# Self-fulfilling Runs: Evidence from the U.S. Life Insurance Industry*

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**Abstract**

Is shadow banking vulnerable to self-fulfilling runs? Investors typically decide to withdraw simultaneously, making it challenging to identify self-fulfilling runs. In this paper, we exploit the contractual structure of funding agreement-backed securities offered by U.S. life insurers to institutional investors. The contracts allow us to obtain variation in investors' expectations about other investors' actions that is plausibly orthogonal to changes in fundamentals. We find that a run on life insurers during the summer of 2007 was partly due to self-fulfilling expectations. Our findings suggest that other contemporaneous runs in shadow banking by institutional investors may have had a self-fulfilling component.

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# Introduction

Institutions and markets that are vulnerable to runs pose a threat to financial stability. In the traditional model of banking, individual banks fund long-term illiquid assets with short-term demand deposits. By contrast, in shadow banking, financial intermediation is perfomed by chains of institutions operating outside of the regulated banking sector (Cetorelli et al. 2012). For example, institutions with spare cash may park it with money market mutual funds, who in turn invest in short-term highly rated securities backed by long-term assets, such as asset-backed commercial paper. While traditional banking is vulnerable to depositor runs, shadow banking is potentially vulnerable to runs at different links in the chain. In our example, runs could occur both *on* money market mutual funds by cash investors and *by* money market mutual funds on the issuers of asset-backed commercial paper. While chains of shadow banking institutions facilitate greater risk sharing in the economy, the increased number of chain-links may render the economy more vulnerable to runs. While great progress has been made toward understanding the last financial crisis, there remains considerable debate among policy makers and academics on the actual causes of runs affecting shadow banking. Understanding the mechanisms behind these runs is vital to address the vulnerabilities of the financial system.

In this paper we study the role of self-fulfilling expectations in runs, that is, when investors run because they expect other investors will run and there are strategic complementarities. In an empirical setting, we would like to analyze investors' responses to other investors' actions. But to study how actions of individuals in a group is associated with actions of the group requires us to confront the reflection problem (Manski 1993). The key empirical hurdle to identifying self-fulfilling runs is that investors may be running in response to common fundamentals.[1] Indeed, theory suggests that the two reasons are connected (Morris & Shin 1998, Goldstein & Pauzner 2005, He & Xiong 2012). Weak fundamentals trigger a run, which is amplified by investors' self-fulfilling expectations about other investors' actions. The interaction between fundamentals and strategic complementarities renders empirical identification of self-fulfilling runs very challenging

[1] The term fundamentals includes, for example, changes in their liquidity demand, risk appetite, regulatory constraints, or information about the liquidity of an issuer. Fundamentals may be revealed to all agents, as in Allen & Gale (1998), or asymmetrically, as in Chari & Jagannathan (1988). Other studies of fundamental-based runs include Gorton (1988), Jacklin & Bhattacharya (1988), Calomiris & Gorton (1991), Saunders & Wilson (1996), Chen (1999) and Calomiris & Mason (2003).

(Goldstein 2012).

Several recent papers have offered empirical strategies to oversome the reflection problem. Chen et al. (2010) show that investors in U.S. mutual funds differ in their response to bad fundamentals as a function of the strength of the strategic complementarity associated with each fund. They exploit variation in the liquidity of assets held by the mutual firms as a proxy for the strength of strategic complementarities. Hertzberg et al. (2011) use the 1998 reform of a national public credit registry in Argentina as a natural experiment that revealed strategic complementarity. In April of that year, the central bank announced an expansion of the registry's coverage that would increase the amount of public information available to lenders. In response to the announcement, but before the reform came into effect, lending declined as creditors realized that other creditors would react to the future increase in public information and reduce lending. And Schmidt et al. (2014) use heterogeneity in the costs associated with investing in money market mutual funds (MMFs) as a proxy for investor sophistication. This creates variation in strategic complementarities across MMFs, and explains the differential response of investors in particular MMFs to the bad fundamentals at the outset of the financial crisis.

