(\theta^*) \\
&- k(1 - \phi) \frac{\partial \theta^*}{\partial s} f(\theta^*).
\end{aligned}$$

Since, by assumption,  $\phi < 1$  and  $(1+h)\phi = 1$ , we have  $\partial \theta^* / \partial s < 0$  and, hence:

$$\frac{\partial \Pi}{\partial s} = \gamma - k(1 - \phi) \frac{\partial \theta^*}{\partial s} f(\theta^*) > 0.$$

Q.E.D.

### Proof of proposition 3

Under the assumption  $h = \phi^{-1} - 1$  and uniform distribution of  $\theta$ , the liquidity cutoff  $\theta^*$  at the optimum  $s^*$  can be rewritten as

$$\theta^* = \bar{\theta} - \sqrt{\bar{\theta}^2 - 2\bar{\theta}(1+\gamma)(1-s^*)}$$

Under the similar assumptions, the definition of the liquidity cutoff simplifies to:

$$\theta^* = (1 - s^*)D$$

Combining the two, one gets:

$$D = \frac{\bar{\theta} - \sqrt{\bar{\theta}^2 - 2\bar{\theta}(1+\gamma)(1-s^*)}}{1 - s^*}$$

Taking the derivative of  $D$  with respect to  $s^*$ , one gets

$$\frac{\partial D}{\partial s^*} = \frac{\bar{\theta} \left( 1 - \frac{\bar{\theta} - (1+\gamma)(1-s^*)}{\sqrt{\bar{\theta}^2 - 2\bar{\theta}(1-s^*)(1+\gamma)}} \right)}{(1 - s^*)^2}$$

Hence, for  $\partial D/\partial s^*$  to be negative it suffices to show that

$$\sqrt{\bar{\theta}^2 - 2\bar{\theta}(1+\gamma)(1-s^*)} < \bar{\theta} - (1+\gamma)(1-s^*)$$

which is true since

$$\begin{aligned} \bar{\theta} - (1+\gamma)(1-s^*) &= \sqrt{(\bar{\theta} - (1+\gamma)(1-s^*))^2} \\ &= \sqrt{\bar{\theta}^2 - 2\bar{\theta}(1+\gamma)(1-s^*) + (1+\gamma)^2(1-s^*)^2} \\ &> \sqrt{\bar{\theta}^2 - 2\bar{\theta}(1+\gamma)(1-s^*)} \end{aligned}$$

Q.E.D.

#### Proof of proposition 4

First denote  $F_H^* \equiv F(\theta_H^*)$  and  $F_L^* \equiv F(\theta_L^*)$ . We define  $\rho$  as the *ex-ante* probability of bank survival:

$$\rho \equiv q_L(1 - F_L^*) + q_H(1 - F_H^*)$$

Rewrite the participation constraint (8) as

$$\begin{aligned} (k\phi_L - s)(1 + q_H\Delta) + q_L \left[ \int_0^{\theta_L^*} \theta dF + \theta_L^*(1 - F_L^*) \right] \\ + q_H \left[ \int_0^{\theta_H^*} \theta dF + \theta_H^*(1 - F_H^*) \right] = (1-s)(1+\gamma) \end{aligned}$$

Differentiating with respect to  $s$  one gets:

$$q_L \left[ \frac{\partial \theta_L^*}{\partial s} (1 - F_L^*) \right] + q_H \left[ \frac{\partial \theta_H^*}{\partial s} (1 - F_H^*) - \Delta F_H^* \right] = -\gamma.$$

Reorganize to get

$$\begin{aligned} \frac{\partial \theta_L^*}{\partial s} &= \frac{1}{\rho} (q_H F_H^* \Delta - \gamma) \\ \frac{\partial \theta_H^*}{\partial s} &= \frac{1}{\rho} ((q_H F_H^* + \rho) \Delta - \gamma) \end{aligned}$$

For given  $s$ ,  $F_H^*$  and  $F_L^*$  are fixed and bounded by 1, thus  $\rho$  is also bounded by 1. Also note that  $\partial \theta_L^*/\partial s$  and  $\partial \theta_H^*/\partial s$  are both continuous and increasing in  $\Delta$ . As  $\Delta$  is close to 0,  $\partial \theta_H^*/\partial s$  is negative. By the property of continuous function, there must exist some  $\Delta_L$  such that for  $\Delta = \Delta_L$ ,  $\partial \theta_H^*/\partial s$  is 0. Then for all  $\Delta < \Delta_L$ ,  $\partial \theta_L^*/\partial s$  and  $\partial \theta_H^*/\partial s$  are both negative.



By analogy, we can show for  $\Delta$  sufficiently large,  $\partial\theta_L^*/\partial s$  is positive. Therefore, there must exist  $\Delta_H$  such that for  $\Delta = \Delta_H$ ,  $\partial\theta_L^*/\partial s$  is 0. Then for all  $\Delta > \Delta_H$ ,  $\partial\theta_L^*/\partial s$  and  $\partial\theta_H^*/\partial s$  are both positive.

Lastly, for  $\Delta_L < \Delta < \Delta_H$ , we have  $\partial\theta_L^*/\partial s < 0$  and  $\partial\theta_H^*/\partial s > 0$ .

Q.E.D.

### Proof of proposition 5

From the proof of Proposition 4, we have three regions for  $\partial\theta_H^*/\partial s$  and  $\partial\theta_L^*/\partial s$ :

1.  $\partial\theta_H^*/\partial s > 0$  and  $\partial\theta_L^*/\partial s > 0$  if  $q_H F_H^* \Delta > \gamma$ ,
2.  $\partial\theta_H^*/\partial s < 0$  and  $\partial\theta_L^*/\partial s < 0$  if  $(q_H F_H^* + \rho)\Delta < \gamma$ , and
3.  $\partial\theta_H^*/\partial s > 0$  and  $\partial\theta_L^*/\partial s < 0$  if  $q_H F_H^* \Delta < \gamma < (q_H F_H^* + \rho)\Delta$ .

We study the case 3 since the other two cases give simple corner solutions.

