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Endogenous Debt Maturity and Rollover Risk

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ABSTRACT

We challenge the common view that short-term debt, by having to be rolled over continuously, is a risk factor that exposes banks to higher default risk. First, we show that the *average* effect of expiring obligations on default risk is insignificant; it is only when a bank has limited access to new funds that maturing debt has a detrimental impact on default risk. Next, we show that both limited access to new funds and shorter maturities are causally determined by deteriorating market expectations about the bank's future profitability. In other words, short-term debt is not a cause of fragility but the result of creditors losing faith in the long-run prospects of the bank, hence forcing it to shorten its debt maturity. Finally, we build a model that endogenizes the debt maturity structure and predicts that worse market expectations lead to a maturity shortening.

JEL classification: G01, G21, G32.

Keywords: Banks, Maturity Structure, Rollover Risk, Debt Issuance, Financial Crisis.

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1 Introduction

Rollover risk arises when preexisting debt obligations become due and the resulting liquidity needs are potentially unmet. It is commonly believed that reliance on short-term liabilities, by requiring a continuous rollover of expiring debt, is by itself responsible for exposing financial institutions to higher default risk.[1] We challenge this *common view* by providing empirical evidence that the need to roll over maturing debt does *not* cause higher default risk.[2] In order to generate higher default risk, we show that two conditions are simultaneously required: a liquidity need induced by expiring debt and the inability to raise new funds. In fact, there is no reason for a bank to experience distress if it can easily roll over its obligations by having cheap access to new funds.

Next, we show that there is a common factor that causally determines both the maturity structure of debt and the probability of getting access to new funds. Specifically, we empirically document that deteriorating market expectations about a bank's future performance lead to both a maturity shortening of its liabilities and a lower likelihood of debt issuance. Therefore, when market forecasts are depressed for long enough, a bank is forced into a very short maturity structure which brings the need to roll over large amounts of debt at higher frequency; in addition, such institution is also less likely to raise new funds. These two elements together then lead to the observed build-up of fragility.

It is therefore incorrect to claim that short-term debt is a cause of fragility, as both maturity shortening and credit market access are causally determined by market expectations about the bank's future performance.[3] Importantly, if one believes that short-term debt is the source of instability it would be optimal to impose restrictions on the use of such an instrument; however, this recommendation could even further destabilize weak

[1]See Diamond and Dybvig (1983), Brunnermeier (2009), Krishnamurthy (2010) and He and Xiong (2012c), Gopalan et al. (2014) and Valenzuela (2015).

[2]The notion that short-term debt is by itself not a risk factor goes back to Calomiris and Kahn (1991), Diamond and Rajan (2000), and Diamond and Rajan (2001); they show that short-term debt arises endogenously as a device used by cash lenders to discipline the banker.

[3]Specifically, we use analysts' forecasts about banks' future return on assets.

banks, which, rationed out of longer-term issuance, would not even be able to obtain short-term funding. Our empirical results suggest that maturity shortening is just the result of the creditors' unwillingness to be locked in long-term obligations with a bank that they expect to perform poorly.[4]

To sum up the empirical analysis, we deliver two main results: first, a set of "backward-looking" regressions show that the average effect of maturing debt on default risk is negligible; however, when interacted with market expectations, maturing debt has a detrimental impact only for banks that are expected to perform poorly – which indicates limited access to new credit to pay back expiring obligations. Second, a set of "forward-looking" regressions analyzes the impact of market expectations on debt issuance and documents that, indeed, banks that are expected to perform poorly issue new debt less frequently, in lower amounts, and with shorter maturity.

Finally, we build a model to capture how a maturity shortening endogenously arises when market expectations deteriorate. A bank invests in projects that yield cash flows in the next two periods by issuing both short- and long-term debt. The main ingredient is that potential creditors have heterogeneous beliefs about the probability of the states of nature. We show that a separating equilibrium can arise in which pessimistic creditors opt for the short-term contract while more optimistic creditors buy long-term debt. Consistent with our empirical findings, the model predicts that a deterioration in average market expectations about the bank's future profitability leads to lower issuance of long-term debt.

In the empirical analysis, we take two approaches to overcome endogeneity issues and establish causation. In the "backward-looking" regressions that document the effect of maturing debt on default risk, we identify exogenous variation in liquidity needs by using the amount of expiring debt that was issued before the unfolding of the 2007 crisis. This approach takes care of any unobserved factor induced by the crisis that jointly affects a bank's default risk and the amount of maturing debt. For instance, as the market

[4]This is similar to He and Milbradt (2015) who theoretically show that deteriorating cash flows can generate a shortening of the maturity structure of debt.

becomes skeptical about the soundness of a bank, creditors are more reluctant to extend long-term credit, forcing such an institution to shorten its debt maturity structure; this shortening mechanically leads to a subsequent surge in debt that needs to be rolled over every period. In this scenario, the correlation between expiring debt and default risk would therefore be induced by a third factor, namely the growing pessimism about the bank's creditworthiness. Again, by focusing on the amount of expiring debt that was issued prior to the crisis, we factor out the component of maturing debt that represents an endogenous response to the deterioration of the bank's creditworthiness due to the crisis. In other words, assuming that the magnitude and timing of the financial crisis were not predicted years in advance, the pre-crisis contractual choice of a certain maturity date is then independent of the liquidity conditions the borrowing bank faces at maturity (between late 2007 and 2014). Thus, the stock of debt issued before 2007 that expires within the current month during the crisis is likely exogenous to the current change in the CDS spread (our proxy for default risk). At the same time, regardless of the original maturity, a large amount of expiring debt in times of crisis should still expose institutions to higher rollover risk.[5,6]

Secondly, whenever we use market expectations as a regressor, we treat it as an endogenous variable and we rely on an instrumental variable approach that exploits past forecast errors to isolate exogenous variation in current market expectations, as in Brancati and Macchiavelli (2014). The need to instrument market expectations comes from possible reverse causality issues in both sets of regressions. In the "backward-looking" exercise, shocks to the CDS spreads are observable by the market and could be internalized in the formulation of current forecasts. In the "forward-looking" regressions that study how expectations affect debt issuance, news about a large issuance of debt scheduled in the near future may affect creditors' expectations about the fundamentals of the

[5] Similar approaches are also used in Almeida et al. (2009), Benmelech and Dvir (2013) and Hu (2010).

[6] We employ alternative measures of rollover risk based on the stock of expiring debt either issued before January 2006 or with original maturity of more than five years regardless of when it is issued, which should also be exogenous to the (monthly) change in the CDS spread at maturity. We also exclude called and puttable bonds, or assume that the put options are exercized at the first available date. All these alternative measures lead to very similar results.

bank. Our IV strategy stems directly from the theory of Bayesian learning and isolates exogenous changes in market expectations. In particular, our instrumenting set is valid if market participants adjust their expectations in light of former mistakes and if past forecast errors have no direct impact on the current realization of the dependent variable (default risk or debt issuance) other than through their learning effect on market expectations. We regard these conditions as highly plausible and test their validity with first stage statistics and several diagnostic tests (see section 2 for more details).

Related Literature. This paper contributes to both theoretical and empirical literatures on rollover risk by providing a new point of view on the interaction between the maturity structure of debt and default risk. On the theoretical side, Diamond and Dybvig (1983), He and Xiong (2012b), and He and Xiong (2012c) consider the maturity of debt as given, while Calomiris and Kahn (1991), Diamond and Rajan (2000), and Diamond and Rajan (2001) see short-term debt as endogenously arising from an incentive mechanism that forces the banker to behave in the interest of cash lenders. In Flannery (1986), the choice of debt maturity can signal the quality of the borrower to outside lenders: in a separating equilibrium, good-quality firms borrow at short terms whereas bad firms borrow at longer maturities; notice that this is potentially in contrast with our findings. Brunnermeier and Oehmke (2013), Cheng and Milbradt (2011), and He and Milbradt (2015) provide additional theories that endogenize the maturity structure of debt. In Brunnermeier and Oehmke (2013) the inability of a bank to commit to a certain term structure leads to excessively short maturities. In Cheng and Milbradt (2011) the optimal maturity trades off liquidity risk with risk-shifting motives, while in He and Milbradt (2015) a shortening of the maturity structure can take place when cash-flows deteriorate over time. Finally, He and Xiong (2012a) extends Geanakoplos (2010) to show that, even in the presence of rollover risk, long-term contracts are never preferred by a borrower to either short-term debt or cash holding. The main difference between He and Xiong (2012a) and our setup is that their main source of disagreement is between borrowers (optimists) and lenders (pessimists) whereas we point at the heterogeneity among lenders in determining the choice of the maturity. More similar to our framework, Darst and Refayet (2016) suggest that positive news induces an increase in short-term relative to long-term debt; this theoretical result is in contrast with the prediction of our model.

Because existing theories are unable to match our empirical findings, we build a model that links heterogeneous beliefs among lenders to the borrower's debt maturity structure and predicts that less favorable forecasts generate a maturity shortening, in line with our empirical findings. Our model is simple enough to be applied to richer environments.

On the empirical side, few papers investigate the nature and causes of rollover risk. Benmelech and Dvir (2013) and Hu (2010) analyze the effect of maturing debt on default risk and find mixed evidence: the former shows that expiring debt during the 1997-1998 Asian crisis actually decreases the banks' probability of default, whereas the latter obtains the opposite result for non-financial firms during the 2008 crisis. On a different topic but with similar identification strategies, Almeida et al. (2009) show that firms that had to roll over large amounts of debt at the onset of the 2007-2008 financial crisis experienced much lower investment rates than otherwise similar companies. Importantly, all these studies view rollover risk as arising from liquidity needs only, while neglecting the crucial aspect of whether or not the entity is able to issue new debt.

To our knowledge, this is the first paper to document that rollover risk is really about the joint occurrence of a liquidity shortage and a lack of access to new funds; the liquidity need originates from pre-existing debt coming due, while the inability to access new funds (or to roll over debt) originates from market participants expecting the bank to perform poorly in the future. This is also the first paper documenting how different features of debt issuance causally depend on market expectations. Of note, there is a substantial strand of research[7] that empirically tests the implications of models of debt maturity under asymmetric information, such as Flannery (1986) and Diamond (1991); differently from what we do, the empirical papers in this literature document correlations between

[7]See Berger et al. (2005), Mitchell (1993), Ortiz-Molina and Penas (2008), Guedes and Opler (1996), Barclay and Smith (1995), Stohs and Mauer (1996), and Johnson (2003).

the maturity structure of non-financial corporate debt and risk ratings.

The remainder of the paper is organized as follows. Section 2 presents the data and discusses the empirical strategy, section 3 shows the results, and section 4 outlines the model. Finally, section 5 concludes.

2 Data and Empirical Strategy

2.1 Data

The main source of data is SDC Platinum Global New Issues (Thomson Reuters), a database covering a wide set of debt instruments including bonds (zero-coupon, convertible, callable, puttable, etc.), deposit notes, certificates of deposit, loans (term, bridge, etc.), commercial papers, banknotes, debentures, asset backed certificates, and revolvers. We collect bank-level debt issuance over the 1965–2015 period and collapse it to the monthly frequency in order to recover information about the maturity structure of banks' debt contracts. In particular, we keep track of both the amount of expiring debt and debt issuance in each month between September 2007 and December 2014.[8] This is then matched with banks' CDS spreads (Markit), analyst earning forecasts (Thomson Reuters, Institutional Brokers' Estimate System – IBES database), balance-sheet data (Bankscope Bureau van Dijk), Tobin's Q and information on the date in which a bond is called by the issuer (Bloomberg).

We employ the 5-year CDS spreads on senior debt as a proxy for banks' default risk.[9] Notice that CDS spreads actually represent the risk-adjusted probability of default, which embeds both the perceived default risk and the expected recovery rate. However, in the

[8]The collection of debt issuance from 1965 is needed to account for any (very) long-term debt expiring in times of crisis and to build a representative structure of maturing debt.

[9]We average across daily CDS spreads to obtain monthly series. The choice of the maturity is entirely driven by data availability, and by the higher liquidity of this specific instrument. Anyway, untabulated results on the 1–year CDS spreads are very similar to the ones presented. Moreover, in order to be consistent with the timing of the IBES surveys, administered within the first half of the month (see footnote 11), we construct monthly CDS data disregarding the second half of the month. However, our results are virtually unchanged even if we average the CDS spread across the entire month.

empirical analysis we factor out the latter by controlling for net charge-offs, the share of non-performing loans over gross loans, and the share of liquid assets over total assets.[10] Market expectations are recovered from a survey of professional forecasters –the IBES dataset– conveying information on banks' expected future performance. In particular, we employ the median forecast of the one-year-ahead return on assets (ROA) of a bank to proxy for its expected fundamentals.[11] Finally, we control for bank-specific characteristics with a rich set of balance-sheet ratios from Bankscope.

Since the dataset covering the least number of banks is Markit, our sample ranges from 190 international banks, when analyzing the impact of expiring debt on default risk, to 550 institutions, once we study the determinants of debt issuance. Our estimating sample includes mostly commercial banks that make a significant use of customer deposits –about half of their funding needs– and finance the rest with debt at different maturities. Importantly, our dataset does not incorporate sources of funding that range from overnight to about one year tenors, while it accounts for the universe of debt issuance at longer maturities. Notice that while overnight funding is an essential component for security dealers, it is much less so for commercial banks.