Our identification approach is different. We first develop a model to show how firms' liability structures is associated with self-fulfilling runs. In particular, we show that bad fundamentals can trigger a self-fulfilling run as a function of the size of potential future creditor withdrawals. Even a low expectation that fundamentals may be bad in future, when combined with a possibility of significant withdrawals by other investors, is enough for investors to run today. The model suggests that progress towards identifying self-fulfilling runs can be made by exploiting exogenous variation in a firm's liability structure.

We take this identification strategy to the data using unusual contractual features of put-table liabilities issued by U.S. life insurers to institutional investors. Since the early 2000s, U.S. life insurers issued *extendible funding agreement-backed notes* (XFABN) to access short-term wholesale funding markets. On pre-determined recurring *election dates*, investors in these securities decide whether or not to extend the maturity of their holding.[2] Hence, XFABN are put-able in the sense that investors have the option not to extend

[2] There is a final maturity date beyond which no extensions are possible.

the maturity of any or all of their holdings. In such cases, the non-extended holdings are converted into short-term fixed maturity securities with new security identifiers. Therefore, XFABN are designed to appeal to short-term investors, such as MMFs, whose investment decisions may be constrained by liquidity and concentration requirements.[3, 4]

The key contractual characteristic we exploit is that each XFABN specifies *different* election dates. We collected data for each XFABN–including daily amounts outstanding, election dates, and terms for withdrawals—by hand from individual security prospectuses and Bloomberg corporate action records. These new data allow us to construct a measure of future withdrawals between election dates as a proxy for expected future withdrawals within a fixed window of time. We focus on institutional investors' actions over the period when bad fundamentals led to runs on the asset-backed commercial paper (ABCP) market (Covitz et al. 2013, Acharya et al. 2013, Schroth et al. 2014) and repo market (Gorton & Metrick 2012, Krishnamurthy et al. 2014). At that time, widespread concerns about financial market liquidity developed in concert with the subprime mortgage crisis and declining house prices. We document that the same institutional investors also ran on U.S. life insurers. Moreover, in a reduced-form analysis, we find a statistically and economically significant relationship between the decisions of investors to withdraw and their expectations that other investors might withdraw in the future. This association is robust to controlling for cross-sectional and time fixed effects, as well as time-varying measures of stability of the insurers and of the financial sector. Of course, this association could well be driven by fundamental developments, rather than by self-fulfulling expectations.

To build the case that there was a self-fulfilling component to the run, we adopt an instrumental variable approach again exploiting the contractual structure of XFABN. Our instrument for investors' expectations is the maximum fraction of XFABN that could be withdrawn between election dates. Differences across each insurer's XFABN

[3] For example, Regulation 2a-7 generally requires MMFs to hold securities with residual maturity not exceeding 397 days (SEC 2010). The initial maturity of a typical XFABN is specified such that MMFs can hold it at issuance. Thereafter, typically once every month, MMFs may elect to extend the maturity of their holding, typically by one month. This means that, from a regulatory perspective, an MMF is continuously holding a legitimate maturity bond. From the insurer's perspective, provided the MMF keeps extending the maturity, it is as if they had sold a long-term bond.

[4] XFABN are not concentrated among MMFs. On a case by case basis, we can observe individual MMF exposure to XFABN conduits through their Securities and Exchange Commission Form N-Q and N-CSR filings. For example, in the third quarter of 2007, Fidelity and JPMorgan held 3.7 percent and 0.5 percent respectively of all outstanding XFABN.

contractual terms creates variation over time in the instrument. Crucially, the election dates are determined when the XFABN were first issued, often years before the run, and are therefore plausibly exogenous to recent changes in fundamentals around the time of the run. Nevertheless, we also calculate the instrument with a lag, to remove any potential effect of the run on the XFABN used in the calculation. Our baseline IV estimates suggest that self-fulfilling expectations played a significant role in the run on XFABN. We find that about 40 percent of the observed $18 billion withdrawals by investors between the third quarter of 2007 and the end of 2008 can be attributed to expectations that other investors were also going to withdraw.