First, given the definitions of  $\theta_H^*$  and  $\theta_L^*$ , rewrite bank's profit as

$$\begin{aligned}\Pi &= q_L \left[ (k(1 - \phi_L) - \theta_L^*)(1 - F_L^*) + \int_{\theta_L^*}^{\bar{\theta}} \theta dF \right] \\ &= q_H \left[ (k(1 - \phi_H) - \theta_H^* + \Delta s)(1 - F_H^*) + \int_{\theta_H^*}^{\bar{\theta}} \theta dF \right].\end{aligned}$$

Differentiating it with respect to  $s$  one gets

$$\begin{aligned}\frac{\partial \Pi}{\partial s} &= q_L \left[ -(k(1 - \phi_L) f_L^* \frac{\partial \theta_L^*}{\partial s} - (1 - F_L^*) \frac{\partial \theta_L^*}{\partial s} \right] \\ &= q_H \left[ -((k(1 - \phi_H) + \Delta s) f_H^* \frac{\partial \theta_H^*}{\partial s} - (1 - F_H^*) \frac{\partial \theta_H^*}{\partial s}) \right].\end{aligned}$$

Taking into account that

$$\frac{\partial \rho}{\partial s} = -q_L f_L^* \frac{\partial \theta_L^*}{\partial s} - q_H f_H^* \frac{\partial \theta_H^*}{\partial s},$$

we can rewrite  $\partial\Pi/\partial s < 0$  as:

$$\frac{\partial \Pi}{\partial s} = -\rho \frac{\partial \theta_L^*}{\partial s} + k(1 - \phi_L) \frac{\partial \rho}{\partial s} + q_H f_H^* \frac{\partial \theta_H^*}{\partial s} (k\phi_L - s)\Delta$$

This implies that at the optimum  $s$  should solve

$$s^* = \left[ -\rho \frac{\partial \theta_L^*}{\partial s} + k(1 - \phi_L) \frac{\partial \rho}{\partial s} \right] \left[ q_H f_H^* \Delta \frac{\partial \theta_H^*}{\partial s} \right]^{-1} + k\phi_L.$$

Note that  $k\phi_L$  is the maximum amount of secured funds  $s$  that can be achieved by the bank in

any equilibrium; hence, given that  $\partial\theta_H^*/\partial s > 0$ , it must be that

$$-\rho \frac{\partial\theta_L^*}{\partial s} + k(1 - \phi_L) \frac{\partial\rho}{\partial s} \leq 0,$$

That is

$$\frac{\partial\rho}{\partial s} \leq \frac{q_H F_H^* \Delta - \gamma}{k(1 - \phi_L)} < 0,$$

which is satisfied for Uniform  $F$ .

Next, since

$$\begin{aligned} \frac{\partial^2\theta_L^*}{\partial s^2} &= \frac{1}{\rho^2} \left[ q_H f_H^* \Delta \rho \frac{\partial\theta_H^*}{\partial s} - (q_H F_H^* \Delta - \gamma) \frac{\partial\rho}{\partial s} \right] \\ &= \frac{1}{\rho} \left[ q_H f_H^* \Delta \frac{\partial\theta_H^*}{\partial s} - \frac{\partial\theta_L^*}{\partial s} \frac{\partial\rho}{\partial s} \right] \\ &= \frac{1}{\rho} \left[ q_H f_H^* \left( \frac{\partial\theta_H^*}{\partial s} - \frac{\partial\theta_L^*}{\partial s} \right) \frac{\partial\theta_H^*}{\partial s} - \frac{\partial\theta_L^*}{\partial s} \frac{\partial\rho}{\partial s} \right] \\ &= \frac{1}{\rho} \left[ q_H f_H^* \left( \frac{\partial\theta_H^*}{\partial s} \right)^2 - \frac{\partial\theta_L^*}{\partial s} \left( q_H f_H^* \frac{\partial\theta_H^*}{\partial s} + \frac{\partial\rho}{\partial s} \right) \right] \\ &= \frac{1}{\rho} \left[ q_H f_H^* \left( \frac{\partial\theta_H^*}{\partial s} \right)^2 + q_L f_L^* \left( \frac{\partial\theta_L^*}{\partial s} \right)^2 \right] > 0, \\ \frac{\partial^2\theta_H^*}{\partial s^2} &= \frac{\partial^2\theta_L^*}{\partial s^2} > 0, \end{aligned}$$

and the fact that under the assumption of Uniform  $F$  the second derivative of profits is

$$\frac{\partial^2\Pi}{\partial s^2} = -\frac{\partial^2\theta_L^*}{\partial s^2} \left[ k(1 - \phi_L)(q_L f_L^* + q_H f_H^*) + \rho - q_H f_H^* \Delta(k\phi_L - s) \right] - q_H f_H^* \Delta \frac{\partial\theta_H^*}{\partial s},$$

the interior optimum is a maximum as long as

$$q_H f_H^* \Delta(k\phi_L - s) < k(1 - \phi_L)(q_L f_L^* + q_H f_H^*) + \rho.$$

Using the FOC, rewrite the LHS of this inequality as

$$\begin{aligned}
q_H f_H^* \Delta (k\phi_L - s) &= q_H f_H^* \Delta \left[ \rho \frac{\partial \theta_L^*}{\partial s} - k(1 - \phi_L) \frac{\partial \rho}{\partial s} \right] \left[ q_H f_H^* \Delta \frac{\partial \theta_H^*}{\partial s} \right]^{-1} \\
&= \rho \frac{\partial \theta_L^* / \partial s}{\partial \theta_H^* / \partial s} - k(1 - \phi_L) \frac{\partial \rho / \partial s}{\partial \theta_H^* / \partial s} \\
&= \rho \left( 1 - \frac{\Delta}{\theta_H^* / \partial s} \right) + k(1 - \phi_L) \left[ q_L f_L^* \left( 1 - \frac{\Delta}{\theta_H^* / \partial s} \right) + q_H f_H^* \right] \\
&= \rho + k(1 - \phi_L)(q_L f_L^* + q_H f_H^*) - \frac{\Delta}{\theta_H^* / \partial s} (\rho + k(1 - \phi_L) q_L f_L^*) \\
&< \rho + k(1 - \phi_L)(q_L f_L^* + q_H f_H^*).
\end{aligned}$$

Therefore, we conclude that  $\partial^2 \Pi / \partial s^2 < 0$ .

If  $\frac{\partial \Pi}{\partial s} \big|_{s=0} < 0$ , let  $\hat{s} = 0$ . Clearly for all  $s > \hat{s}$ ,  $\frac{\partial \Pi}{\partial s} < \frac{\partial \Pi}{\partial s} \big|_{s=0} < 0$ .

If  $\frac{\partial \Pi}{\partial s} \big|_{s=\frac{k}{1+h}} > 0$ , let  $\hat{s} = \frac{k}{1+h}$ . Clearly for all  $s < \hat{s}$ ,  $\frac{\partial \Pi}{\partial s} > \frac{\partial \Pi}{\partial s} \big|_{s=\frac{k}{1+h}} > 0$ .