Many international financial institutions have been borrowing overnight on fed funds and eurodollar markets not as a liquidity management tool, but only for arbitrage purposes; namely, to earn the spread between the interest on excess reserves offered by the Federal Reserve and the fed funds or eurodollar borrowing rate. We also miss any certificate of deposit (CD) and financial commercial paper (Fin-CP) of original maturity of less than one year; in recent years, the large majority of issuance of CD and Fin-CP had original maturities of less than a week. In our regressions, we control for the amount of short term funding over total funding exactly to account for the amount of short term

[10] The rationale for using these balance-sheet ratios is that, upon default, the recovery rate will be higher for a larger share of liquid assets or a lower fraction of non-performing loans.

[11] IBES surveys several professional forecasters within the first 15 days of every month asking for their forecasts at different horizons on several key indicators, ROA, ROE and EPS included. The dataset contains forecast horizons of one, two and three years ahead and long run forecasts; we mainly use one-year-ahead forecasts on ROA to limit the drop of observations and to ensure the highest explanatory power. However, our results are not sensitive to the choice of alternative horizons, as shown in section 3.

debt that has to be rolled over at high frequency. Moreover, our identification strategy for the "backward-looking" analysis relies on the amount of expiring debt that was issued pre-crisis, namely before September 2007. Therefore, not having data on issuance with maturities of less than a year – most of which with maturity of a week or less – does not affect the vast majority of our sample that runs from September 2007 to December 2014.

In the "backward-looking" analysis we care about identifying the effect of maturing debt on default risk. It is therefore important to properly take care of callable and puttable bonds; indeed, if either call or put options are exercized, the actual maturity date will differ from the original maturity date written on the contract at issuance.[12] While SDC Platinum records features of the debt contract at issuance (including potential call and put options), it does not keep track of whether a bond is called or put at any point in time. Bloomberg is the only data source we found that provides systematic information on bonds that are actually called by the issuer. From 2008 to 2014, the percentage of debt contracts issued with a call option is 19% and the percentage of maturing contracts that were called is 13%. There seems not to be any data available on the share of puttable bonds that are actually put, possibly because each single bond holder can individually decide whether to keep the bond or sell it back to the issuer, making the data collection prohibitive.[13] In any way, the percentage of puttable contracts issued over the total is negligible (1.5%). We obtain very similar percentages if we consider percentages of the total value of debt issued instead of the total number of contracts issued.

Table 1 presents some descriptive statistics for the banks in our sample. The median maturity of new debt at issuance is roughly four years, with 25% of contracts below 24 months and another 25% with expiration date beyond seven years. Even if in some periods our proxy for rollover risk (the share of maturing debt issued pre-crisis) is essentially zero, it accounts for an average value of debt expiring each month that is about 6.5% of the

[12]When a call option is exercized, the issuer buys back the bond from the bond holders at a predetermined call price; similarly, when a put option is exercized, the bond holder sells the bond back to the issuer at a predetermined put price. See Vu (1986) for an analysis of the exercise of call options on debt contracts.

[13]On the other hand, the exercise of a call option is usually publicly announced by the issuer.

banks' total assets. Our alternative proxy, expiring debt with original maturity of more than five years, presents similar dynamics, with an average monthly liquidity need of 4.7% of total assets.

2.2 Empirical Strategy

This section presents the empirical strategy of the paper, which is twofold. First, we perform a "backward-looking" exercise that takes as given the maturity structure of debt and quantifies the effect of expiring debt on banks' default risk; this approach exemplifies the standard view on rollover risk, namely that expiring debt exposes a bank to higher probability of default; the second part of the "backward-looking" piece serves as a bridge to motivate the "forward-looking" exercise. In the latter, we explore the nature of rollover risk by documenting the underlying relationship between issuance of new debt and market expectations. In what follows we lay out the identification strategies for the backward- and forward-looking exercises separately.

2.2.1 Backward-Looking Exercise

The commonly held view on rollover risk is that a large stock of obligations becoming due at a certain date increases the default risk of an institution. We capture such an effect with the following equation for the evolution of the CDS spread:

$$CDS_{i,t} = \rho CDS_{i,t-1} + \gamma_0 EXPIRING_{i,t} + \beta^\top x_{i,t-1} + \eta_i + \lambda_t + \varepsilon_{i,t} \tag{1}$$

where $CDS_{i,t}$ is the monthly average of daily Credit Default Swap spreads of bank i at time t (proxying for default risk), and $EXPIRING_{i,t}$ is the stock of debt expiring within the month, scaled by total assets.[14] Finally, $x_{i,t-1}$ is a rich vector of controls for banks' fundamentals, η_i are bank-specific (CDS-specific) fixed effects controlling for unobserved heterogeneity that is constant over time, and λ_t are time fixed effects capturing common

[14]Results are qualitatively similar if we employ total funding as an alternative scaling factor.

shocks and cyclical factors. Notice that we employ a dynamic specification of the dependent variable to accommodate for the empirical persistence of CDS spreads. However, because of the large time dimension of our sample –roughly 90 periods– we do not need to rely on dynamic-panel-data techniques to instrument the lagged dependent variable and consistently estimate equation 1.[15]

In order to shed light on the causal effect of rollover risk on banks' probability of default we have to deal with the potential endogeneity of expiring debt in the CDS regression; *i.e.,* reverse causality and omitted-variable bias. For instance, it might be the case that cash lenders expecting a certain bank to perform poorly in the near future are willing to extend only short-term funding, thus exposing the institution to higher rollover risk in subsequent months. In this scenario, we would estimate a large and positive effect of expiring debt on default risk, but mostly due to omitted-variable bias, namely adverse market expectations influencing both the amount of expiring debt and the perceived probability of default. Similarly, a higher default risk may also directly affect a bank's maturity structure by discouraging the lenders' investment in long-term obligations, thus giving rise to reverse causality issues.

Instead of analyzing the mere effect of maturing debt on banks' default risk, we study whether the CDS spread is affected by longer-term obligations that were issued pre-crisis and that become due during the crisis. Indeed, independently of the issuance date of a contract, large amounts of expiring obligations should still expose institutions to higher rollover risk, therefore impacting their vulnerability. At the same time, the use of obligations issued pre-crisis rules out the possibility that expiring debt represents a financial policy response to deteriorating economic conditions in times of crisis. In particular, we eliminate concerns about the endogeneity of maturing debt by only employing obligations

[15] The instrumentation of the lagged dependent variable ($CDS_{i,t-1}$), while necessary in a small-T panel setting, is not needed here because the so called Nickell bias (Nickell, 1981) induced by the demeaning process through bank fixed effects tends to vanish as the time dimension increases. Notice also that standard dynamic panel techniques (*e.g.*, Arellano and Bover, 1995; Blundell and Bond, 1998) are not applicable to our context because of the loss in efficiency induced by the excessive number of instruments (quadratic in the length of the time-series available).

issued prior to the onset of the crisis (September 2007).[16] To the extent that the timing and the severity of the financial turmoil were unexpected years in advance, our measure of rollover risk does not contain any information on how a certain institution performed during the Great Recession. In a similar vein, we also employ debt with original maturity of more than five years, which is allegedly exogenous to the (monthly) change in the CDS spread in times of crisis.[17] These two alternative proxies allow us to consistently estimate equation 1 and make inference on γ_0 to test the average effect of expiring debt on banks' default risk.

As pointed out in Section 2.1, a non-negligible percentage of debt contracts is issued with either call or put options. When a callable bond is called, the borrowing bank buys back the security; therefore, there will not be any cash outflow at the final maturity date specified at issuance. In order to accommodate for such a revision in the maturity date, we also present regressions excluding called bonds in the calculation of expiring debt and results are essentially unchanged. The alternative would have been to change the maturity date from the original maturity date specified at issuance to the date in which the bond is called. However, the decision to call the bond mostly reflects the fact that the bank was able to refinance the loan at a lower rate and therefore does not represent a liquidity need that could potentially lead to rollover risk. For this reason, we do not entertain this alternative. In addition, we also purge the sample from any debt contract with a put option, or make the assumption that put options are exercized at the first available date during the crisis period, thus changing the effective maturity date to such put date. Again, our results are virtually unchanged.

Next, as a way to transition from the common view on rollover risk to its "forward-looking" nature, we show that the probability of default does not respond to liquidity

[16] We use September 2007 as the starting period of the crisis. This timing is consistent with the jump in the haircut rate on repos (large haircuts can be thought of as debt runs) or in the LIBOR-OIS spread (the first signals of danger in the interbank market) documented by Gorton and Metrick (2012). A very similar chronology of events is described in Brunnermeier (2009). Also, looking at the ABCP market (see for instance Covitz et al., 2013) we notice a large collapse in the outstanding value of ABCP around August-September 2007.

[17] In unreported analyses, we also employ debt issued prior to August 2007 or January 2007 and our findings are again unaffected.

needs when the market expects a bank to perform well enough. On the contrary, the CDS spread increases only when an institution is expected to perform poorly while at the same time having to roll over some expiring obligations. In order to capture this heterogeneous response we augment the previous specification with a linear interaction term and estimate the following model:

$$\begin{aligned} CDS_{i,t} = \; & \rho CDS_{i,t-1} + \gamma_1 EXPIRING_{i,t} + \gamma_2 EXPIRING_{i,t} \times \mathbb{E}_t(\mathrm{ROA}_{i,t+1Y}) + \\ & + \gamma_3 \mathbb{E}_t(\mathrm{ROA}_{i,t+1Y}) + \beta^\top x_{i,t-1} + \eta_i + \lambda_t + \varepsilon_{i,t} \end{aligned} \tag{2}$$

where $\mathbb{E}_t(\mathrm{ROA}_{i,t+1Y})$ is the level of market expectations as captured by the median of the analyst forecasts formed at time t on the one-year ahead ROA of bank i.[18] Notice that the introduction of $EXPIRING_{i,t} \times \mathbb{E}_t(\mathrm{ROA}_{i,t+1Y})$ allows the effect of expiring debt to vary with the level of market expectations: $\partial CDS_{i,t}/\partial EXPIRING_{i,t} = \gamma_1 + \gamma_2 \mathbb{E}_t(\mathrm{ROA}_{i,t+1Y})$, where we expect $\gamma_1 > 0$ and $\gamma_2 < 0$. While most of the analysis employs expectations on the one-year ahead horizon, we also adopt the principal component of the one-, two-, and three-year ahead median forecasts as an alternative proxy.

Since innovations in default risk can be observed by analysts and potentially internalized in their forecasts, we need to treat $\mathbb{E}_t(\mathrm{ROA}_{i,t+1Y})$ as endogenous in the CDS regression. To deal with this issue, we use the IV approach developed in Brancati and Macchiavelli (2014), relying on Bayesian learning theory to recover a set of exogenous instruments, namely past forecast errors. Our strategy goes beyond standard dynamic panel data techniques that rely solely on appropriately-lagged values of the endogenous regressors (internal instruments). In particular, if market participants are uncertain about the dynamic of banks' fundamentals, we show that Bayesian-learning agents take advantage of past forecast errors to correct and update current expectations (see Appendix 7 for a more rigorous discussion). Importantly, because we model a dynamic specification

[18] Throughout the paper we mainly focus on the one-year ahead expected ROA; we use ROA because it best measures the strength of banks' fundamentals and profitability. However, our results are consistent if we employ alternative timings (two or three-year ahead forecasts), or alternative proxies for market expectations (expected ROE and earnings-per-share).

for default risk, our exclusion restriction requires the instrumenting set to be uncorrelated with the *change* in the CDS spread over the month. In other words, we need past forecast errors to affect innovations in banks' default risk only indirectly, through a learning channel whereby previous errors are used by agents to update their current beliefs. Since forecast errors are defined as the difference between the realized measure and its expectation formed one period in advance, our assumption implicitly requires that market participants engage in a process of learning and update their beliefs at least once a month, which is very reasonable in the current financial context. We mainly use both past forecast errors and lagged expectations as instruments for $\mathbb{E}_t(\text{ROA}_{i,t+1Y})$. However, our results are unchanged if we employ a more conservative IV strategy only relying on past forecast errors. Empirically, we check the validity of our excluded instruments with the Hansen J-test of overidentifying restrictions, and verify their power with underidentification test and F test of the first stage regressions. We find our instrumenting strategy to be always internally consistent.

2.2.2 Forward-Looking Exercise

The analysis proposed so far serves as a motivation to explore the dynamic nature of rollover risk. Within this context, we study how the bank's ability to issue new debt depends on market expectations about its future performance as well as its actual need to roll over expiring obligations. We focus on several dimensions of the ability to issue new debt: the total amount issued (intensive margin), the probability of issuance (extensive margin), and the original maturity at issuance. We therefore estimate the following equation:

$$Y_{i,t} = \gamma_4 \mathbb{E}_t(\text{ROA}_{i,t+1Y}) + \beta^\top x_{i,t-1} + \eta_i + \lambda_t + \varepsilon_{i,t} \tag{3}$$

where $Y_{i,t}$ is either the overall stock of debt issued by bank i at time t (scaled by total assets), a dummy variable taking value of 1 if bank i issues any debt at time t and 0 otherwise, or the natural logarithm of 1 + *maturity*, defined as the number of months between issuance and expiration date.[19] Notice that using $ln(1 + maturity)$ allows us to interpret the coefficient γ_4 as an elasticity.