To add weight to our IV findings, we implement a series of robustness tests. We estimate our IV specification including week fixed effects to address the reasonable concern that our results are driven by a common shock to fundamentals affecting the U.S. life industry as a whole, or a common shock to short-term investors' liquidity demand. We further test for unobservable fundamentals by including a lagged dependent variable as a proxy for group behaviour unrelated to expectations. Another potentially omitted variable we check is the time until the next election date, since a longer window makes it more likely that investors in other securities will have an opportunity to withdraw. We then explore the sensitivity of our estimates to variation in the lag length used to calculate the instrumental variable. We narrow the window of our analysis to test whether our sample selection leads to underestimates of the standard errors. We also test whether our results are due to time-series persistence in our instrumental variable, rather than expectations about future withdrawals. We investigate whether XFABN issuers designed their liability structure intentionally to be fragile. And we argue that there is no risk of firesales that could be a potential source of bias for our estimates. Taken together, the results from these tests consistently suggest that there was a sizeable self-fulfilling component to the run on U.S. life insurers in 2007.

Our evidence of a self-fulfilling run on U.S. life insurers contributes to a deeper understanding of the vulnerability of shadow banking to runs. While the market for XFABN is small relative to the repo and asset-backed commercial paper markets, the same institutional investors participate in all of them. Since their behavior is likely to have been similar across markets, our study offers some evidence that there may have been a self-fulfilling component to the contemporaneous runs by institutional investors

in those larger markets.[5]

A better understanding of self-fulfilling runs by institutional investors is critical as the traditional methods of dealing with self-fulfilling runs by bank depositors – i.e., liability insurance and regulatory supervision of assets – are either infeasible or ineffective to cope with runs by institutional investors. Efforts to mitigate the run risk have been made at some links in the shadow banking chain by adapting the traditional methods of dealing with runs. For example, regulations adopted by Securities and Exchange Commission intended to reduce the likelihood of runs on MMFs (Cipriani et al. 2014). However, the wide range of liabilities and assets on institutional investors' balance sheets renders liability insurance and regulatory supervision impractical for dealing with runs by institutional investors.

The remainder of the paper proceeds as follows: In Section 3 we discuss the institutional background that lead to the rise and fall of the FABS market. Section 3 derives the conditions under which there could be a self-fulfilling run on XFABN issued by U.S. life insurers. Section 4 presents our data and summary statistics on these securities. Section 5 presents our main empirical results, including our IV estimates and robustness tests. We conclude in Section 6 with some remarks on broader implications and further study.

# 2 Institutional Background

The use of institutional funding agreements by U.S. life insurers emerged as a response to long-run macroeconomic and regulatory changes that affected the industry. Life insurers traditionally offer insurance to cover either the financial position of dependents in the event of the death of the main income earner, or individuals at risk of outliving their financial wealth. Under this model, policyholders make regular payments to an insurance company in exchange for promised transfers from the insurer at a future date. The promised transfers are long-term illiquid liabilities for insurers, which are backed by

[5] There are two reasons why it is difficult to identify self-fulfilling runs in the repo and ABCP markets. First, they do not have the XFABN institutional structure. Second, unlike the run on XFABN, the run on asset-backed commercial paper and the run on repo triggered asset firesales. The absence of a firesale following the run on XFABN implies that the price of assets funded by XFABN are unlikely to have changed because of the run. The absence of this channel alleviates some of the concern that fundamentals could have biased our estimates of the effect of self-fulfilling beliefs on the decisions of institutional investors.

assets funded by the regular payments from policyholders. The assets backing insurance liabilities need to be low risk and highly liquid to pay insurance claims as required. Ideally, these assets also deliver high returns to improve insurers' profitability.

Throughout the middle part of the twentieth century, U.S. life insurers enjoyed easy profits as high interest rates on safe long-term U.S. Treasuries that were attractive during World War II were replaced with high interest rates on long-term corporate bonds (Briys & De Varenne 2001). Soon after, however, pension funds emerged, offering higher returns to savers and challenging the traditional business model of life insurers. Pension funds could afford to offer much higher returns because they could invest freely in booming equity markets. Life insurers responded to the threat from pension funds by pursuing more aggressive investment strategies and offering products with higher (sometimes guaranteed) yields and greater flexibility to withdraw funds early.