If  $\frac{\partial \Pi}{\partial s} \big|_{s=0} > 0$  and  $\frac{\partial \Pi}{\partial s} \big|_{s=\frac{k}{1+h}} < 0$ , by the intermediate value theorem, there exists  $\hat{s} \in [0, \frac{k}{1+h}]$  such that  $\frac{\partial \Pi}{\partial s} \big|_{s=\hat{s}} = 0$ . For all  $s < \hat{s}$ ,  $\frac{\partial \Pi}{\partial s} > \frac{\partial \Pi}{\partial s} \big|_{s=\hat{s}} = 0$ , and for all  $s > \hat{s}$ ,  $\frac{\partial \Pi}{\partial s} < \frac{\partial \Pi}{\partial s} \big|_{s=\hat{s}} = 0$ .

Q.E.D.

**Proof of proposition 6**—to be completed

## B Appendix: Definitions and Sources of Asset Encumbrance

In this section we review the definitions of asset encumbrance and describe how assets become encumbered. We also review the most common sources of asset encumbrance (i.e. the liabilities or obligations that give rise to encumbered assets).

### B.1 Defining asset encumbrance

European regulations define encumbered assets as “*assets pledged or subject to any form of arrangement to secure, collateralize or credit enhance any transaction from which it cannot be freely withdrawn*”.<sup>17</sup> The Basel Committee on Banking Supervision (BCBS) defines unencumbered assets as those assets which are “*free of legal, regulatory, contractual or other restrictions on the ability of the bank to liquidate, sell, transfer, or assign the asset*”.<sup>18</sup>

To clarify the definition of encumbrance, let us consider a bank (Bank A) whose assets include loans and a portfolio of securities (government or corporate bonds, equities, etc.), financed via equity capital, retail deposits and unsecured wholesale funding, as shown in the left hand side of figure 5. Bank A could obtain additional funding from a counterparty, let us say Bank B, by entering into a secured financing transaction, as shown in the right hand side of figure 5. Under such arrangement Bank A provides collateral to Bank B in order to mitigate the risk of failing to keep interest repayments or repaying the borrowings. In exchange, Bank A benefits from cheaper funding when compared to an equivalent unsecured transaction.<sup>19</sup> The arrangement imposes restrictions to Bank A on its ability to sell, transfer or dispose of the collateral provided during the term of the transaction. Bank A would consider such assets encumbered.

[Figure 5]

Figure 5 represents the securities provided as collateral as recorded or recognised in Bank A’s balance sheet rather than being transferred to Bank B’s balance sheet. Collateral obtained by Bank B is therefore represented in an off-balance sheet (OBS) rather than an on-balance sheet, and is known as “OBS collateral” or simply “collateral received”. The assumption that the collateral remains recognised from Bank A’s balance sheet is a necessary condition for being considered an encumbered asset of Bank A. If the assets used as collateral were derecognised

---

<sup>17</sup>See European Commission [2015].

<sup>18</sup>See BCBS [2013]

<sup>19</sup>In addition, the arrangement may provide for savings in regulatory capital requirements to Bank B as well as lower regulatory liquidity requirements to Bank A and Bank B.

by Bank A then they would be recognised by Bank B and they would not be encumbered for Bank A.

In practice, the recognition or derecognition of collateral provided depends on the contractual terms of the transaction as well as its accounting treatment. Derecognition cannot occur unless the securities are transferred to the counterparty. This can be achieved by using “title transfer” arrangements, whereby full ownership of the collateral is passed on to the counterparty during the term of the transaction.<sup>20</sup> Collateral can also be provided under “security interest” arrangements, which do not transfer ownership but concede rights to the counterparty to obtain full ownership of the collateral under some pre-determined event, such as failure to repay.<sup>21</sup> The use of one technique over the other depends on market practice. Collateral provided in secured financing transactions such as repurchase agreements (i.e. repo) is typically provided by way of title transfer whereas collateral used as a margin for OTC derivatives can be provided using both methods.<sup>22</sup>

The transfer of title over collateral, however, is not a sufficient condition for derecognition to occur, with the actual outcome depending on the applicable accounting treatment. Under International Financial Reporting Standards (IFRS), IAS 39 applies a set of tests to assess whether (i) the risks and rewards and (ii) control over the asset have been transferred.<sup>23</sup> If the risks and rewards have not been transferred, or in other words, if the collateral provider continues to be exposed to the risks of ownership of the assets such as loss in market value and/or the benefits that they generate such as dividends, then the collateral would remain recognised on its balance even if a transfer of assets has occurred. But even if the risks and rewards had been transferred, further control tests are undertaken to understand which entity controls the asset. If the collateral provider could direct how the benefits of that asset are realised, then the collateral would not be derecognised either.

As illustrated in figure 5, the value of securities that Bank A posted as collateral is higher than the value of the borrowings. This practice is known as overcollateralisation and is intended to mitigate the risk of the collateral falling in value during the term of the transaction. It is usually undertaken by means of a “haircut” or “margin ratio”.<sup>24</sup> Collateral agreements often

---

<sup>20</sup>Under title transfer, Bank B would have to return the collateral (or equivalent securities) to Bank A when the original transaction matures.

<sup>21</sup>Security interest arrangements are also known as collateral pledges.

<sup>22</sup>Under English Law the collateral for OTC derivatives is typically provided by way of title transfer, whereas under New York Law collateral is typically provided under security interest.

<sup>23</sup>The treatment under US GAAP (ASC 860) differs from IFRS since the focus is on whether the transferor has surrendered control over a financial asset.

<sup>24</sup>The agreed haircut or margin ratio determines the percentage by which the market value of a security is reduced for the purpose of calculating the amount of collateral being provided.

require a frequent (sometimes daily) marked-to-market valuation of the collateral and requests to top up the value of collateral, known as collateral calls, may be triggered if its market value falls below certain pre-determined threshold amounts.

Even in the case in which the collateral received is not reflected in its balance sheet, Bank B could reuse some or all of the collateral received from Bank A to obtain financing from a third party (let us say, Bank C). As illustrated in figure 6, this re-use of collateral by Bank B would result in the encumbrance of OBS collateral. As such, encumbrance can affect both on-balance sheet assets as well as OBS collateral. The practice of providing collateral that has been previously received is known as collateral re-use or re-hypothecation. It is common practice and may result in long “collateral chains”.<sup>25</sup>.