Of note, we do not use the yield to maturity either as dependent or independent variable. First of all, it is only possible to define such a variable for fixed rate zero coupon bonds, which represent a very small part of the sample. For fixed rate coupon bonds, one needs to assume a path of rates used to discount future cash flows, while for floating rate notes, which specify the coupon rate as a fixed spread over a reference rate, one needs to additionally assume the expected future path of the reference rate, most commonly either the 3-month Libor or the 3-month Euribor. It is therefore not possible to reliably compare the yield to maturity across debt instrument types, such as zero coupon fixed rates, fixed rates with coupons, adjustable fixed rates or floating rates. For this reason, we do not use it as a dependent variable. In addition, even if all bond issuance was carried out by zero coupon bonds we would still not use it as a regressor. Indeed, most of the information contained in the maturity choice is also present in the yield: given an upward sloping yield curve, a bank deciding to borrow at longer term has to pay a premium.[20] Since yield and maturity are jointly determined, it does not make sense to control for the yield in these forward-looking regressions, especially when studying the maturity choice.[21]

Although market expectations are more exogenous in this specification than in the backward-looking regressions, it is still likely that knowledge about future debt issuance is internalized by forecasters. In particular, if cash lenders receive news about a large issuance of debt scheduled for the near future they may revise their expectations either upwards or downwards, giving rise to possible endogeneity problems. Indeed, it is common

[19] In case of multiple issuances within the same month *maturity* is computed as the weighted average number of months to expiration date (where the weights are the share of debt issued at a specific maturity over total debt issued in month t). Instead, stocks are simply computed as the sum of all debt contracts issued within the month.

[20] From the point of view of the borrower that faces an upward sloping term structure of rates, the relative advantage of issuing short- instead of long-term debt comes from paying a lower interest rate while the relative advantage of longer-term debt has to do with facing rollover risk less frequently.

[21] The path of monetary policy target rates is however controlled for by use of country-month fixed effects.

for institutions, or their book-runners, to file a prospectus as a way to inform markets about future debt issuance. Therefore, as in section 2.2.1, we treat $\mathbb{E}_t(\text{ROA}_{i,t+1Y})$ as an endogenous variable and employ an IV strategy relying on its lagged values and past forecast errors. The use of past forecast errors is valid to the extent that they do not affect issuance directly, but only indirectly through their impact on current market expectations – the learning channel. Moreover, to the extent that news about future issuance is not released several months in advance, appropriately-lagged values of $\mathbb{E}_t(\text{ROA}_{i,t+1Y})$, namely internal instruments, would also be suitable for our purposes. We mainly employ a broad strategy including both internal instruments and past forecast errors. However, we also show that results are robust to the adoption of a more conservative IV approach based on past forecast errors only. Again, we test for the correlation between the excluded instruments and the error term with the Hansen J-test of overidentifying restrictions, and assess the power of our instruments with under-identification tests and F-tests of the first stage regressions. All the analyses pass our diagnostic tests and point at an IV strategy that is internally consistent.

All the econometric estimations are performed via two-stage GMM models with bank and time fixed effects and White, heteroskedasticity-consistent, standard errors.

3 Results

3.1 Backward-Looking Exercise

Table 2 displays the results of our backward-looking exercise: we use the amount of expiring debt issued more than five years in advance (left panel), or the stock of maturing debt issued before the onset of the crisis (September 2007, in the right panel).

Columns 1 and 3 present the estimates for the baseline specification in equation 1, estimating the average effect of expiring debt on banks' probability of default. Our results show that the *average* effect of expiring obligations is never significantly different from zero. This piece of evidence goes against the commonly held view that the need of rolling-over expiring debt is by itself responsible for exposing a bank to higher default risk. On the other hand, a bank that is expected to perform well enjoys lower CDS spreads. Finally, the diagnostic tests presented in the bottom rows indicate an IV strategy that is internally consistent. In particular, past forecast errors and lagged expectations have a powerful predictive power for current forecasts –as showed by the Kleibergen-Paap F test, the underidentification test, and the first-stage regressions presented in Table 3– being at the same time uncorrelated with the error term in equation 1 (as documented in the Hansen J-test).[22]

For a better understanding of the nature of rollover risk, columns 3 and 4 allow the effect of expiring debt to depend on market expectations, by means of a linear interaction term between market expectations and the bank's expiring obligations. Our results show a detrimental effect of maturing debt limited to institutions that are expected to perform poorly in the near future. On the other hand, the need to roll over large amounts of expiring obligations does not seem to pose any threat for banks that are perceived to be sound by the market. This strong non-linearity is portrayed in Figure 1, which reports the marginal effect of expiring debt for different values of $\mathbb{E}_t(\text{ROA}_{i,t+1Y})$. The 95%-confidence intervals indicate a strong and positive effect of maturing debt on default risk for about half of the banks in our sample, while no significant impact for the institutions with higher expected profitability.[23] This evidence provides the motivation for our forward-looking analysis (see Section 3.2) that studies the role of market expectations in affecting the bank's ability to issue new debt.

3.1.1 A Note on Dynamic Coordination

Next, Tables 4 and 5 attempts to test for dynamic coordination motives: as suggested in He and Xiong (2012b), in making his rollover decision, each maturing creditor is worried

[22] Forecast errors are defined as the difference between realized ROA and lagged expected ROA; thus, the positive coefficient of past forecast errors in Table 3 is consistent with agents updating current expectations in light of past mistakes.

[23] The marginal effect turns even negative for a few institutions in the very right tail of the distribution of $\mathbb{E}_t(\text{ROA}_{i,t+1Y})$.

about future creditors not rolling over debt and dragging the bank into default during the lifetime of the new debt contract. Therefore, the paper argues that the expectation of creditors not rolling over debt in the near future can lead current maturing creditors to stop funding the bank ("preemptive rat race") in order to avoid being locked in a debt contract right before the default of the institution. Similarly, we argue that in the presence of dynamic coordination externalities, a large amount of debt maturing in the near future can make current creditors less likely to roll over debt because they are afraid of being locked in the debt contract while future creditors run on the bank. In this case, the knowledge of a large amount of debt coming due in the near future may trigger a preemptive rat race, and lead to an immediate deterioration of funding condition and a sudden spike in default risk. Table 4 uses the amount of expiring debt issued pre-crisis, while Table 5 uses expiring debt with original maturity of more than five years. Columns (3) and (4) both Tables provide evidence *against* the presence of such dynamic coordination externalities: the expiring debt that matters in explaining default risk is the one maturing during the current month (Expiring_t), not the total amount of debt maturing in the next three months ($\sum_{s=1}^{3} \text{Expiring}_{t+s}$).[24] We also try different maturity horizons, summing up expiring debt maturing in the next four, five, or six months, and results are unchanged. Against our priors, dynamic coordination externalities are not even present for banks that are believed to perform poorly in the future: the coefficient of the interaction between $\sum_{s=1}^{3} \text{Expiring}_{t+s}$ and $\mathbb{E}_t(\text{ROA}_{t+1Y})$ is statistically insignificant.

3.1.2 Backward-Looking Exercise: Robustness Checks

Table 6 compares the impact of expiring long-term obligations on default risk before and after the financial crisis. Our estimates suggest that both market expectations and maturing debt have no impact on banks' default risk prior to September 2007: in other words, CDS spreads do not price in any rollover risk in normal times.[25]

[24] A more conservative interpretation of our results is that dynamic coordination externalities are at best short-lived and that only obligations maturing within the current month matter.

[25] In order to keep a consistent measure of expiring debt across the two time periods, Table 6 only shows results for the amount of expiring debt with original maturity of more than five years. Our findings

Next, Tables 7 and 8 show that our results are unchanged under the following alternatives for expiring debt: removing called bonds (columns (1) and (2)), removing puttable bonds (columns (3) and (4)), or moving the maturity date from the original one recorded at issuance to the first put date available by contract (columns (5) and (6)). In Table 7 we use the amount of expiring debt issued pre-crisis, while in Table 8 we use the amount of expiring debt with orginal maturity of more than five years.

Finally, we run a number of other robustness tests to check the validity of our results:

- employing the 6-month, 1-year, and 2-year CDS spreads as alternative dependent variables to test whether our findings are related to a differential sensitivity to rollover risk of the default probabilities at different horizons;[26]
- using the monthly change in the CDS spreads as an alternative dependent variable;
- adopting more conservative IV strategies that rely on further lags of expectations (more than four periods in advance) or *only* lagged forecast errors;
- employing more conservative thresholds for pre-crisis issuance (January 2007 or January 2006) in the definition of expiring debt.

In all cases results are largely consistent with the ones presented in the main text and suggest that the need to roll over maturing debt by itself does not pose any threat. Instead, it is the joint occurrence of a liquidity need (generated by sizable amounts of expiring obligations) and a lack of access to new funding (as captured by market expectations) that exposes a bank to higher default risk.

3.2 Forward-Looking Exercise

Having established that expiring debt has a detrimental effect on default risk only for

are broadly consistent if, instead, we employ the amount of expiring debt issued prior to August 2007 for the crisis period and the total stock of expiring obligations in normal times.

[26] To this regard, Hu (2010) shows that CDS spreads for longer maturities are less sensitive to rollover risk than the one-year CDS. Even though our choice of the 5-year CDS spread is driven by the higher liquidity of its market, we find that the insignificant effect of expiring debt holds across the term structure of CDS spreads.

banks that are expected to perform poorly, we now explicitly document how market expectations affect a bank's ability to raise new funds. The following analysis points out that a bank that is expected to perform poorly is indeed less likely to issue debt and, in case it does, it issues shorter term debt.

Table 9 presents the general idea of this forward-looking exercise by showing the effect of analysts' forecasts on the amount of debt issued by a bank (scaled by total assets). In the left panel we proxy market expectations with the one-year ahead expected ROA, while in the right panel we employ the principal component of one-, two-, and three-years ahead forecasts.[27] Th dependent variable is the total amount of debt issued (in columns 1 and 5), as well as the amount of debt issued with maturities of less than five years (columns 2 and 6), higher than five years (columns 3 and 7), and beyond ten years (columns 4 and 8).

Our results indicate a significant effect of market expectations on debt issuance which is, however, highly heterogeneous across maturities; a one-percent *decrease* in future expected ROA causes a decrease in longer-term issuance (more than five or ten years) by 7% of total assets, while increasing at the same time the issuance at shorter maturities (by roughly 5%). We interpret this result as follows: *less* favorable forecasts do not allow a bank to issue long-term debt while forcing the institution to rely on shorter-term obligations. In a broader context, this evidence suggests that deteriorating market expectations can be responsible for the shortening of the maturity structure of debt experienced at the onset of the 2007/2009 financial crisis. Such a maturity shortening may then lead to a build-up of fragility: during a maturity shortening, debt has to be rolled over at higher and higher frequency, and a temporary loss of access to credit markets can have huge consequences. This is consistent with the narrative in Krishnamurthy (2010) and Gorton et al. (2015). Notice that, once again, the diagnostic tests in the bottom rows indicate a valid instrumenting strategy.

Next, we look at the effect of market expectations on both probability and maturity

[27] The first principal component loads positively on each factor and explains 62% of the total variance.

of new issuance. Table 10 presents a linear probability model to estimate the effect of expectations on the probability of issuance at different horizons. Our results document that expectations have a positive effect on issuance at longer tenors (+3% probability of issuance) whereas the effect is not statistically significant for shorter maturities (less than five years).[28] Table 11 directly focuses on the effect of expectations on the original maturity at issuance and confirms that more favorable forecasts significantly lengthen the maturity structure of debt.

Finally, we add more color to the previous results by showing that market expectations matter for debt issuance especially when the bank has to roll over a sizable amount of debt. To this regard, the top panel of Table 14 allows the effect of $\mathbb{E}_t(\text{ROA}_{i,t+1Y})$ to depend on whether the institution needs to roll over a large or small portion of its liabilities. The interacting variable, Fragile_t, is an indicator function that takes unitary value if the ratio of expiring debt to total assets exceeds the 75^{th} percentile (in columns 1-to-4) or the median (in columns 5-to-8) of its time-specific cross-sectional distribution. Consistent with our previous results, worsening market expectations have a more pronounced negative impact on debt issuance when the bank has to rollover a considerable amount of debt. It is therefore the joint occurrence of large liquidity needs and lack of access to new funds that contributes to the build-up of fragility, by forcing the bank to shorten its maturity structure –*i.e.*, reducing issuance at long tenors and increasing the reliance on short-term obligations. Conversely, market expectations do not seem to play any significant role if liquidity needs are moderate. As a robustness test, the mid and bottom panels of Table 14 present alternative measures of fragility by taking into account the ratios of short-term funding to total funding and total funding to customer deposits. Both measures proxy for greater instability in the sources of funding and possibly for a bank's need to tap credit markets more frequently.[29] Similarly, the results suggest an impact of market expectations on access to new credit that is much more pronounced

[28] Notice that, because we employ linear probability models, our coefficients can be directly interpreted as the effect of a one-percent increase in expected future ROA on the probability of issuance in the current month.