The combination of greater liability run-risk and risky assets resulted in an insurance crisis in the late 1980s. Many insurers failed as capital losses on high-risk assets caused surrender runs by policyholders, intensified by falling credit ratings of insurers (DeAngelo et al. 1994). Realizing that life insurers had overweighed their portfolios with risky assets, the National Association of Insurance Commissioners (NAIC) proposed several model reforms for state insurance regulation, including risk-based capital (RBC) requirements, financial regulation accreditation standards, and an initiative to codify accounting principles.[6] For their part, life insurers redressed the balance of their portfolios towards safer and more liquid assets.

Insurers' re-focus on safe assets after the crisis of the late 1980s gave rise to a new problem as interest rates on safe assets continued the decline they had begun in the early 1980s. The prospect of persistently low interest rates meant life insurers were at risk of being unable to deliver the guaranteed returns promised to policyholders when the expected path of interest rates was higher. This rising interest rate risk led insurance industry state regulators to adopt new regulations requiring life insurers to hold higher statutory reserves in connection with term life insurance policies and universal life insurance policies with secondary guarantees.[7] However, higher risk-based capital

[6]Under the state-based insurance regulation system, each state operates independently to regulate its own insurance market, typically through a state insurance department. State insurance regulators created the NAIC in 1871 to address the need to coordinate regulation of multistate insurers. The NAIC acts as a forum for the creation of model laws and regulations.

[7] NAIC Model Regulation 830 (Regulation XXX) and Actuarial Guideline 38 (Regulation AXXX).

requirements necessarily imply a lower return on equity, as larger reserves must be backed by safe, low-yield assets.[8]

Life insurers responded to higher capital requirements and falling interest rates by finding innovative ways to increase their return on equity. One way is to reduce the risk-based capital requirement by shifting insurance risk off-balance sheet to captive reinsurers (Koijen & Yogo 2014).[9] Another way is to loan out securities to raise cash and fund a portfolio of longer-term, higher return assets (Foley-Fisher et al. 2015). And yet another way is to fund an expansion of the insurer's portfolio of high yield assets using funding agreement-backed securities (FABS), which is known in the industry as an "institutional spread business."[10]

Life insurers issue FABS and invest the proceeds in a portfolio of relatively higher yield assets such as mortgages, corporate bonds and private label ABS, to earn a spread. In a typical FABS structure, shown in Figure 2, a hypothetical life insurer sells a single funding agreement to a special purpose vehicle (SPV).[11] The SPV funds the funding agreement by issuing smaller denomination FABS to institutional investors. Importantly, FABS issuance programs inherit the ratings of the sponsoring insurance company, and investors are treated *pari passu* with other insurance obligations since the funding agreement issued to the SPV is an insurance liability. This provides FABS investors with seniority over regular debt holders, and implies a lower cost of funding for the insurer relative to senior unsecured debt. For example, this structure allows a AA-rated life insurer to "borrow" at AAA, and earn a sizeable return by investing the funds in BAA- or lower-rated assets. A further benefit is that FABS do not increase standard measure of leverage as a funding agreement is legally an insurance obligation.

The U.S. FABS market grew rapidly during the early 2000s. Figure 1 shows the end-

[8] The new statutory reserve requirements are typically higher than the reserves that life insurers' actuarial models suggest will be economically required to back policy liabilities. For context, insurers' statutory reserves tend to be much higher than reserve requirements for banks under U.S. generally accepted accounting principles (GAAP).

[9] Captive reinsurers are onshore and offshore affiliated unauthorized reinsurers that are not licensed to sell insurance in the same state as the ceding insurer, and do not face the same capital regulations as the ceding insurer. Koijen & Yogo (2014) estimate that the regulatory capital reduction from transferring insurance liabilities to captives increased from $11 billion in 2002 to about $324 billion in 2012.

[10] Funding Agreement Backed Notes (FABN) are sometime referred to as Guaranteed Investment Contract-Backed Notes (GICBN), and were created in 1994 by Jim Belardi, former president of SunAmerica Life Insurance Company and Chief Investment Officer of AIG Retirement Services, Inc., and current Chairman & CEO of Athene Holding.

[11] Note that FABS can only be issued by life insurers since a funding agreement is a type of annuity product.

of-year total FABS amount outstanding by insurance company. At its peak in 2007, new issuance reached over $50 billion, with more than $170 billion in notes outstanding, or about 90 percent of the Auto ABS market. It is apparent from Figure 1 that only the largest highly rated U.S. life insurer issue FABS.