[Figure 6]

## **B.2 Sources of asset encumbrance**

The liabilities or obligations that give rise to encumbered assets are known as “sources of asset encumbrance” or “matching liabilities”. The typical bank will have encumbered assets from several sources but the simplest institutions may rely only on a single source or may present no encumbered assets at all. We now discuss some of the most common sources of asset encumbrance.<sup>26</sup>

### **B.2.1 Secured financing transactions**

Secured financing transactions encompass myriad transactions involving the temporary provision of securities to borrow cash or other securities. Common types include repurchase agreements (repos), buy/sell backs or securities borrowing and lending. Collateral in repo is provided under a title transfer but it remains recognised in the balance sheet of the collateral provider’s

---

<sup>25</sup>The terms re-hypothecation and re-use are often used interchangeably and we will do so here. In practice there are legal distinctions between them that may be relevant in a different context. Recent studies have analysed the concept of re-hypothecation and “collateral velocity”. Analytical work includes Adrian and Shin [2010] and Singh [2010] More recent work has focussed on liquidity mismatches and the role of collateral in intermediation chains. Brunnermeier and Krishnamurthy [2014] introduced the Liquidity Mismatch Index (LMI) which compares the market liquidity of assets and the funding liquidity of liabilities, thus capturing the length of collateral intermediation chains.

<sup>26</sup>In addition to the sources covered in this section, transactions that may result in encumbered assets include collateral swaps, also known as collateral upgrade transactions, where collateral of a different quality is exchanged. Collateralised guarantees rely on securities to secure an existing or future liability. Other arrangements, such as factoring which include the transfer of trade receivables to an institution may result in similar encumbrance to securitisations.

(i.e. the repo seller) since the risks and rewards of the collateral are retained.<sup>27</sup> Thus, repo collateral is encumbered for the collateral provider. Encumbered assets in repo are predominantly government bonds, followed by corporate bonds and covered bonds. Asset-backed securities and equities are also used as collateral. Most of the funding provided by central banks is transacted through repo. Like Dexia, many European banks were, and some still are, heavily reliant on repo financing from the ECB.

## **B.2.2 Asset-backed securities (ABS) and mortgage-backed securities (MBS)**

Another potential source of asset encumbrance is securitisations. These entail ABS and MBS bonds or notes being issued and receivables, which may include retail or commercial mortgages in MBS, or credit card debt or other loans in ABS, being used as collateral.

A traditional two-step securitisation involves the initial transfer of the receivables of the originating bank to a Special Purpose Vehicle (SPV) and the sale of the ABS or MBS to investors. The overall securitisation structure is intended to make sure that there is a true sale of receivables to the SPV and that the SPS is “bankruptcy remote”. Accounting standards however, may require that the SPV is consolidated into the “sponsoring” bank balance sheet, including all of its assets and liabilities, even the receivables.<sup>28</sup> If the underlying receivables were consolidated, this would result in the recognition of such receivables on the sponsor’s balance sheet. However, tests to assess whether the assets meet the criteria for accounting derecognition, as discussed earlier, shall still be undertaken. If derecognition criteria are not met the receivables would be encumbered. This is often the case since it is common for the sponsoring bank to keep an active role in the securitisation, for example, by servicing the assets or providing support by retaining certain tranches to absorb first losses and potential risks in relation to timings in the collection of the receivables.

ABS or MBS can be used as collateral to raise funding with counterparties and central banks. Thus, a common practice across some banks, especially during the Eurozone crisis, is the retention of their self-issued ABS or MBS rather than its sale to investors.<sup>29</sup> If notes are retained, they would not be encumbered. But if the notes are used to raise fresh funding, for

---

<sup>27</sup>If this was not the case, banks could artificially reduce its overall leverage by derecognising collateral in repurchase agreements. This treatment was exploited by Lehman Brothers under the well-known “Repo 105” scheme, characterised by the New York Attorney General Andrew Cuomo as a “massive accounting fraud” and leading to a review by the accounting standard setters of the accounting treatment of repo transactions.

<sup>28</sup>The consolidation models under IFRS and GAAP are relatively similar and are based on the criteria of entity control over the SPV.

<sup>29</sup>The acceptance of securitised notes as collateral in the ECB facilities led to an important increase in retention levels during the Eurozone crisis, with overall retention as a proportion of total gross issuance increasing from 26% in the first half of 2007 to 42% in the first half of 2012 (IMF [2013]).

example, from the central bank via repo, the receivables would become encumbered as it occurs in securities' financing transactions.

Figure 7 (left-hand side) illustrates how securitised receivables can be encumbered (highlighted in green) by collateralising ABSs that are either (i) sold to investors or (ii) used as repo collateral to obtain funding from another counterparty.

[Figure 7]

### **B.2.3 Covered bonds**

Covered bonds are similar to MBS but the mortgages used as collateral always remain recognised on the consolidated balance sheet of the issuing entity and thus always generate encumbrance. The issuer and the investors have dual recourse to the collateral. This feature, together with the existence of overcollateralisation requirements and the dynamic replenishment of non-performing loans in the collateral pool imply that these instruments are perceived as being very safe. There is indeed no known default on covered bonds since their inception.

The use of covered bonds as collateral has significantly increased in recent times. For many banks in peripheral European countries (GIIPS) funding collateralised by retained covered bonds became the main source of long-term funding during the Eurozone sovereign crisis, as their access to unsecured markets was partially or fully closed (Van Rixtel and Gasperini [2013]).

### **B.2.4 Derivatives**

Derivatives also generate encumbrance, as collateralisation has become a key method of mitigating counterparty credit risk in derivative markets, both on over-the-counter (OTC) and exchange-traded (ETD) derivatives. Collateralisation occurs because of the provisioning of the margin, in two different forms. A variation margin is posted during the course of the transaction to cover adverse changes in value (i.e. a negative mark-to-market value). Initial margin (also known as an independent amount) is posted at the beginning of a transaction to cover potential future adverse changes in the value of the contract, and is recalculated on a regular basis.

The margin provided is subject to restrictions and therefore constitutes encumbered assets. This is illustrated in figure 7 (right-hand side).<sup>30</sup> The margin can be provided in the form of cash

---

<sup>30</sup>The figure assumes that the variation margin is not offset against the derivative liability (i.e. the negative fair value from the derivative) therefore becoming encumbered. Some contracts allow for such an offsetting of the variation margin. The outstanding exposure between the counterparties is settled and the terms of the derivative contracts are reset so that the fair value is zero, leading to no encumbered assets due to an exchange of the variation



or securities and it is common to provide re-hypothecation rights to the counterparty. According to the latest ISDA Margin Survey, for non-cleared OTC derivatives cash represents 76.6% of the collateral provided, followed by government bonds (13.4%) and other securities (10.1%), including US municipal bonds, government agency/government-sponsored enterprises (GSEs), and equities (ISDA [2015]).

---

margin.