[29] See for instance Cornett et al. (2011).

when the bank is exposed to larger liquidity needs. Identical results (not shown here) hold when the dependent variable is the probability of issuance. In some specifications we also allow for a continuous interaction of a bank's liquidity needs, obtaining qualitatively similar findings.[30]

3.2.1 Forward-Looking Exercise: Robustness Checks

Since debt contracts reflect the realized equilibrium in the bond market, the observed features of debt issuance, such as amount raised and maturity, are a function of both credit demand and supply factors. While we build our narrative around supply-side factors, the reader may suspect that our results could be driven by a correlation between the analyst forecasts and the bank's demand for funds. In other words, if institutions with declining investment opportunities and decreasing demand for funds are also perceived as unprofitable by the market, our findings may reflect the bank's lack of demand for new funds rather than a reluctance by investors to supply new credit. It is worth stressing that our instrumenting strategy is already taking care of this issue. Indeed, it is very plausible that the risk management group within each bank has much better information about its own bank's investment opportunities than outsiders do; therefore, it is more likely that outsiders rather than insiders engage in a process of learning by which past forecast errors discipline their current expectations. In other words, it is more likely that past forecast errors provide exogenous variation to credit supply rather than credit demand factors.

Moreover, if credit demand was driving our main results we should not observe the patterns presented in the backward-looking exercise (Table 2). Specifically, if reduced demand for new funding is driving the lower value of $\mathbb{E}_t(\mathrm{ROA}_{i,t+1Y})$, we should not see any build up of default risk when expectations drop and some debt is maturing. That is the case precisely because the maturing debt is not going to be rolled over due to

[30]Notice however that with continuous interactions, the magnitude and significance of the estimates are less striking than those presented in the paper; this speaks of a strong non-linearity in the effect of banks' liquidity needs on debt issuance.

the reduced demand for funding. Therefore, the negative coefficient on the interaction between expiring debt and expectations is only consistent with the bank needing to roll over maturing debt while the market is not so willing to provide such funding.

However, in order to explicitly account for credit demand factors, we also control for banks' Tobin's Q, which is a widely used proxy for investment opportunities.[31] Table 12 shows the results: even though the effect of Tobin's Q is statistically significant, our results are qualitatively unchanged and they still stress the importance of credit supply factors in determining both amount and maturity of newly-issued debt. However, Tobin's Q, defined as the ratio of market to book value, is an imperfect measure of investment opportunities and credit demand factors: indeed, the market to book value of a bank mostly reflects the market perception of its future performance (which is already contained in our main regressor $\mathbb{E}_t(\text{ROA}_{i,t+1Y})$), not necessarily the bank's own assesment of its investments opportunities.

Next, as pointed out in the Section 2.2.2, the possibility that news about future debt issuance could have an effect on contemporaneous market expectations may invalidate the use of lagged expectations as additional instruments for current forecasts. To deal with this issue, Table 13 presents the results with a more conservative IV strategy relying on further lags of expectations (more than four periods in advance, in the left panel) or only lagged forecast errors (in the right panel). Results are largely consistent with the ones presented so far. We have also run a number of additional robustness checks (untabulated) purging country-month components (demeaning), allowing for an AR(1) process of the dependent variable, and testing alternative proxies for market expectations (expected ROE or earnings per share). Once again, our findings are roughly unchanged.

In the next section we build a model that aims at capturing our main result on the link between market expectations and the maturity structure of debt issuance.

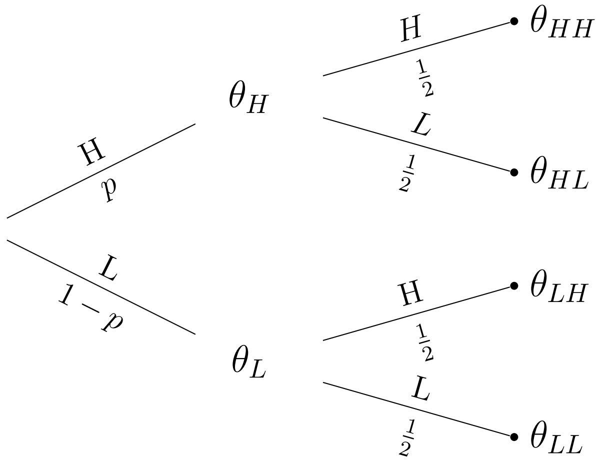
[31]See for instance Blundell et al. (1992).

4 Model

Our model highlights how, under heterogeneous beliefs about a bank's fundamentals, the maturity structure of liabilities is endogenously determined by market expectations.

There are three periods, $t = 0, 1, 2$. At $t = 0$, risk-neutral agents decide whether to invest one unit of endowment either in a safe asset or in a bank either as short-term or long-term debt. At $t = 1$, the bank faces an uncertain cash flow, $\theta_1 \in \{\theta_L, \theta_H\}$, and agents differ as to their beliefs about the probability distribution of θ_1. Some agents of type G receive good news and expect $\theta_1 = \theta_H$ with probability p_g (and $\theta_1 = \theta_L$ with probability $1 - p_g$) while agents of type B receive bad news and expect $\theta_1 = \theta_H$ with probability p_b (and $\theta_1 = \theta_L$ with probability $1 - p_b$). Assume $1 > p_g > p_b > 0$ and $\theta_H > \theta_L$ for consistency. Also, the risk-free asset yields a per-period return of R_f.

At $t = 2$, which is the final period, the bank has an uncertain cash flow of θ_2; conditional on $\theta_1 = \theta_H$, θ_2 can either be high or low with probability 1/2, *i.e.* $\theta_2 \mid \theta_H \in \{\theta_{HH}, \theta_{HL}\}$. Similarly, $\theta_2 \mid \theta_L \in \{\theta_{LH}, \theta_{LL}\}$. We assume that $\theta_{HH} > \theta_{HL} \geq \theta_{LH} > \theta_{LL}$.



Consider a limited enforceability problem whereby, upon default, creditors can only get a fraction χ of the bank's current cash flow. A debt contract specifies the maturity (short or long) and repayments in case of no default: call R_s and R_l these repayments for the short-term and the long-term contracts respectively.

Short-term debt. Suppose that there exists a short-term debt contract that attracts agents of type B and that offers to repay R_s in case of no default. Moreover, suppose that upon the bad realization of θ_1 the bank goes bankrupt; namely, $R_s > \theta_L$. The participation constraint for type-B agents (PC_B) is $R_f \leq p_b R_s + (1-p_b)\chi\theta_L$; suppose there are infinitely many small agents of type B that operate in a competitive environment, so that PC$_B$ holds with equality.[32] Then,

$$R_s = \frac{R_f - (1-p_b)\chi\theta_L}{p_b} \tag{4}$$

For the bank to have enough cash to repay debt in the good scenario, we need $R_s \leq \theta_H$ or equivalently $p_b \geq \frac{R_f - \chi\theta_L}{\theta_H - \chi\theta_L} \equiv p_{**}$. Also, requiring that $R_s > \theta_L$ together with equation 4 translates into the condition $R_f > \underline{R} \equiv \theta_L \left[\chi + (1-\chi)p_b\right]$, which we assume to hold.

This short-term contract is palatable to agents of type G as well. If the bank wants to issue some long-term debt it has to design a repayment schedule that attracts type-G agents and provides them with enough incentives to generate a separating equilibrium, whereby type-B agents buy short-term debt while type-G agents buy long-term debt.

Notice that according to type-G agents' beliefs, the short-term debt yields in expectation more than the risk free rate as these agents attach a smaller probability to the default event than agents of type B, to whom the short-term contract is tailored, do. Indeed, the expected excess return on the short-term contract according to type-G beliefs is

$$p_g R_s + (1-p_g)\chi\theta_L - R_f = p_g \frac{R_f - (1-p_b)\chi\theta_L}{p_b} + (1-p_g)\chi\theta_L - R_f = \frac{p_g - p_b}{p_b}(R_f - \chi\theta_L) > 0 \tag{5}$$

where the inequality follows from the fact that $p_g > p_b$ and that $R_f - \chi\theta_L > 0$; the former is true by assumption while the latter follows from substituting in the participation

[32] Suppose also that the cash flow in period 2 cannot be transferred to period 1 by liquidating the investment.

constraint for type-B agents, PC_B. Indeed,

$$R_f - \chi\theta_L = p_b R_s + (1-p_b)\chi\theta_L - \chi\theta_L = p_b(R_s - \chi\theta_L) > p_b(R_s - \theta_L) > 0 \tag{6}$$

where $(R_s - \theta_L) > 0$ because parameters are chosen to induce default in the low state, θ_L. Even though type-G agents prefer the short-term contract to the risk free rate, we show next that it is possible to design a long-term contract that type-G agents prefer to the short-term one.

Long-term debt. Assume that, conditional on state H being realized at $t = 1$, it is common knowledge that θ_{HL} and θ_{HH} are equally likely and that they average to $\gamma\theta_H$, with $\gamma \geq 1$; moreover, they are both large enough so as to allow repayment, *i.e.* $\theta_{HL} > R_l$. Similarly assume that, conditional on state L being realized at time one, it is common knowledge that θ_{LL} and θ_{LH} are equally likely and that they average to θ_L; moreover, they are both small enough so as not to allow repayment, *i.e.* $\theta_{LH} < R_l$.

Long-term debt is designed so that the participation constraint for type-G agents is satisfied and so that it induces them to weakly prefer the long-term contract to investing in the short-term debt at $t = 0$ and reinvesting the proceeds in the risk-free asset from $t = 1$ to $t = 2$ (incentive compatibility):

$$\begin{aligned} &p_g R_l + (1-p_g)\chi E[\theta_2 \mid \theta_L] \geq R_f^2 && (\text{PC}_G) \\ &p_g R_l + (1-p_g)\chi E[\theta_2 \mid \theta_L] \geq R_f\left(p_g R_s + (1-p_g)\chi\theta_L\right) && (\text{IC}_G) \end{aligned} \tag{7}$$

Notice that once the incentive compatibility is satisfied, the participation constraint is satisfied as well; this is because agents of type G prefer the short-term debt contract to investing at the risk free rate, as we have shown in equation 5.

The smallest possible repayment on the long-term contract is such that IC_G holds with equality. That is,

$$R_l = R_f R_s + \frac{(1-p_g)}{p_g}\chi\theta_L(R_f - 1) \tag{8}$$

Having imposed that $\theta_{HL} > R_l$ implies assuming that

$$p_g(\theta_{HL} - \chi\theta_L - R_f(R_s - \chi\theta_L)) > \chi\theta_L(R_f - 1) \tag{9}$$

which gives the lowest p_g that sustains long-term funding to the bank. Call this p_*:

$$p_* \equiv \frac{\chi\theta_L(R_f - 1)}{\theta_{HL} - \chi\theta_L - R_f(R_s - \chi\theta_L)} \tag{10}$$

Finally we need to prove that type-B agents weakly prefer to invest in the short-term contract and then reinvest the proceeds in the risk free rate for an additional period instead of investing in the long-term contract. Thus, we need to show that

$$(p_b R_s + (1 - p_b)\chi\theta_L)\, R_f \geq p_b R_l + (1 - p_b)\chi E[\theta_2 \mid \theta_L] \tag{11}$$

After using $E[\theta_2 \mid \theta_L] = \theta_L$ and equations 4 and 8, which define R_s and R_l respectively, equation 11 becomes

$$\frac{1 - p_b}{p_b}\chi\theta_L(R_f - 1) \geq \frac{1 - p_g}{p_g}\chi\theta_L(R_f - 1) \tag{12}$$

Given that $R_f > 1$, condition 12 requires that $\frac{1-p_b}{p_b} \geq \frac{1-p_g}{p_g}$; the last inequality simplifies to $p_g \geq p_b$, which holds by assumption. We can then state the following proposition:

Proposition 4.1 *If $p_g \geq p_*$ and $p_b \geq p_{**}$ there exists a Separating Equilibrium in which type-B agents lend short-term and type-G agents lend long-term. On the other hand, if $p_g < p_*$ and $p_b \geq p_{**}$ there exists a Pooling Equilibrium where both types lend only short-term.*

Suppose that we restrict the analysis to the Separating Equilibrium and that there is a mass s_g of type-G agents and a mass $s_b = 1 - s_g$ of type-B agents. Then, long-term funding and short-term funding are s_g and $1 - s_g$ respectively. Also , the $t = 0$ average market expectation about θ_1 is

$$\bar{E}[\theta_1] = s_g E[\theta_1 \mid G] + (1-s_g) E[\theta_1 \mid B] = (s_g p_g + (1-s_g) p_b)\, \theta_H + (s_g(1-p_g) + (1-s_g)(1-p_b))\, \theta_L \tag{13}$$

Notice that a larger share of type-G agents implies that the average market expectation improves:

$$\frac{\partial \bar{E}[\theta_1]}{\partial s_g} = (p_g - p_b)(\theta_H - \theta_L) > 0 \tag{14}$$

We can restate what we have just discussed with the following lemma:

Lemma 4.2 *In a Separating Equilibrium there is a positive relationship between the ability to issue long-term debt and average market expectations.*

If we consider the distribution of market expectations as a primitive of the model, then the direction of causality goes from market expectations to the ability to issue long-term debt. This point will be clearer in the more general model introduced next.