FABS are flexible capital market instruments that may feature different types of embedded put option to meet demands from various investors, including short-term investors, such as MMFs. One particular type of FABS designed for short-term investors is an Extendible Funding Agreement-Backed Note (XFABN) that gives investors the option to extend again the maturity of their investment.[12] In normal times, the maturity of these instruments is always extended, allowing insuers to borrow long-term at shorter-term interest rates. Investors in XFABN typically receive a higher interest rate than on other short-term securities and have the option to *withdraw* by not extending the maturity of the note.

Each XFABN prospectus specifies *election dates* on which investors may extend the maturity by a pre-specified term of some or all of their holdings.[13] If the holder chooses to extend, the XFABN maturity date is extended by some pre-specified term and the option to extend carries over to the next election date, or until the maturity date reaches a pre-specified *final maturity date*. The period over which the XFABN maturity may be extended is called the *election window*.

If some or all of a particular XFABN is not extended, that portion is converted into a new zero-coupon security, called a *spinoff*. Each spinoff is given a different identifier (CUSIP) from that of the original XFABN. These new securities are no longer eligible for extension and have a pre-specified fixed duration. Any remaining portion of the XFABN continues to be eligible for extension and retains its original CUSIP identifier.

The decision to extend the maturity of an XFABN trades off the risk of future illiquidity for the coupon offered on the security. Insolvency is rarely an issue for life insurers. In the event that they breach the regulatory capital threshold, which happens

[12]Extendible FABN are fundamentally different from the more common non-insurance asset-backed extendible securities (ABES). ABES typically allow the issuer to extend the duration of the asset (Fitch 2006). Thus, these securities are structurally similar to callable notes. By contrast, XFABNs give the holder the option of extending the security, thereby making them structurally similar to put-able notes.

[13] Typically, holders only notify the XFABN dealer on or around each election date if they want to extend the maturity of their XFABN (either in part or the entire security). In the event that no notification is made, the security holder is assumed to have elected not to extend the security. See Appendix B for an example of the first three pages of an XFABN prospectus specifying the election dates and relevant conditions; the overall prospectus totals over 900 pages.

much sooner than insolvency, life insurers are immediately taken over by their State regulator. Consequently, insurance liability holders can be reasonably certain they will eventually be repaid. However, there could be tremendous uncertainty over *when* investors will get their money back. This uncertainty is of great concern to MMFs that are extremely sensitive to possible disruption to timely redemption and the rating of their investments (Hanson et al. 2013).

The issuance of XFABN is not the first time that funding agreements have been used to access short-term wholesale funding markets. During the 1990s, life insurers accessed short-term funding from the money market by issuing floating rate funding agreements, often with put options, directly to MMFs. And these liability structures also exposed issuers to run risk. In 1999, a $30 billion highly-rated life insurer, General American, had $6.8 billion in outstanding funding agreements with put options, of which about $5 billion were issued to MMFs with seven-day put options (Moody's 1999). At the end of July 1999, Moody's downgraded General American by one notch to A3 amid general concerns about the insurer's liquidity. There was never any concern about the insurer's solvency. Nonetheless, over a two-week period around the time of the rating downgrade, MMFs exercised put options totalling over $4 billion, leading to a severe liquidity crisis. On August 10, the company announced that, although it believed it was still solvent, it could not meet investors' claims. Within days General American was seized by the Missouri Department of Insurance and acquired by Metropolitan Life at a steep discount. While the rescue meant that General American would remain liquid, and the outstanding funding agreements would inherit MetLife's high rating and pay a relatively attractive yield, MMFs still requested their money back from MetLife at the time the purchase was announced (Lohse & Niedzielski 1999).

This anecdote illustrates a general principle that short-term institutional investors withdraw when facing even a small risk of illiquidity. Their run on ABCP in August 2007 (Covitz et al. 2013) and the run on repo in September 2007 (Gorton & Metrick 2012) were an early signal of an impending financial crisis, with widespread illiquidity. Coincident with those runs, the XFABN market collapsed. Beyond the anticipation of broader distress, investors may plausibly have been concerned about insurers' holdings of asset backed securities, or use of securities lending programs.