**List of Figures**

1 Timeline . . . . . 43

2 Low Rates of Overcollateralization . . . . . 44

3 High Rates of Overcollateralization . . . . . 45

4 Asset encumbrance metrics . . . . . 46

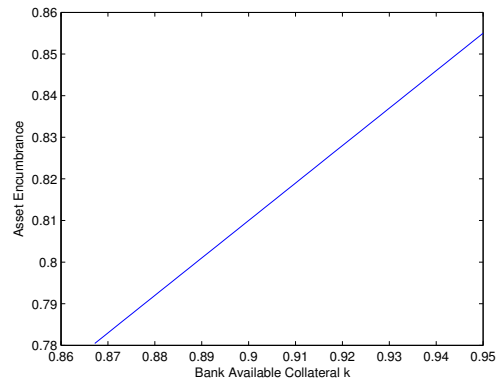
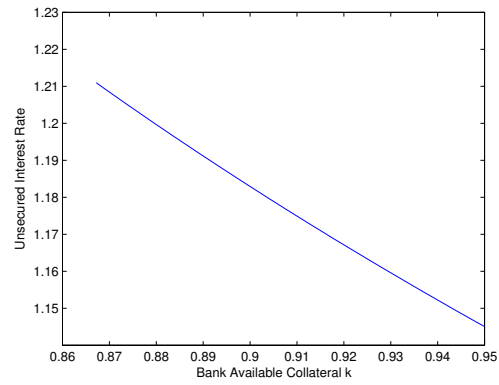
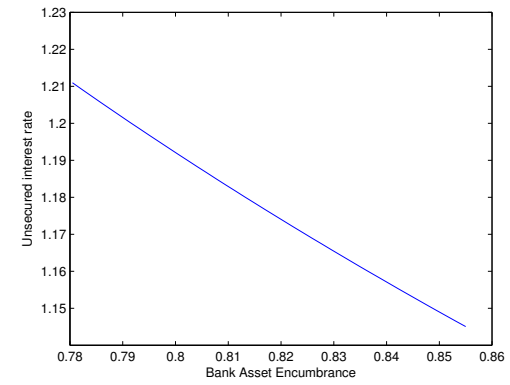
5 Encumbrance of assets when obtaining secured funding . . . . . 47

6 Collateral received and re-used . . . . . 48

7 Encumbered and unencumbered assets from securitization and derivative transactions . . . . . 49

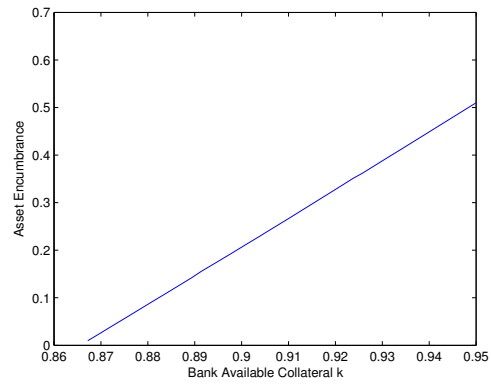
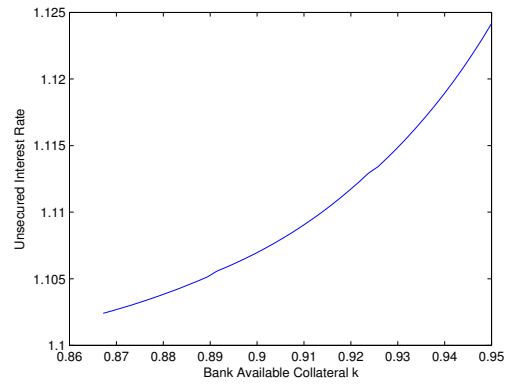
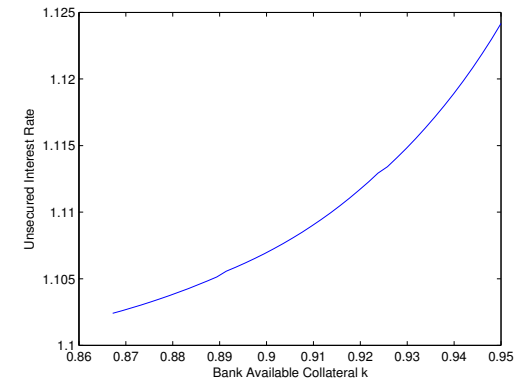


Figure 2. Low Rates of Overcollateralization

(a) Available Collateral  $k$  and Unsecured Debt Interest Rate(b) Available Collateral  $k$  and Asset Encumbrance

(c) Asset Encumbrance and Unsecured Debt Interest Rate

Figure 3. High Rates of Overcollateralization

(a) Available Collateral  $k$  and Unsecured Debt Interest Rate(b) Available Collateral  $k$  and Asset Encumbrance