4.1 The Continuum Case

In this section we extend the model to make it more general while preserving the main result linking market expectations to the ability to issue long-term debt. Suppose now that there is a continuum of types distributed in the $[0, 1]$ interval according to the cumulative distribution function $F : [0, 1] \to [0, 1]$, with $F(0) = 0$ and $F(1) = 1$. A type is assigned a number between 0 and 1 which represents its belief about the probability that $\theta_1 = \theta_H$.

First, we need to find the marginal type, $\hat{p}$, who is indifferent between lending short- and long-term. More precisely, $\hat{p}$ is such that

$$R_f \left(\hat{p} R_s + (1-\hat{p}) \chi \theta_L\right) = \hat{p} R_l + (1-\hat{p}) \chi \theta_L \tag{15}$$

which implies that

$$\hat{p} = \frac{\chi\theta_L(R_f - 1)}{R_l - R_s R_f + \chi\theta_L(R_f - 1)} \tag{16}$$

Since probabilities are bounded between 0 and 1, the same has to hold for $\hat{p}$. This requires both $R_l \geq R_f R_s - \chi\theta_L(R_f - 1)$ and $R_l \geq R_s R_f$ respectively; since $R_f - 1 > 0$, the first condition is implied by the second. Thus, we only require $R_l \geq R_s R_f$, which we refer to as Assumption 1. According to a generic type p, the excess return obtained by lending long-term as opposed to short-term is

$$pR_l + (1-p)\chi\theta_L - R_f\left(pR_s + (1-p)\chi\theta_L\right) \tag{17}$$

which is positive if and only if $p > \hat{p}$ and increasing in p if and only if $R_l > R_f R_s - \chi\theta_L(R_f - 1)$, which is the same condition for $\hat{p} > 0$; the latter holds by Assumption 1. Therefore, agents of type $p \in [\hat{p}, 1]$ invest in the long-term debt contract.
Next, call p_0 the type that is indifferent between the risk free rate and the short-term contract. Then, $p_0 = (R_f - \chi\theta_L)/(R_s - \chi\theta_L)$. Therefore, agents of type $p \in [p_0, \hat{p}]$ invest in the short-term debt contract; in order to have a nonempty set of creditors willing to lend short-term, we need $p_0 \leq \hat{p}$. The latter is equivalent to requiring that $R_l - R_s R_f \leq \chi\theta_L \frac{R_f - 1}{R_f - \chi\theta_L}(R_s - R_f)$; we refer to this as Assumption 2.

This leads to the following proposition:

Proposition 4.3 *Under Assumptions 1 and 2, the amount of long-term funding is* $1 - F(\hat{p})$ *while the amount of short-term funding is* $F(\hat{p}) - F(p_0)$*.*

The exact quantities of short-term and long-term funds and the associated repayments, R_s and R_l, are then chosen by the borrower to maximize its objectives. Once the model is closed, Assumptions 1 and 2 will then depend on the structural parameters of the model.

Closing the Model: Zero Profits Conditions. Under the assumption that banks are operating in a competitive environment, we should impose a zero profits condition.

Moreover, the zero profits condition should be satisfied under the probability distribution consistent with borrower's beliefs, which do not have to necessarily reflect the true underlying probabilities of the states of nature. Note that the zero profits condition will then reveal the subjective borrower's beliefs; however, this does not pose a problem because agents disagree, even in equilibrium: the disagreement is a structural feature of the model and does not reflect any informational advantage of insiders.

Banks operating in a competitive environment need to get zero profits in expectations. This has to hold true for each contract they offer. Suppose on the contrary that they make zero profits between the short- and long-term contracts, with the short-term one making positive profits while subsidizing the long-term contract that makes losses. This would not be an equilibrium because a bank has an incentive to deviate by offering a large number of short-term contracts that yield more advantageous conditions for the lenders than the short-term contracts offered by other banks; all the lenders would then want to purchase this contract and nobody would buy short-term contracts from the other banks, which are now able to sell only long-term contracts. However, these banks are now making negative profits because they are not able to sell the short-term contracts that were supposed to subsidize the losses generated by the long-term ones. This situation is not an equilibrium. Therefore the only equilibrium entails both short- and long-term contracts, each of them making zero profits in expectation. We then require both short- and long-term contracts to make zero profits under the subjective probability distribution of a bank. To this regard, we call π the bank's subjective belief that $\theta_1 = \theta_H$. Then, the zero profits conditions are

$$\begin{aligned} \pi R_s + (1-\pi)\chi\theta_L &= \pi\theta_H + (1-\pi)(1-\chi)\theta_L \\ \pi R_l + (1-\pi)\chi E(\theta_2 \mid \theta_L) &= \pi E(\theta_2 \mid \theta_H) + (1-\pi)(1-\chi)E(\theta_2 \mid \theta_L) \end{aligned} \tag{18}$$

which can be rewritten as

$$\begin{aligned} R_s &= \theta_H + \tfrac{(1-\pi)}{\pi}(1-2\chi)\theta_L \\ R_l &= E(\theta_2 \mid \theta_H) + \tfrac{(1-\pi)}{\pi}(1-2\chi)E(\theta_2 \mid \theta_L) \end{aligned} \tag{19}$$

The last two equations allow us to express Assumptions 1 and 2 in terms of structural parameters; indeed, Assumption 1 is equivalent to

$$\theta_H \geq \frac{1-\pi}{\pi}\frac{R_f - 1}{\gamma - R_f}(1-2\chi)\theta_L$$

which we call Assumption 1a, while Assumption 2 is equivalent to

$$\theta_H[\chi\theta_L(1+\gamma) - R_f(\gamma - R_f)] \geq R_f(R_f-1)\theta_L\left[\chi + \frac{1-\pi}{\pi}(2\chi - 1)\right]$$

which we call Assumption 2a. Finally, plugging 19 into the equations for $\hat{p}$ and p_0 leads to the equilibrium thresholds

$$\begin{aligned} p_0 &= \tfrac{R_f - \chi\theta_L}{\theta_H + \frac{1-\pi}{\pi}\theta_L(1-2\chi)} \\ \hat{p} &= \tfrac{\chi\theta_L(R_f-1)}{(\gamma - R_f)\theta_H + \theta_L(R_f-1)\left(\chi - \frac{1-\pi}{\pi}(1-2\chi)\right)} \end{aligned} \tag{20}$$

4.2 Comparative Statics

Next, we investigate the impact of changes in market expectations on the maturity structure of debt. We will show how deteriorating expectations endogenously lead to a shortening of the maturity of debt. On the other hand, an improvement in market expectations allows a bank to issue more long-term debt.

For convenience, consider the subjective probabilities of $\theta_1 = \theta_H$ following a uniform distribution in the interval $[m-\varepsilon, m+\varepsilon]$, with $\varepsilon > 0$, $m+\varepsilon \leq 1$ and $m - \varepsilon \geq 0$:

$$F(p) = \begin{cases} 0 & \text{if } p < m - \varepsilon \\ \frac{p+\varepsilon-m}{2\varepsilon} & \text{if } m - \varepsilon \leq p \leq m + \varepsilon \\ 1 & \text{if } p > m + \varepsilon \end{cases} \tag{21}$$

where by construction m is the average market expectation about future bank's fundamentals. Call the amount of short-term and long-term funding F_s and F_l respectively. From Proposition 4.3 we obtain that the amount of long-term funding is $F_l = 1 - F(\hat{p})$. Then, assuming that $\hat{p} \in [m - \varepsilon, m + \varepsilon]$, we have that

$$\frac{\partial F_l}{\partial m} = \frac{1}{2\varepsilon} > 0 \tag{22}$$

which leads to the main testable implication of the model:

Proposition 4.4 *Under Assumptions 1a and 2a, an improvement in average market expectations allows a bank to issue more long-term debt; conversely, a deterioration of market expectations leads to a shortening of the maturity structure of debt.*

As shown in Tables 9, 11 and 14, this implication of the model is strongly supported by the data.

5 Conclusion

This paper provides a new perspective on the nature of rollover risk. It is commonly believed that short-term debt, by having to be rolled over continuously, is a risk factor that causes fragility and exposes banks to higher default risk. We challenge this view by showing that the mere need to roll over expiring debt does not pose a threat by itself. Instead, default risk increases only when the need to roll over maturing obligations is paired with adverse market expectations reducing a bank's access to new funds. Hence, it is the joint occurrence of a liquidity need and a limited access to the bond market that is ultimately responsible for the rise in default risk. We then explicitly document how market expectations about the future profitability of a bank affect its debt maturity structure. Our results show that adverse market expectations limit the bank's ability to issue new debt and force such institution to shorten its debt maturity structure, thus increasing future rollover risk and causing a progressive build-up of fragility. In other words, short-term debt should not be seen as a cause of fragility, but instead the consequence of deteriorating expectations on the bank's ability to pay back longer-term obligations. According to this view, banning or restricting the use of short-term debt would not reduce the fragility of an institution; on the contrary, it could exacerbate the problem because weak banks, which are already rationed out of longer-term debt, would not even be able to obtain short-term funding.

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6 Tables and Figures

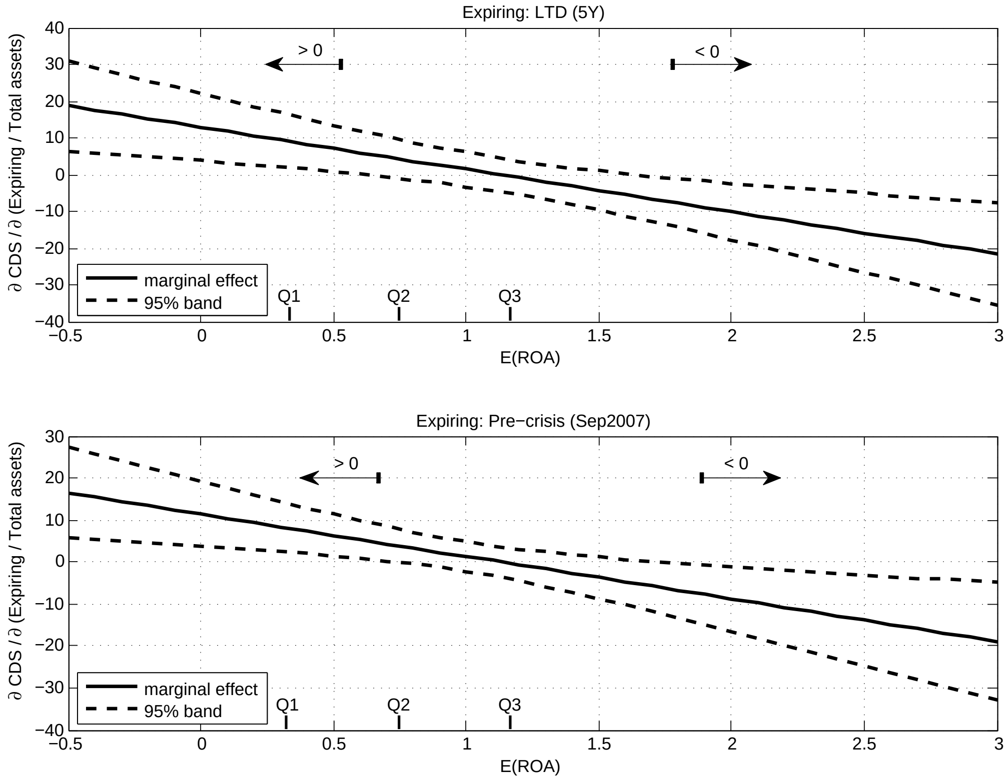

Figure 1: Marginal effect of a unitary increase in $\frac{\text{Expiring}_t}{\text{Total assets}_{t-1}}$ on banks' CDS spread for different values of $\mathbb{E}_t(\text{ROA}_{t+1Y})$. Expiring_t is the amount of debt expiring in month t with maturity greater than 5 years (in the top plot) or issued before the crisis (in the bottom plot). The black arrows highlight the regions of significance at the 5%. Q1, Q2, and Q3 report the values of $\mathbb{E}_t(\text{ROA}_{t+1Y})$ at the first, second, and third quartiles.

Table 1: Descriptive statistics.