Importantly, the actual trigger for the run on U.S. life insurers does not play a role in

our empirical strategy. What matters is that, once the run begins, investors's decisions take into account their expectations about other investors' decisions. The contractual terms (initial maturity date, election dates, extension term, spinoff duration, and final maturity) described above allow us to separate these decisions over time. Intuitively, investors that are deciding how much of their holdings to extend on a particular election date need to take into account whether or not other security holders will have an opportunity to run before their next election date. If no-one can run before the next election date, there is no need for the current decision maker to take other security holders' potential actions into account. But if many other securities can be spunoff before the next election date, investors need to factor into their decision today some belief about whether other security holders will run. In the next section, we formalize this intuition in a model that shows how variation in a firm's liability structure plays a critical role in self-fulfilling runs.

# 3 A model of liability structure and self-fulfilling runs

In this section, we present a new link between firms' liability structure and self-fulfilling runs. Building on He & Xiong (2012), we model variation over time in the liability structure of a firm issuing put-able securities to finance an asset. As in Goldstein & Pauzner (2005) and He & Xiong (2012) self-fulfilling expectations are triggered by the prospect of bad fundamentals, and lead to a run. Unlike Goldstein & Pauzner (2005) and He & Xiong (2012) in which an issuer's liability structure is fixed, we show that variation in the liability structure of the issuer over time has a significant impact on investors' propensity to run. In particular, we show that concerns about bad fundamentals can trigger a self-fulfilling run only if a large enough fraction of securities is set to rollover. Moreover, variation in a firm's liability structure, orthogonal to the asset's fundamental value, plays a critical role in the self-fulfilling component to the run. This implies that we can potentially exploit exogenous variation of a firm's liability structure to make some progress in identifying the self-fulfilling component in the run on XFABN, without relying on structural assumption about fundamentals.

Time is continuous and infinite. We model a firm financing a single long-term asset by issuing securities to a continuum of investors. Investors are risk-neutral and discount

the future at rate $\rho > 0$. The funds raised by issuing securities are used to finance a long-term asset that generates a constant stream of coupon $r > 0$. The asset matures at a random date, and the arrival of the maturity date follows a Poisson process with arrival rate $\phi > 0$. The pay-off upon maturity depends on the publicly observable state of the asset's *fundamental* value. If the fundamental state is *good*, investors receive their unit of investment back. If the fundamental state is *bad*, investors get nothing. The fundamental state switches from good (bad) to bad (good) according to a Poisson process with arrival rate $\pi_{gb}$ ($\pi_{tn}$).

The firm issues a mix of *extendible* and *non-extendible* securities to investors. The fraction of extendible securities outstanding at time $t$ is denoted by $e_t \in (0,1)$. This captures the ratio of liabilities subject to roll over at time $t$. Investors in extendible securities have the option to withdraw, but this option can only be exercised on certain *election dates*. The arrival of election dates is idiosyncratic and follows a Poisson process with arrival rate $\delta > 0$. Securities for which investors exercise their put option to withdraw are either replaced by new extendible securities or the asset is liquidated (more on this later). Investors in non-extendible securities do not have the option to withdraw. Both types of securities may be repaid early by the firm before the asset matures–as with callable bonds–, in which case investors receive their principal back. Early repayments are idiosyncratic and follow a Poisson process with arrival rate $\varepsilon$. The firm replaces the securities it retires early with either type of securities. We assume that the replacement of retired securities follows a geometric Brownian motion with volatility parameter $\sigma > 0$:

$$\frac{dx_t}{x_t} = \sigma dZ_t \ , \tag{1}$$

where $x_t = \frac{e_t}{1-e_t}$ and $\{Z_t\}$ is a standard Brownian motion.

A run in this model occurs if all investors in extendible securities refuse to extend them. During a run, the firm may be able to rollover by issuing new securities. However, the firm may be forced to liquidate the asset if it cannot issue new securities. Liquidation of the asset during a run follows a Poisson process with arrival rate $\theta > 0$. Upon liquidation, investors in extendible securities receive $L(e_t)$, where $L[0,1] \to [0,1]$ is a strictly decreasing smooth function with $L(1) = 0$ and $L(0) = 1$. The function $L(\cdot)$ captures the asset liquidation cost, and, as will be made clear later, also captures the *run externality*.