(c) Asset Encumbrance and Unsecured Debt Interest Rate

Figure 4. Asset encumbrance metrics

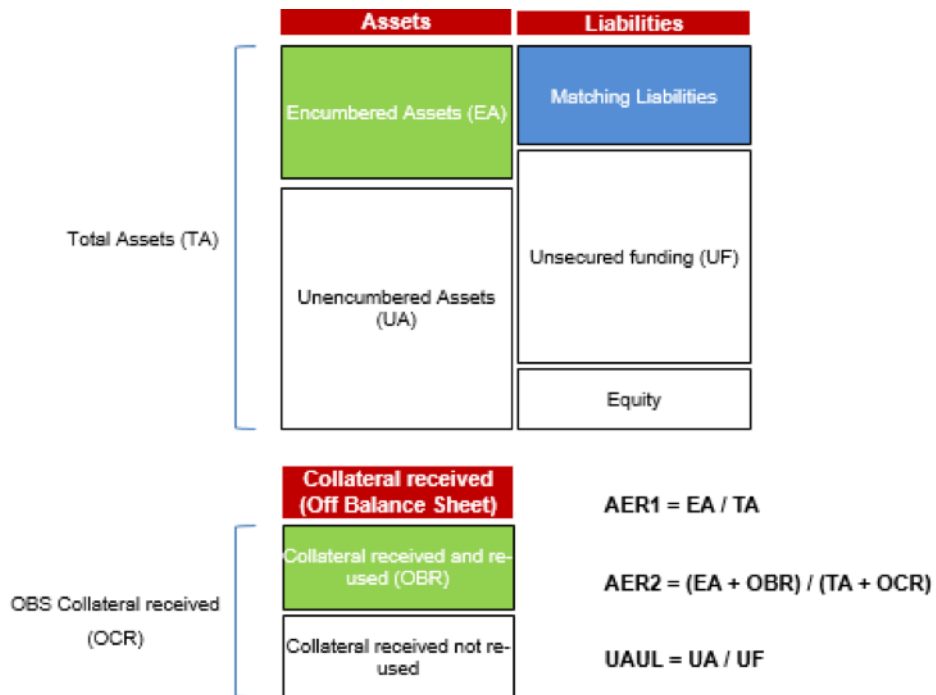


Figure 5. Encumbrance of assets when obtaining secured funding

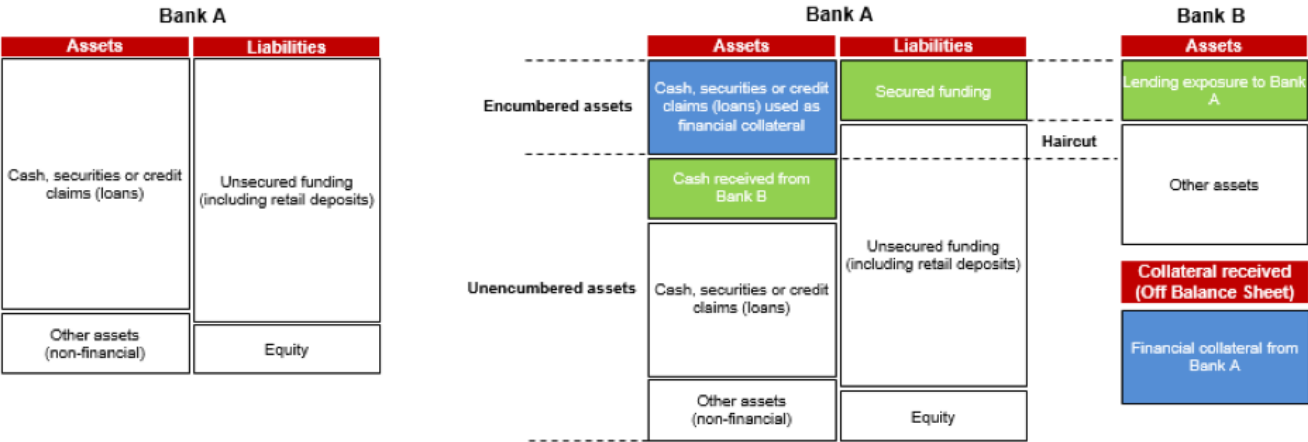


Figure 6. Collateral received and re-used

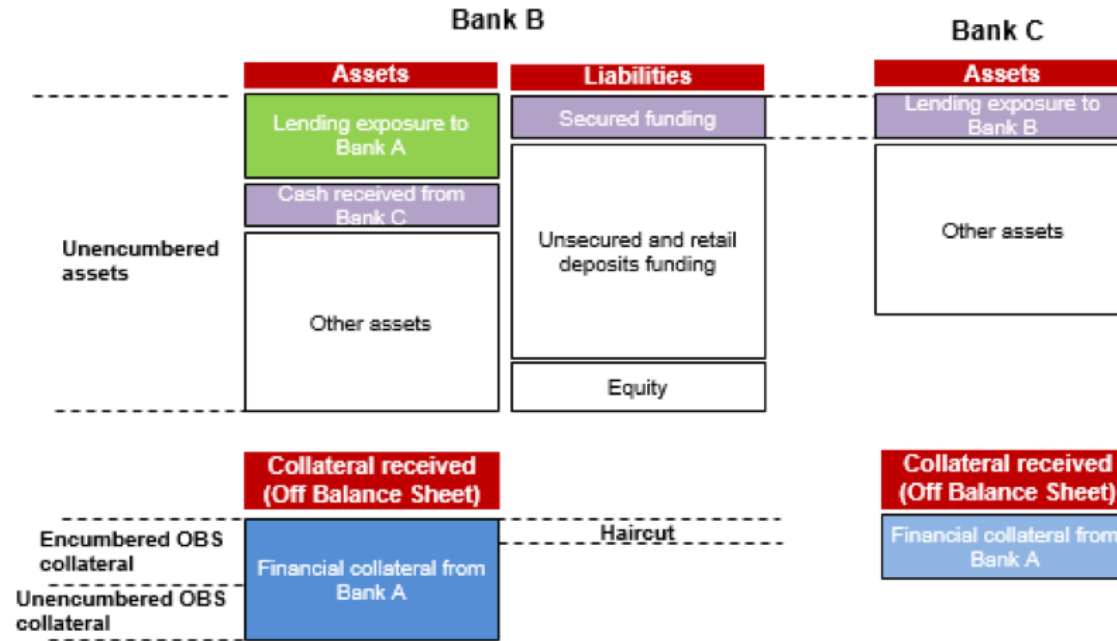




Figure 7. Encumbered and unencumbered assets from securitization and derivative transactions

	Assets	Liabilities		Assets	Liabilities
Encumbered assets	Securitized receivables backing ABS sold to investors	ABS sold to investors	-----	Variation margin	Negative fair-value from derivative transactions
	Securitized receivables backing ABS retained and repo'ed	Secured funding (repo)			
Unencumbered assets	Securitized receivables backing ABS retained (not repo'ed)	Other secured funding	-----	Initial margin	Unsecured funding
	Cash received from ABS sold to investors	Unsecured funding	-----	Other assets	
	Cash received from ABS retained and repo'ed				Equity (E)
	Other assets		-----		

## List of Tables

1	Summary of encumbrance measures . . . . .	51
2	Mean encumbrance levels by rating, size and business model . . . . .	52
3	Summary statistics of variables used in cross-sectional estimation . . . . .	53
4	CDS vs AE in a cross-section of banks . . . . .	54
5	CDS vs AE <sup>+</sup> in a cross-section of banks . . . . .	55
6	CDS vs ULUA in a cross-section of banks . . . . .	56
7	CDS vs AE in a cross-section of banks (all CAMELs) . . . . .	57
8	CDS vs AE in a cross-section of banks: controls for past level of credit risk and weighted regressions . . . . .	58
9	Summary statistics of variables used in panel estimation . . . . .	59
10	CDS vs AE in a panel of banks . . . . .	60
11	Factor loadings of CAMEL variables . . . . .	61
12	Capital, liquidity and asset encumbrance . . . . .	62

Table 1. Summary of encumbrance measures

	Mean	Median	SD	Min	Max
AE	12.8	9.1	11.9	0.1	81.0
AE <sup>+</sup>	13.2	9.3	12.2	0.1	81.0
ULUA	92.9	91.5	11.2	21.7	127.3

Encumbrance measures are in percentage points.  
Number of banks is 534.