	Mean	Std	Median	25 pctile	75 pctile
CDS	232.9	361.0	136.2	52.64	258.6
$\mathbb{E}(ROA)$	0.983	0.692	0.900	0.440	1.360
$\frac{\text{Expiring(LTD)}}{\text{Tot. assets}}$	0.047	0.155	0.000	0.000	0.003
$\frac{\text{Expiring(Pre-crisis)}}{\text{Tot. assets}}$	0.065	0.178	0.001	0.000	0.011
Maturity (months)	73.00	81.21	49.00	24.00	90.38
Tobin's Q	1.053	0.169	1.025	0.991	1.076
ln(assets)	18.11	2.002	18.15	16.75	19.60
Tier 1 capital	0.115	0.164	0.103	0.083	0.126
Tot. capital	0.162	0.281	0.133	0.115	0.156
$\frac{\text{Equity}}{\text{Tot. assets}}$	0.083	0.107	0.073	0.050	0.100
$\frac{\text{Imp. loans}}{\text{Gross loans}}$	0.044	0.070	0.023	0.009	0.049
$\frac{\text{Short-term}}{\text{Tot. fund.}}$	0.791	0.194	0.846	0.722	0.930
$\frac{\text{Liquid}}{\text{Tot. assets}}$	0.186	0.160	0.074	0.139	0.250
$\frac{\text{Reserves}}{\text{Gross loans}}$	0.033	0.049	0.019	0.011	0.037
$\frac{\text{Reserves}}{\text{Imp. loans}}$	1.225	1.174	0.808	0.552	1.412
$\frac{\text{Cust. dep}}{\text{Tot. assets}}$	0.517	0.210	0.535	0.372	0.681
$\frac{\text{Charge-offs}}{\text{Gross loans}}$	1.273	17.91	0.274	0.072	0.769

Notes: descriptive statistics for the main variables employed. CDS is the daily 5-years CDS spread on senior debt averaged over the month. $\mathbb{E}(ROA)$ is the median of the analyst forecasts formed on the one-year ahead ROA. Expiring(LTD) is the amount of expiring debt with maturity greater than 5 years. Expiring(Pre-crisis) is the total amount of expiring debt issued before September 2007. Maturity is debt maturity at issuance expressed in number of months. Tobin's Q is the monthly average of daily Tobin's Q. Ln(assets) is the log of total assets (in billion of €). Remaining variables are standard balance-sheet ratios for capitalization (Tier 1 capital and Total capital ratios), leverage (equity to total assets), quality of the loan portfolio (net charge-offs to gross loans, impaired loans to gross loans, and reserves to gross loans), liquidity (liquid assets to total assets), and composition of funding (short-term funding to total funding and customer deposits to total assets).

Table 2: Rollover-risk, probability of default, and the role of expectations.

Dependent variable: CDS_t

Expiring$_t$:	LTD(5Y)		Pre-crisis(Sep07)	
	(1)	(2)	(3)	(4)
CDS_{t-1}	0.941***	0.939***	0.942***	0.941***
	(0.0188)	(0.0187)	(0.0187)	(0.0185)
$\mathbb{E}_t(ROA_{t+1Y})$	-10.34**	6.371	-9.598*	6.493
	(5.165)	(7.149)	(5.215)	(7.495)
$\frac{\text{Expiring}_t}{\text{Total assets}_{t-1}}$	2.016	13.03***	1.092	10.19**
	(2.180)	(4.506)	(1.722)	(4.047)
$\frac{\text{Expiring}_t}{\text{Total assets}_{t-1}} \times \mathbb{E}_t(ROA_{t+1Y})$		-11.11***		-8.705***
		(3.396)		(3.153)
Bank FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
# obs.	3134	3014	3134	3014
R^2	0.908	0.904	0.908	0.904
p(Hansen)	0.249	0.830	0.357	0.690
p(Underid. test)	0.000	0.000	0.000	0.000
Kleibergen-Paap F	274.6	20.21	266.7	17.44

Notes: two-step GMM estimator with time and bank-specific fixed effects. The dependent variable is CDS_t, defined as the monthly average of daily 5-years CDS spreads on senior debt. $\mathbb{E}_t(ROA_{t+1Y})$ is the median of the analyst forecasts formed at time t on the one-year ahead ROA of bank i. Expiring$_t$ is the amount of debt expiring in month t with maturity greater than 5 years (in columns 1 and 2) or issued before the crisis (in columns 3 and 4). Instrumented regressors: $\mathbb{E}_t(ROA_{t+1Y})$, $\frac{\text{Expiring}_t}{\text{Total assets}_{t-1}} \times \mathbb{E}_t(ROA_{t+1Y})$. We instrument $\mathbb{E}_t(ROA_{t+1Y})$ with its values lagged once or more and lagged forecast error. Additional regressors (not shown): $\ln(\text{total assets})_{t-1}$, $\frac{\text{Equity}_{t-1}}{\text{Tot. assets}_{t-1}}$, $\frac{\text{Imp. loans}_{t-1}}{\text{Gross loans}_{t-1}}$, $\frac{\text{Short term}_{t-1}}{\text{Tot. fund.}_{t-1}}$, $\frac{\text{Liquid}_{t-1}}{\text{Tot. assets}_{t-1}}$, $\frac{\text{Reserves}_{t-1}}{\text{Gross loans}_{t-1}}$, $\frac{\text{Reserves}_{t-1}}{\text{Imp. loans}_{t-1}}$. Robust standard errors in parentheses. ***,**,* indicate statistical significance at 1%, 5%, and 10%, respectively.

Table 3: The effect of lagged expectations and forecast errors.

	(1)	(2)	(3)	(4)
$\mathbb{E}_{t-1}(\text{ROA}_{t+1Y})$	0.338***		0.247***	
	(0.00573)		(0.00554)	
$\mathbb{E}_{t-2}(\text{ROA}_{t+1Y})$	0.0814***	0.304***	0.0443***	0.199***
	(0.00571)	(0.00630)	(0.00548)	(0.00602)
$\mathbb{E}_{t-3}(\text{ROA}_{t+1Y})$		0.0809***		0.0345***
		(0.00626)		(0.00596)
Forecast error_{t-1}	0.0469***		0.0166***	
	(0.00456)		(0.00461)	
Forecast error_{t-2}	0.0543***	0.0504***	0.0334***	0.0149***
	(0.00456)	(0.00497)	(0.00461)	(0.00500)
Forecast error_{t-3}		0.0601***		0.0380***
		(0.00499)		(0.00500)
Bank FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
Balance-sheet controls	No	No	Yes	Yes
# obs.	29587	28671	22216	21608
R^2	0.614	0.526	0.671	0.597

Notes: within estimator with bank and time fixed effects. The dependent variable is $\mathbb{E}_t(\text{ROA}_{t+1Y})$. Forecast error_t is defined as the difference between the realized and expected ROA of bank i in time t. Additional regressors in columns 3 and 4 (not shown): $\ln(\text{total assets})_{t-1}$, $\frac{\text{Equity}_{t-1}}{\text{Tot. assets}_{t-1}}$, $\frac{\text{Imp. loans}_{t-1}}{\text{Gross loans}_{t-1}}$, $\frac{\text{Short term}_{t-1}}{\text{Tot. fund.}_{t-1}}$, $\frac{\text{Liquid}_{t-1}}{\text{Tot. assets}_{t-1}}$, $\frac{\text{Reserves}_{t-1}}{\text{Gross loans}_{t-1}}$, $\frac{\text{Reserves}_{t-1}}{\text{Imp. loans}_{t-1}}$. Robust standard errors in parentheses. ***,**,* indicate statistical significance at 1%, 5%, and 10%, respectively.

Table 4: Rollover-risk, probability of default, and the role of expectations: dynamic coordination.

Dependent variable: CDS_t

Expiring_t:	Pre-crisis(Sep07)		Pre-crisis(Sep07)	
	(1)	(2)	(3)	(4)
$\frac{\sum_{s=0}^{3} \text{Expiring}_{t+s}}{\text{Total assets}_{t-1}}$	0.469	4.952 **		
	(0.943)	(2.196)		
$\frac{\sum_{s=0}^{3} \text{Expiring}_{t+s}}{\text{Total assets}_{t-1}} \times \mathbb{E}_t(\text{ROA}_{t+1Y})$		-3.934 **		
		(1.663)		
$\frac{\text{Expiring}_t}{\text{Total assets}_{t-1}}$			0.486	5.819 **
			(1.253)	(2.961)
$\frac{\sum_{s=1}^{3} \text{Expiring}_{t+s}}{\text{Total assets}_{t-1}}$			-0.0781	-1.464
			(0.974)	(2.152)
$\frac{\text{Expiring}_t}{\text{Total assets}_{t-1}} \times \mathbb{E}_t(\text{ROA}_{t+1Y})$				-5.212 **
				(2.275)
$\frac{\sum_{s=1}^{3} \text{Expiring}_{t+s}}{\text{Total assets}_{t-1}} \times \mathbb{E}_t(\text{ROA}_{t+1Y})$				1.019
				(1.837)
Bank FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
# obs.	2289	3460	3888	4046
R^2	0.916	0.916	0.856	0.864
p(Hansen)	0.246	0.477	0.699	0.703
p(Underid. test)	0.000	0.000	0.000	0.000
Kleibergen-Paap F	166.1	15.91	32.21	42.53

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: two-step GMM estimator with time and bank-specific fixed effects. The dependent variable is CDS_t, defined as the monthly average of daily 5-years CDS spreads on senior debt. $\mathbb{E}_t(\text{ROA}_{t+1Y})$ is the median of the analyst forecasts formed at time t on the one-year ahead ROA of bank i. Expiring_t is the amount of debt expiring in month t that was issued before the crisis. Instrumented regressors: $\mathbb{E}_t(\text{ROA}_{t+1Y})$, $\frac{\text{Expiring}_t}{\text{Total assets}_{t-1}} \times \mathbb{E}_t(\text{ROA}_{t+1Y})$ and $\frac{\sum_{s=1}^{3} \text{Expiring}_{t+s}}{\text{Total assets}_{t-1}} \times \mathbb{E}_t(\text{ROA}_{t+1Y})$. We instrument $\mathbb{E}_t(\text{ROA}_{t+1Y})$ with its values lagged once or more and lagged forecast error. Additional regressors (not shown) follow the specification in Table 2. Robust standard errors in parentheses. ***,**,* indicate statistical significance at 1%, 5%, and 10%, respectively.

Table 5: Rollover-risk, probability of default, and the role of expectations: dynamic coordination.

Dependent variable: CDS_t				
Expiring_t:	LTD(5Y)		LTD(5Y)	
	(1)	(2)	(3)	(4)
$\frac{\sum_{s=0}^{3} \text{Expiring}_{t+s}}{\text{Total assets}_{t-1}}$	2.332	9.092***		
	(1.708)	(3.455)		
$\frac{\sum_{s=0}^{3} \text{Expiring}_{t+s}}{\text{Total assets}_{t-1}} \times \mathbb{E}_t(\text{ROA}_{t+1Y})$		-7.979***		
		(2.903)		
$\frac{\text{Expiring}_t}{\text{Total assets}_{t-1}}$			6.669*	28.24***
			(3.963)	(9.598)
$\frac{\sum_{s=1}^{3} \text{Expiring}_{t+s}}{\text{Total assets}_{t-1}}$			2.487	0.769
			(1.881)	(4.495)
$\frac{\text{Expiring}_t}{\text{Total assets}_{t-1}} \times \mathbb{E}_t(\text{ROA}_{t+1Y})$				-27.21***
				(8.899)
$\frac{\sum_{s=1}^{3} \text{Expiring}_{t+s}}{\text{Total assets}_{t-1}} \times \mathbb{E}_t(\text{ROA}_{t+1Y})$				1.566
				(4.261)
Bank FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
# obs.	1346	1394	1329	1362
R^2	0.783	0.781	0.773	0.793
p(Hansen)	0.245	0.505	0.371	0.281
p(Underid. test)	0.000	0.000	0.000	0.000
Kleibergen-Paap F	12.19	14.99	10.10	21.35

Notes: two-step GMM estimator with time and bank-specific fixed effects. The dependent variable is CDS_t, defined as the monthly average of daily 5-years CDS spreads on senior debt. $\mathbb{E}_t(\text{ROA}_{t+1Y})$ is the median of the analyst forecasts formed at time t on the one-year ahead ROA of bank i. Expiring_t is the amount of debt expiring in month t with maturity greater than 5 years. Instrumented regressors: $\mathbb{E}_t(\text{ROA}_{t+1Y})$, $\frac{\text{Expiring}_t}{\text{Total assets}_{t-1}} \times \mathbb{E}_t(\text{ROA}_{t+1Y})$ and $\frac{\sum_{s=1}^{3} \text{Expiring}_{t+s}}{\text{Total assets}_{t-1}} \times \mathbb{E}_t(\text{ROA}_{t+1Y})$. We instrument $\mathbb{E}_t(\text{ROA}_{t+1Y})$ with its values lagged once or more and lagged forecast error. Additional regressors (not shown) follow the specification in Table 2. Robust standard errors in parentheses. ***,**,* indicate statistical significance at 1%, 5%, and 10%, respectively.

Table 6: Rollover-risk, probability of default, and the role of expectations: pre-crisis vs. crisis.