Table 2. Mean encumbrance levels by rating, size and business model

	AE	AE <sup>+</sup>	ULUA
<i>By credit rating</i>			
A	6.8	6.8	94.5
A/B	19.2	21.1	92.9
B	14.4	14.7	94.0
B/C	11.7	12.4	92.9
C	13.1	13.3	92.6
C/D	11.5	11.7	94.5
D	7.8	8.2	91.0
D/E	11.3	11.4	79.9
E/F	2.9	2.9	84.8
<i>By bank size</i>			
< 3.5 bn	10.0	10.3	92.3
3.5–15 bn	11.0	11.5	93.1
15–50 bn	24.4	24.8	95.9
50–170 bn	28.0	28.2	91.9
170–600 bn	28.1	28.6	100.0
> 600 bn	17.1	22.1	89.0
<i>By bank type</i>			
BHC & Commercial	19.2	20.2	93.9
Cooperative	11.6	11.8	94.1
Saving	8.9	9.4	91.1
Other	25.9	26.4	96.6

Encumbrance measures are in percentage points.  
Number of banks is 534.

Table 3. Summary statistics of variables used in cross-sectional estimation

	Mean	Median	SD	Min	Max
<i>ln</i> CDS' 15 ( $\times 100$ )	506.67	504.45	26.97	454.23	639.47
<i>ln</i> AE	2.20	2.21	0.89	-1.99	4.39
<i>ln</i> AE <sup>+</sup>	2.22	2.23	0.90	-1.99	4.39
<i>ln</i> ULUA	4.52	4.52	0.14	3.08	4.85
<i>ln</i> AE <sup>On+Off</sup> / AE <sup>On</sup>	0.07	0.00	0.20	0.00	1.06
<i>ln</i> TA <sup>On</sup> / TA <sup>On+Off</sup>	-0.04	0.00	0.16	-2.56	0.00
<i>ln</i> UL / TA	-0.23	-0.18	0.17	-1.60	-0.07
Loans to deposits	75.55	73.68	23.97	18.04	201.76
Liquid assets	12.63	9.02	11.02	1.50	69.25
Tier 1 ratio	14.76	14.04	3.99	7.53	32.71
ROA	0.21	0.21	0.38	-2.17	1.47
Unreserved impaired loans	23.89	12.46	33.92	0.28	199.30
Investment grade	0.69	1.00	0.46	0.00	1.00
GIIPS	0.17	0.00	0.38	0.00	1.00
Eurozone	0.94	1.00	0.24	0.00	1.00
<i>ln</i> CDS' 14 ( $\times 100$ )	512.23	503.06	30.76	459.59	609.18

Encumbrance measures and balance sheet ratios are in percentage points.  
Number of banks is 534.

Table 4. CDS vs AE in a cross-section of banks

	(1)	(2)	(3)
<i>ln AE</i>	-7.6*** (2.47)	-3.5*** (1.23)	-3.0*** (1.07)
Loans to deposits		-0.1 (0.07)	-0.1 (0.08)
Liquid assets		0.0 (0.08)	-0.1 (0.07)
Tier 1 ratio		0.3 (0.25)	0.3 (0.33)
ROA		-12.2*** (3.74)	-13.7*** (3.05)
Unreserved impaired loans		0.1* (0.04)	0.0 (0.04)
CB exposure		1.6*** (0.50)	0.9* (0.49)
Size		-4.7*** (0.59)	-5.6*** (0.63)
Investment grade		-31.7*** (3.34)	-29.1*** (2.30)
GIIPS		2.3 (3.80)	
Eurozone		-17.6*** (6.53)	
Country FE, Business model FE	n	n	y
$R^2$	0.06	0.60	0.67
# observations	534	534	534
# clusters	62	62	62

The dependent variable in all regressions is the average log of daily implied CDS premiums ( $\times 100$ ) of banks in 2015. All explanatory variables are as of end-2014.

Standard errors (in parenthesis) are clustered by the intersection of country and business model.

\*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

Table 5. CDS vs  $AE^+$  in a cross-section of banks

	(1)	(2)	(3)
$\ln AE^+$	-7.5*** (2.43)	-3.0** (1.16)	-2.5** (0.95)
$R^2$	0.06	0.60	0.67
$\ln AE$	-7.6*** (2.52)	-3.3*** (1.23)	-2.8** (1.05)
$\ln AE^{On+Off} / AE^{On}$	-8.0 (8.87)	6.3*** (2.34)	7.6*** (1.96)
$\ln TA^{On} / TA^{On+Off}$	-0.1 (5.06)	-0.8 (2.33)	-1.4 (2.32)
$R^2$	0.07	0.60	0.68
Controls	n	y	y
Country FE, Business model FE	n	n	y
# observations	534	534	534
# clusters	62	62	62

The dependent variable in all regressions is the average log of daily implied CDS premiums ( $\times 100$ ) of banks in 2015. All explanatory variables are as of end-2014. Controls in columns 2 and 3 are similar to the ones in Table 4.

Standard errors (in parenthesis) are clustered by the intersection of country and business model.

\*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

Table 6. CDS vs ULUA in a cross-section of banks

	(1)	(2)	(3)
<i>ln</i> ULUA	-24.9* (13.28)	-14.4* (7.38)	-5.7 (6.47)
$R^2$	0.02	0.60	0.67
AE	-0.5** (0.21)	-0.3** (0.10)	-0.2** (0.09)
<i>ln</i> UL / TA	-11.3 (13.22)	-11.4 (7.59)	-2.1 (6.31)
$R^2$	0.04	0.60	0.67
Controls	n	y	y
Country FE, Business model FE	n	n	y
# observations	534	534	534
# clusters	62	62	62

The dependent variable in all regressions is the average log of daily implied CDS premiums ( $\times 100$ ) of banks in 2015. All explanatory variables are as of end-2014. Controls in columns 2 and 3 are similar to the ones in Table 4.

Standard errors (in parenthesis) are clustered by the intersection of country and business model.

\*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$



Table 7. CDS vs AE in a cross-section of banks (all CAMELs)

	(1)	(2)	(3)
<i>ln</i> AE	-7.6*** (2.47)	-2.7** (1.13)	-2.6** (1.02)
Liquid assets		0.0 (0.08)	-0.1 (0.07)
Loans to deposits		-0.1* (0.06)	-0.1* (0.07)
Tier 1 ratio		0.0 (0.39)	0.3 (0.46)
Equity to assets		0.4 (0.78)	-0.4 (0.71)
ROA		5.9 (9.65)	4.6 (9.55)
ROE		-1.5** (0.62)	-1.4** (0.62)
Unreserved impaired loans		0.0 (0.05)	0.0 (0.05)
Loan loss reserves		1.4*** (0.42)	0.9** (0.41)
CB exposure		1.2** (0.47)	0.8* (0.48)
Size		-4.5*** (0.59)	-5.6*** (0.64)
Investment grade		-29.8*** (2.34)	-28.2*** (2.15)
GIIPS		-0.9 (4.16)	
Eurozone		-19.1*** (6.02)	
Country FE, Business model FE	n	n	y
$R^2$	0.06	0.63	0.68
# observations	534	534	534
# clusters	62	62	62

The dependent variable in all regressions is the average log of daily implied CDS premiums ( $\times 100$ ) of banks in 2015. All explanatory variables are as of end-2014.