Dependent variable: CDS_t		
$Expiring_t$:	LTD(5Y)	
	(1)	(2)
CDS_{t-1}	0.939***	0.908***
	(0.0174)	(0.0289)
Pre-Crisis: Jan2005–Aug2007		
$\mathbb{E}_t(ROA_{t+1Y})$	-1.319	4.372
	(3.532)	(3.495)
$\frac{Expiring_t}{Total\ assets_{t-1}}$	-0.0240	0.348
	(1.267)	(3.340)
$\frac{Expiring_t}{Total\ assets_{t-1}} \times \mathbb{E}_t(ROA_{t+1Y})$		0.382
		(1.936)
Crisis: Sep2007–Dec2014		
$\mathbb{E}_t(ROA_{t+1Y})$	-9.679**	-1.241
	(3.763)	(3.215)
$\frac{Expiring_t}{Total\ assets_{t-1}}$	2.235	11.80***
	(2.593)	(3.866)
$\frac{Expiring_t}{Total\ assets_{t-1}} \times \mathbb{E}_t(ROA_{t+1Y})$		-9.456***
		(2.787)
Bank FE	Yes	Yes
Time FE	Yes	Yes
# obs.	3164	3098
R^2	0.913	0.886
p(Hansen)	0.307	0.155
p(Underid. test)	0.000	0.000
Kleibergen-Paap F	31.19	14.90

Notes: two-step GMM estimator with time and bank-specific fixed effects. The dependent variable is CDS_t, defined as the monthly average of daily 5-years CDS spreads on senior debt. $\mathbb{E}_t(ROA_{t+1Y})$ is the median of the analyst forecasts formed at time t on the one-year ahead ROA of bank i. $Expiring_t$ is the amount of debt expiring in month t with maturity greater than 5 years. All coefficients are allowed to vary across pre-crisis (Jan2005–Aug2007) and crisis (Sep2007–Dec2014) periods. Instrumented regressors: $\mathbb{E}_t(ROA_{t+1Y})$, $\frac{Expiring_t}{Total\ assets_{t-1}} \times \mathbb{E}_t(ROA_{t+1Y})$. We instrument $\mathbb{E}_t(ROA_{t+1Y})$ with its values lagged once or more and lagged forecast error. Additional regressors (not shown) follow the specification in Table 2. Robust standard errors in parentheses. ***,**,* indicate statistical significance at 1%, 5%, and 10%, respectively.

Table 7: Rollover-risk, probability of default, and the role of expectations: call and put options.

Dependent variable: CDS_t

$Expiring_t$:	Pre-crisis(Sep07)_a		Pre-crisis(Sep07)_b		Pre-crisis(Sep07)_c	
	(1)	(2)	(3)	(4)	(5)	(6)
CDS_{t-1}	0.944***	0.941***	0.944***	0.941***	0.944***	0.941***
	(0.0136)	(0.0139)	(0.0136)	(0.0139)	(0.0136)	(0.0139)
$\mathbb{E}_t(ROA_{t+1Y})$	-2.248	7.708	-2.255	7.685	-1.581	6.720
	(4.264)	(5.830)	(4.264)	(5.831)	(4.274)	(5.842)
$\frac{Expiring_t}{Total\ assets_{t-1}}$	1.465	9.936***	1.456	10.00***	1.293	8.797***
	(1.345)	(3.372)	(1.361)	(3.420)	(1.304)	(3.271)
$\frac{Expiring_t}{Total\ assets_{t-1}} \times \mathbb{E}_t(ROA_{t+1Y})$		-7.848***		-7.914***		-6.931***
		(2.589)		(2.627)		(2.516)
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
# obs.	4682	4432	4682	4432	4728	4471
R^2	0.914	0.910	0.914	0.910	0.914	0.910
p(Hansen)	0.441	0.890	0.443	0.889	0.382	0.884
p(Underid. test)	0.000	0.000	0.000	0.000	0.000	0.000
Kleibergen-Paap F	345.9	21.62	345.9	21.62	348.6	21.73

Notes: two-step GMM estimator with time and bank-specific fixed effects. The dependent variable is CDS_t, defined as the monthly average of daily 5-years CDS spreads on senior debt. $\mathbb{E}_t(ROA_{t+1Y})$ is the median of the analyst forecasts formed at time t on the one-year ahead ROA of bank i. $Expiring_t$ is the amount of debt expiring in month t issued before the unfolding of the financial crisis. In columns 1 and 2 we purge our measure of rollover risk from the amount of debt that was previously called by the bank (Pre-crisis(Sep07)_a). In columns 3 and 4 we also exclude the stock of debt with a put option on (Pre-crisis(Sep07)_b). In columns 5 and 6 we assume put options are exercised in the first available date (Pre-crisis(Sep07)_c) and generate an anticipated liquidity need. Instrumented regressors: $\mathbb{E}_t(ROA_{t+1Y})$, $\frac{Expiring_t}{Total\ assets_{t-1}} \times \mathbb{E}_t(ROA_{t+1Y})$. We instrument $\mathbb{E}_t(ROA_{t+1Y})$ with its values lagged once or more and lagged forecast error. Additional regressors (not shown) follow the specification in Table 2. Robust standard errors in parentheses. ***,**,* indicate statistical significance at 1%, 5%, and 10%, respectively.

Table 8: Rollover-risk, probability of default, and the role of expectations: call and put options.

Dependent variable: CDS_t

$Expiring_t$:	LTD(5Y)_a		LTD(5Y)_b		LTD(5Y)_c	
	(1)	(2)	(3)	(4)	(5)	(6)
CDS_{t-1}	0.939***	0.937***	0.939***	0.937***	0.940***	0.937***
	(0.0184)	(0.0184)	(0.0184)	(0.0184)	(0.0184)	(0.0184)
$\mathbb{E}_t(ROA_{t+1Y})$	-10.05**	6.175	-10.03**	6.190	-9.433*	4.938
	(5.107)	(7.103)	(5.106)	(7.106)	(5.129)	(7.104)
$\frac{Expiring_t}{Total\ assets_{t-1}}$	1.971	13.09***	2.055	13.53***	1.749	11.37***
	(2.184)	(4.537)	(2.228)	(4.665)	(2.019)	(4.200)
$\frac{Expiring_t}{Total\ assets_{t-1}} \times \mathbb{E}_t(ROA_{t+1Y})$		-11.12***		-11.52***		-9.711***
		(3.414)		(3.525)		(3.184)
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
# obs.	3229	3103	3229	3103	3275	3142
R^2	0.908	0.904	0.908	0.904	0.908	0.904
p(Hansen)	0.220	0.821	0.224	0.822	0.185	0.782
p(Underid. test)	0.000	0.000	0.000	0.000	0.000	0.000
Kleibergen-Paap F	275.3	20.16	275.3	20.18	278.2	20.38

Notes: two-step GMM estimator with time and bank-specific fixed effects. The dependent variable is CDS_t, defined as the monthly average of daily 5-years CDS spreads on senior debt. $\mathbb{E}_t(ROA_{t+1Y})$ is the median of the analyst forecasts formed at time t on the one-year ahead ROA of bank i. $Expiring_t$ is the amount of debt expiring in month t with maturity greater than 5 years. In columns 1 and 2 we purge our measure of rollover risk from the amount of debt that was previously called by the bank (LTD(5Y)_a). In columns 3 and 4 we also exclude the stock of debt with a put option on (LTD(5Y)_b). In columns 5 and 6 we assume put options are exercised in the first available date (LTD(5Y)_c) and generate an anticipated liquidity need. Instrumented regressors: $\mathbb{E}_t(ROA_{t+1Y})$, $\frac{Expiring_t}{Total\ assets_{t-1}} \times \mathbb{E}_t(ROA_{t+1Y})$. We instrument $\mathbb{E}_t(ROA_{t+1Y})$ with its values lagged once or more and lagged forecast error. Additional regressors (not shown) follow the specification in Table 2. Robust standard errors in parentheses. ***,**,* indicate statistical significance at 1%, 5%, and 10%, respectively.

Table 9: Amount of debt issued and expectations.

Horizon(s):	1Y	1Y	1Y	1Y	1:3Y	1:3Y	1:3Y	1:3Y
Y_t:	Iss(tot)	Iss($<$5)	Iss($\geq$5)	Iss($\geq$10)	Iss(tot)	Iss($<$5)	Iss($\geq$5)	Iss($\geq$10)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\mathbb{E}_t(\text{ROA}_{t+s})$	0.049**	-0.049*	0.065**	0.068***	0.061**	-0.026	0.076***	0.071***
	(0.022)	(0.025)	(0.025)	(0.023)	(0.025)	(0.030)	(0.024)	(0.025)
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
# obs.	11180	11180	11180	11180	9951	9052	10062	10062
R^2	0.0546	0.0561	0.0720	0.0932	0.0489	0.0542	0.0638	0.0970
p(Hansen)	0.662	0.345	0.247	0.280	0.828	0.291	0.848	0.766
p(Underid. test)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Kleibergen-Paap F	125	90.8	90.8	90.8	125	59.1	93.7	93.7

Notes: two-step GMM estimator with time and bank-specific fixed effects. The dependent variable varies across columns and in listed in the second row. Iss(tot) is the total amount of debt issued in t rescaled by the previous-year total assets. Iss($<$5) is the amount of debt issued in t with maturity lower than five years rescaled by the previous-year total assets. Iss($\geq$5) is the amount of debt issued in t with maturity grater than five years rescaled by the previous-year total assets. Iss($\geq$10) is the amount of debt issued in t with maturity greater than ten years rescaled by the previous-year total assets. $\mathbb{E}_t(\text{ROA}_s)$ is the median of the analyst forecasts formed at time t on the ROA of bank i in s. The forecast horizon s is one year in columns 1-4, and a combination of one, two, and three years in columns 5-8 (the first principal component loading positively on each factor and explaining 60% of total variance). Instrumented regressor: $\mathbb{E}_t(\text{ROA}_s)$. Set of instruments: values lagged once or more and lagged forecast error. Additional regressors (not shown): ROA_{t-1}, $\ln(\text{total assets})_{t-1}$, Tier1 ratio$_{t-1}$, $\frac{\text{Equity}_{t-1}}{\text{Tot. assets}_{t-1}}$, $\frac{\text{Cust. dep.}_{t-1}}{\text{Tot. fund.}_{t-1}}$, $\frac{\text{Imp. loans}_{t-1}}{\text{Gross loans}_{t-1}}$, $\frac{\text{Charge–offs}_{t-1}}{\text{Gross loans}_{t-1}}$, $\frac{\text{Short term}_{t-1}}{\text{Tot. fund.}_{t-1}}$, $\frac{\text{Liquid}_{t-1}}{\text{Tot. assets}_{t-1}}$, $\frac{\text{Reserves}_{t-1}}{\text{Gross loans}_{t-1}}$, $\frac{\text{Reserves}_{t-1}}{\text{Imp. loans}_{t-1}}$. Robust standard errors in parentheses. ***,**,* indicate statistical significance at 1%, 5%, and 10%, respectively.

Table 10: Probability of debt issuance and expectations.

Horizon(s):	1Y	1Y	1Y	1Y	1:3Y	1:3Y	1:3Y	1:3Y
Y_t:	Pr(tot)	Pr(<5)	Pr(≥5)	Pr(≥10)	Pr(tot)	Pr(<5)	Pr(≥5)	Pr(≥10)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\mathbb{E}_t(\text{ROA}_{t+s})$	0.0297**	0.00807	0.0306**	0.0336***	0.0336*	0.0210	0.0380**	0.0278***
	(0.0144)	(0.0161)	(0.0136)	(0.00866)	(0.0173)	(0.0210)	(0.0179)	(0.0102)
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
# obs.	11123	11180	11123	11123	10391	8968	10062	9006
R^2	0.0498	0.0347	0.0409	0.0415	0.0486	0.0373	0.0346	0.0389
p(Hansen)	0.207	0.0965	0.355	0.1000	0.322	0.102	0.320	0.240
p(Underid. test)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Kleibergen-Paap F	141	125	95.9	95.9	203	180	93.7	59.7

Notes: two-step GMM estimator with time and bank-specific fixed effects. The dependent variable varies across columns and in listed in the second row. Pr(tot) is a dummy variable identifying the issuance of debt (independently by the maturity) in t. Pr(<5) is a dummy variable identifying the issuance of in t with maturity lower than five years. Pr(≥5) is a dummy variable identifying the issuance of debt in t with maturity greater than five years. Pr(>10) is a dummy variable identifying the issuance debt in t with maturity greater than ten years. $\mathbb{E}_t(\text{ROA}_s)$ is the median of the analyst forecasts formed at time t on the ROA of bank i in s. The forecast horizon s is one year in columns 1-4, and a combination of one, two, and three years in columns 5-8 (the first principal component loading positively on each factor and explaining 60% of total variance). Instrumented regressor: $\mathbb{E}_t(\text{ROA}_s)$. Set of instruments: values lagged once or more and lagged forecast error. Additional regressors (not shown) follow the specification in Table 9. Robust standard errors in parentheses. ***,**,* indicate statistical significance at 1%, 5%, and 10%, respectively.

Table 11: Maturity and expectations.

Dependent variable: Mat		
Horizon(s):	1Y	1:3Y
	(1)	(2)
$\mathbb{E}_t(\text{ROA}_{t+s})$	0.128***	0.176***
	(0.0480)	(0.0654)
Bank FE	Yes	Yes
Time FE	Yes	Yes
# obs.	6455	5692
R^2	0.0729	0.0653
p(Hansen)	0.501	0.954
p(Underid. test)	0.000	0.000
Kleibergen-Paap F	82.73	53.32

Notes: two-step GMM with time and bank-specific fixed effects. The dependent variable is Mat, defined as the (log of one plus) average maturity of debt issued at time t; if no debt is issued at time t, the observation is set as missing. $\mathbb{E}_t(\text{ROA}_s)$ is the median of the analyst forecasts formed at time t on the ROA of bank i in s. The forecast horizon s is one year in column 1, and a combination of one, two, and three years in column 2 (the first principal component loading positively on each factor and explaining 60% of total variance). Instrumented regressor: $\mathbb{E}_t(\text{ROA}_s)$. Set of instruments: values lagged once or more and lagged forecast error. Additional regressors (not shown) follow the specification in Table 9. Robust standard errors in parentheses. ***,**,* indicate statistical significance at 1%, 5%, and 10%, respectively.