Standard errors (in parenthesis) are clustered by the intersection of country and business model.

\*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

Table 8. CDS vs AE in a cross-section of banks: controls for past level of credit risk and weighted regressions

	(1)	(2)	(3)	(4)	(5)	(6)
<i>ln</i> AE	-1.9*** (0.43)	-1.6*** (0.44)				
<i>ln</i> AE <sup>+</sup>			-1.6*** (0.49)	-1.4*** (0.51)		
<i>ln</i> ULUA					-12.3*** (2.67)	-8.4** (3.22)
<i>ln</i> CDS' 14 ( $\times 100$ )	0.5*** (0.04)	0.5*** (0.02)	0.5*** (0.04)	0.5*** (0.02)	0.5*** (0.04)	0.5*** (0.02)
$R^2$	0.79	0.81	0.79	0.81	0.79	0.81
# observations	528	528	528	528	528	528
<i>ln</i> AE	-7.7*** (2.19)	-7.9*** (2.25)				
<i>ln</i> AE <sup>+</sup>			-6.8* (3.70)	-6.5* (3.72)		
<i>ln</i> ULUA					-30.8*** (9.74)	-29.3*** (11.00)
$R^2$	0.71	0.79	0.70	0.78	0.71	0.78
# observations	534	534	534	534	534	534
Controls	y	y	y	y	y	y
Country FE, Business model FE	n	y	n	y	n	y
# clusters	62	62	62	62	62	62

The dependent variable in all regressions is the average log of daily implied CDS premiums ( $\times 100$ ) of banks in 2015. All explanatory variables are as of end-2014. Controls in columns 2 and 3 are similar to the ones in Table 4. Standard errors (in parenthesis) are clustered by the intersection of country and business model.

\*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

Table 9. Summary statistics of variables used in panel estimation

	Mean	Median	SD	Min	Max
<i>ln</i> CDS ( $\times 100$ )	477.19	481.84	41.50	360.72	574.98
<i>ln</i> AE	2.88	3.02	0.82	0.17	4.59
Loans to deposits	80.61	84.65	28.57	1.57	145.12
Liquid assets	19.12	14.79	17.17	1.37	97.33
Tier 1 ratio	15.37	13.70	8.49	7.71	76.50
ROA	0.18	0.22	0.75	-2.85	2.47
Unreserved impaired loans	44.41	26.99	46.17	0.08	214.13
CB exposure	2.51	0.35	4.76	0.00	31.35
Size	3.91	3.88	2.17	0.05	7.55
$\Delta \ln$ CDS ( $\times 100$ )	-3.92	-0.26	23.75	-90.47	55.88
$\Delta \ln$ AE	0.02	0.00	0.39	-1.39	1.51
$\Delta$ Loans to deposits	-0.89	-0.58	10.79	-63.01	70.87
$\Delta$ Liquid assets	0.07	0.14	4.61	-37.30	14.65
$\Delta$ Tier 1 ratio	1.27	0.70	4.27	-4.68	36.60
$\Delta$ ROA	0.02	0.02	0.76	-3.05	3.07
$\Delta$ Unreserved impaired loans	-1.13	-0.76	14.17	-50.14	59.06
$\Delta$ CB exposure	0.33	0.00	2.44	-10.43	14.85
$\Delta$ Size	-0.03	0.00	0.24	-1.40	1.55

Encumbrance measures and balance sheet ratios are in percentage points.

Number of banks is 99.

Table 10. CDS vs AE in a panel of banks

	Levels		Differences	
	(1)	(2)	(3)	(4)
<i>ln</i> AE	-9.2*	-6.2***	-6.3**	-6.8**
	(4.77)	(2.25)	(2.77)	(2.62)
Loans to deposits		-0.1		0.0
		(0.13)		(0.13)
Liquid assets		0.2		0.4
		(0.25)		(0.28)
Tier 1 ratio		-0.1		0.1
		(0.16)		(0.17)
ROA		3.7**		4.6**
		(1.66)		(1.90)
Unreserved impaired loans		0.3***		0.2***
		(0.06)		(0.08)
CB exposure		0.0		-0.1
		(0.37)		(0.46)
Size		3.0		-0.1
		(3.84)		(4.40)
Bank FE	n	y	n	n
Year FE	y	y	y	y
$R^2$	0.12	0.96	0.74	0.77
# observations	297	297	198	198
# banks	99	99	99	99

The dependent variable in all regressions is the average log of daily implied CDS premiums ( $\times 100$ ). All explanatory variables are lagged by one year.

Standard errors (in parenthesis) are clustered by bank.

\*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

Table 11. Factor loadings of CAMEL variables

	Component 1	Component 2
Loans to deposits	-0.035	0.685
Liquid assets	-0.062	-0.682
Tier 1 ratio	0.357	-0.132
ROA	0.668	0.172
Unreserved impaired loans	-0.649	0.132

Factor loadings after orthogonal varimax rotation.

Table 12. Capital, liquidity and asset encumbrance

	(1)	(2)	(3)	(4)	(5)	(6)
<i>ln</i> AE	-9.4*** (2.61)	-3.0*** (1.06)	-5.7** (2.36)	-2.2** (0.98)	-7.4*** (2.56)	-2.3** (0.97)
<i>ln</i> AE × Capital	-0.4 (2.00)	0.0 (1.04)			-0.3 (1.45)	0.4 (1.04)
<i>ln</i> AE × Liquidity			5.5*** (1.22)	2.8*** (0.92)	4.8*** (1.16)	2.9*** (0.92)
Capital	-7.1** (2.71)				-7.1*** (1.95)	
Liquidity			-5.6*** (2.05)		-6.0*** (2.03)	
Controls	n	y	n	y	n	y
Country FE, Business model FE	n	y	n	y	n	y
$R^2$	0.13	0.67	0.13	0.68	0.20	0.68
# observations	534	534	534	534	534	534
# clusters	62	62	62	62	62	62

The dependent variable in all regressions is the average log of daily implied CDS premiums ( $\times 100$ ) of banks in 2015. All explanatory variables are as of end-2014. Controls are similar to the ones in Table 4.

Capital and Liquidity are bank scores based on the first two principal components of correlation matrix of CAMEL variables; both are centered and standardized to have unit variance.

Standard errors (in parenthesis) are clustered by the intersection of country and business model.

\*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$