Table 12: Debt issuance and expectations: controlling for Tobin's Q.

Y_t:	Iss(tot)	Iss(<5)	Iss(≥5)	Iss(≥10)	Pr(tot)	Pr(<5)	Pr(≥5)	Pr(≥10)	Mat
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$\mathbb{E}_t(\text{ROA}_{t+1Y})$	0.032**	0.001	0.020	0.033***	0.032*	0.024	0.004	0.028***	0.111**
	(0.015)	(0.020)	(0.016)	(0.012)	(0.019)	(0.018)	(0.014)	(0.009)	(0.054)
Tobin's Q_{t-1}	0.655	-1.15***	1.14***	0.530***	-0.417*	-0.873***	0.486***	0.304**	2.23***
	(0.424)	(0.438)	(0.361)	(0.194)	(0.222)	(0.216)	(0.171)	(0.118)	(0.878)
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
# obs.	8388	8388	8388	8388	8352	8388	8352	8177	4777
R^2	0.037	0.034	0.043	0.057	0.053	0.038	0.043	0.038	0.073
p(Hansen)	0.285	0.585	0.164	0.148	0.157	0.136	0.400	0.186	0.606
p(Underid. test)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Kleibergen-Paap F	132.4	65.54	65.54	65.54	62.81	132.4	62.81	51.14	74.21

Notes: two-step GMM estimator with time and bank-specific fixed effects. The dependent variable varies across columns and in listed in the first row. Iss(tot) is the total amount of debt issued in t rescaled by the previous-year total assets. Iss(<5) is the amount of debt issued in t with maturity lower than five years rescaled by the previous-year total assets. Iss(≥5) is the amount of debt issued in t with maturity grater than five years rescaled by the previous-year total assets. Iss(≥10) is the amount of debt issued in t with maturity greater than ten years rescaled by the previous-year total assets. Pr(tot) is a dummy variable identifying the issuance of debt (independently by the maturity) in t. Pr(<5) is a dummy variable identifying the issuance of in t with maturity lower than five years. Pr(≥5) is a dummy variable identifying the issuance of debt in t with maturity greater than five years. Pr(≥10) is a dummy variable identifying the issuance debt in t with maturity greater than ten years. Mat is defined as the (log of one plus) average maturity of debt issued at time t. $\mathbb{E}_t(\text{ROA}_{t+1Y})$ is the median of the analyst forecasts on the one-year ahead ROA of bank i formed in time t. Instrumented regressor: $\mathbb{E}_t(\text{ROA}_{t+1Y})$. Set of instruments: values lagged once or more and lagged forecast error. Additional regressors (not shown) follow the specification in Table 9. Robust standard errors in parentheses. ***,**,* indicate statistical significance at 1%, 5%, and 10%, respectively.

Table 13: Amount of debt issued and expectations: alternative IV strategy.

IV:	Further lags				Only forecast error			
Y_t:	Iss(tot)	Iss(<5)	Iss(≥5)	Iss(≥10)	Iss(tot)	Iss(<5)	Iss(≥5)	Iss(≥10)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\mathbb{E}_t(\text{ROA}_{t+1Y})$	0.0805**	-0.178***	0.163***	0.153***	0.0834**	-0.0552*	0.0863**	0.0828***
	(0.0397)	(0.0464)	(0.0435)	(0.0416)	(0.0393)	(0.0329)	(0.0405)	(0.0313)
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
# obs.	10789	10789	10789	10789	11175	11175	11175	11175
R^2	0.0544	0.0597	0.0758	0.0982	0.0544	0.0563	0.0724	0.0968
p(Hansen)	0.571	0.501	0.169	0.284	0.595	0.596	0.387	0.550
p(Underid. test)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Kleibergen-Paap F	162.4	162.4	162.4	162.4	48.35	48.35	48.35	37.45

Notes: two-step GMM estimator with time and bank-specific fixed effects. The dependent variable varies across columns and in listed in the second row. Iss(tot) is the total amount of debt issued in t rescaled by the previous-year total assets. Iss(<5) is the amount of debt issued in t with maturity lower than five years rescaled by the previous-year total assets. Iss(≥5) is the amount of debt issued in t with maturity grater than five years rescaled by the previous-year total assets. Iss(≥10) is the amount of debt issued in t with maturity greater than ten years rescaled by the previous-year total assets. $\mathbb{E}_t(\text{ROA}_s)$ is the median of the analyst forecasts formed at time t on the one-year ahead ROA of bank i. Instrumented regressor: $\mathbb{E}_t(\text{ROA}_s)$. Set of instruments: values lagged *four-to-six times* of expectations and forecast errors in columns (1-4), only lagged forecast errors in columns (5-8). Additional regressors (not shown) follow the specification in Table 9. Robust standard errors in parentheses. ***,**,* indicate statistical significance at 1%, 5%, and 10%, respectively.

Table 14: Issuance, expectations, and exposure to rollover risk.

Threshold for fragility	75^{th} percentile				Median			
Y_t:	Iss(tot)	Iss(<5)	Iss(≥5)	Iss(≥10)	Iss(tot)	Iss(<5)	Iss(≥5)	Iss(≥10)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Fragility measure:	Expiring debt / Total assets							
$\mathbb{E}_t(\text{ROA}_{t+1Y})\times\text{Fragile}_t$	0.110***	-0.099***	0.111***	0.136***	0.077***	-0.071***	0.078***	0.087***
	(0.030)	(0.032)	(0.035)	(0.037)	(0.024)	(0.027)	(0.029)	(0.032)
$\mathbb{E}_t(\text{ROA}_{t+1Y})\times\text{Sound}_t$	0.013	-0.019	0.019	0.022	0.014	-0.018	0.016	0.016
	(0.020)	(0.022)	(0.023)	(0.025)	(0.023)	(0.025)	(0.026)	(0.027)
# obs.	10193	11341	11341	11341	10193	11341	11341	11341
R^2	0.0692	0.0776	0.0882	0.109	0.0671	0.0765	0.0867	0.107
p(Hansen)	0.449	0.274	0.229	0.623	0.408	0.184	0.113	0.399
p(Underid. test)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Kleibergen-Paap F	65.27	75.62	75.62	75.62	74.12	86.71	86.71	86.71
p(Fragile=Sound)	0.000	0.001	0.000	0.000	0.000	0.005	0.001	0.000

Fragility measure:	Short-term funding / Total funding							
$\mathbb{E}_t(\text{ROA}_{t+1Y})\times\text{Fragile}_t$	0.086***	-0.077**	0.115***	0.131***	0.083***	-0.067**	0.091***	0.117***
	(0.032)	(0.036)	(0.034)	(0.036)	(0.028)	(0.029)	(0.025)	(0.023)
$\mathbb{E}_t(\text{ROA}_{t+1Y})\times\text{Sound}_t$	0.047**	-0.027	0.050**	0.056***	0.048**	-0.017	0.038*	0.036*
	(0.021)	(0.021)	(0.021)	(0.020)	(0.022)	(0.021)	(0.021)	(0.018)
# obs.	11076	11076	11076	11076	11076	11076	11076	11076
R^2	0.0556	0.0580	0.0747	0.0964	0.0556	0.0581	0.0745	0.0970
p(Hansen)	0.189	0.537	0.684	0.185	0.905	0.371	0.694	0.416
p(Underid. test)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Kleibergen-Paap F	79.35	79.35	79.35	79.35	82.98	82.98	82.98	82.98
p(Fragile=Sound)	0.0773	0.0801	0.0173	0.0119	0.1191	0.0318	0.0101	0.000

Fragility measure:	Total funding / Customer deposits							
$\mathbb{E}_t(\text{ROA}_{t+1Y})\times\text{Fragile}_t$	0.056***	-0.055**	0.064***	0.072***	0.073***	-0.046**	0.067***	0.079***
	(0.017)	(0.022)	(0.020)	(0.021)	(0.021)	(0.022)	(0.022)	(0.022)
$\mathbb{E}_t(\text{ROA}_{t+1Y})\times\text{Sound}_t$	0.018	0.038	-0.012	-0.019	0.048*	0.015	0.013	-0.001
	(0.025)	(0.029)	(0.026)	(0.026)	(0.026)	(0.027)	(0.023)	(0.021)
# obs.	11076	11076	11076	11076	11076	11076	11076	11076
R^2	0.0557	0.0584	0.0739	0.0949	0.0541	0.0583	0.0736	0.0967
p(Hansen)	0.122	0.0580	0.0690	0.0506	0.00571	0.285	0.0462	0.219
p(Underid. test)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Kleibergen-Paap F	80.37	80.37	80.37	80.37	81.06	81.06	81.06	81.06
p(Fragile=Sound)	0.0945	0.0008	0.0049	0.0022	0.2876	0.0088	0.0061	0.0000

Notes: two-step GMM estimator with time and bank-specific fixed effects. The dependent variable varies across columns and in listed in the second row. Iss(tot) is the total amount of debt issued in t rescaled by the previous-year total assets. Iss(<5) is the amount of debt issued in t with maturity lower than five years rescaled by the previous-year total assets. Iss(≥5) is the amount of debt issued in t with maturity grater than five years rescaled by the previous-year total assets. Iss(≥10) is the amount of debt issued in t with maturity greater than ten years rescaled by the previous-year total assets. $\mathbb{E}_t(\text{ROA}_{t+1Y})$

7 Appendix: Bayesian Learning and Forecast Errors

Here we show that under Bayesian Learning, current expectations are affected by past forecast errors; this, together with the assumption that exclusion restriction holds, establishes the validity of past forecast errors as instruments for current forecasts. We closely follow Bullard and Suda (2008). Suppose that the true fundamental, θ, follows an AR(1) process:

$$\theta_t = a + b\theta_{t-1} + u_t \tag{23}$$

where a and b are unknown parameters, and $u_t \sim N(0, \nu^2)$. A Bayesian learner has priors on the parameters of equation 23: $\phi_0' = (a_0 \; b_0) \sim N(\mu_0, \Omega_0)$. In her mind, the conditional distribution of θ_t given all the information known in the period before is

$\theta_t \mid \Theta_{t-1}, \phi_{t-1} \sim N(a_{t-1} + b_{t-1}\theta_{t-1}, \nu^2)$, where Θ_t is the history of θ_s up to period t.

By Bayes' rule, $f(\phi \mid \Theta_t) \propto f(\Theta_t \mid \phi)f(\phi) \propto f(\theta_t \mid \phi, \Theta_{t-1})f(\theta_{t-1} \mid \phi, \Theta_{t-2}) \ldots f(\theta_1 \mid \phi)f(\phi)$.

Define $z_t = (1 \; \theta_{t-1})'$ and Z_t being the history of z_s up to period t. Then, $f(\phi \mid \Theta_t) = N(\mu_t, \Omega_t)$, where $\mu_t = \Omega_t \left(\Omega_0^{-1}\phi_0 + \nu^{-2}(Z_t'\Theta_t)\right)$ and $\Omega_t = \left(\Omega_0^{-1} + \nu^{-2}(Z_t'Z_t)\right)^{-1}$.

In recursive form, $\Omega_t^{-1} = \Omega_{t-1}^{-1} + \nu^{-2}z_t z_t'$ and $\mu_t = \mu_{t-1} + \Omega_t\nu^{-2}z_t(\theta_t - z_t'\mu_{t-1})$.

Finally, $E_t\theta_{t+1} = z_{t+1}'\mu_t = z_{t+1}'\mu_{t-1} + z_{t+1}'\Omega_t\nu^{-2}z_t(\theta_t - z_t'\mu_{t-1})$, where $\theta_t - z_t'\mu_{t-1}$ is the forecast error in the last period. We can also write it as a weighted sum of all the past forecast errors:

$$E_t\theta_{t+1} = z_{t+1}' \sum_{j=0}^{\infty} \Omega_{t-j}\nu^{-2}z_{t-j}(\theta_{t-j} - z_{t-j}'\mu_{t-j-1}) \tag{24}$$

Therefore, today's forecast $E_t\theta_{t+1}$ is a weighted sum of past forecast errors. We would obtain essentially the same expression for the case of recursive learning[33].

Finally, we take a linear approximation of equation 24 around the unbiased stochastic

[33] See Evans and Honkapohja (2001) for a reference.

steady state[34] to obtain

$$dE_t\theta_{t+1} \approx \sum_{j=0}^{\infty} \bar{c}_{-j} dfe_{t-j} + \sum_{j=0}^{\infty} dc_{t-j} \bar{fe} \tag{25}$$

where $fe_{t-j} \equiv (\theta_{t-j} - z'_{t-j}\mu_{t-j-1})$, $c_{t-j} \equiv z'_{t+1}\Omega_{t-j}\nu^{-2}z_{t-j}$ and the upper bar denotes a variable at the non-stochastic steady state. Since on average forecast errors are zero, *i.e.* $\bar{fe} = 0$, equation 25 simplifies to

$$dE_t\theta_{t+1} \approx \sum_{j=0}^{\infty} \bar{c}_{-j} dfe_{t-j} \tag{26}$$

which is linear in the forecast errors.

[34] By unbiased we mean that forecast errors are on average zero and the notion of a stochastic steady state is required for the sequence of variance-covariance matrices $\{\Omega_{t-j}\}$ not to be degenerate at the steady state, which would have been the case at a non-stochastic steady state.