We now discuss the value function associated with investing in an extendible security. Assume for the moment that there exist two thresholds $e^g$ and $e^b$ such that an investor expects other investors to withdraw if $e > e^g$ and $e > e^b$ in good and bad fundamental states, respectively.[14] It follows that the value of one unit of extendible security in the good state is given by the following partial differential equation

$$\begin{aligned} \rho V^g\left(e; e^g\right) &= \frac{\sigma^2}{4} e^2 \left(1-e\right) V^g_{ee} + \pi_{gb}(V^t - V^g) \\ &\quad + r + \phi(1 - V^g) \\ &\quad + \theta \cdot \mathbf{1}_{\{e > e^g\}} \cdot \left(L\left(e\right) - V^g\right) \\ &\quad + \varepsilon\left(1 - V^g\right) + \delta \cdot \max\left\{0, 1 - V^g\right\} \end{aligned} \tag{2}$$

and similarly, the value of one unit of extendible security in the bad state is given by

$$\begin{aligned} \rho V^b\left(e; e^b\right) &= \frac{\sigma^2}{4} e^2 \left(1-e\right) V^b_{ee} + \pi_{tn}(V^g - V^t) \\ &\quad + r + \phi(-V^g) \\ &\quad + \theta \cdot \mathbf{1}_{\{e > e^b\}} \cdot \left(L\left(e\right) - V^b\right) \\ &\quad + \varepsilon\left(1 - V^b\right) + \delta \cdot \max\left\{0, 1 - V^b\right\}. \end{aligned} \tag{3}$$

The left-hand sides of equations (2) and (3) denote an investor's return from investing in the extendible security in the good and bad states, respectively. The terms in the first lines of the right-hand sides of equations (2) and (3) capture the expected change in investment value caused by variations in the firm's liability structure and the fundamental state.[15] The second lines capture the return generated by the asset before it matures, and its payoff at maturity. Recall that while the asset pays one unit at maturity in the good state, it pays zero in the bad state. The third line captures the run externality imposed by other investors, which we discuss in more detail below. The fourth line captures the funds returned to investors in the event the security is repaid early by the firm or the investor withdraws by exercising the put option. Naturally, investors always choose to withdraw if the value of their investment is less than one.

From the values $V^g$ and $V^b$ above, it is possible to see how an investor's withdrawal

[14] We will establish later the existence and uniqueness of these thresholds.

[15] Note that by expressing $V^g$ and $V^b$ as a function of $x = \frac{e}{1-e}$, the first terms on the right-hand sides of equations (2) and (3) take the more familiar form $\frac{\sigma^2}{2} x^2 V^s_{xx}$.

decision is a function of the run externality imposed by other investors. Note that the run externaility is captured by the asset liquidation cost $L(e)$. Specifically, since $L(e)$ is a strictly decreasing function, it is straightforward to show that both $V^g$ and $V^b$ are non-increasing functions of $e$, the fraction of extendible securities. As $e$ increases, the value of being in the good or the bad fundamental state does not increase. It follows that $V^g$ and $V^b$ are non-decreasing in the run thresholds $e^g$ and $e^b$, respectively. That is, as investors' run thresholds increase and they become less sensitive to changes in the firm's liability structure, the value of holding extendible securities does not decrease. Consequently, an investor's expectation about other investors' withdrawals affects her decision to withdraw.

We now turn to the definition of an equilibrium. In a symmetric equilibrium, an investor's expectation about other investors' withdrawals is summarized by the threshold $e^g$ and $e^b$, and these thresholds should be consistent with other investors' optimal withdrawal decisions. Formally, a symmetric equilibrium consists of two thresholds $e^{g*}$ and $e^{b*}$ and two functions $V^{g*}$ and $V^{b*}$ such that equations (2) and (3) hold, and

$$V^{g*}(e^{g*}; e^{g*}) \quad \begin{cases} < 1 & \text{if } e^{g*} = 0 \\ = 1 & \text{if } e^{g*} \in (0,1) \\ > 1 & \text{if } e^{g*} = 1 \end{cases}$$

$$V^{b*}(e^{b*}; e^{b*}) \quad \begin{cases} < 1 & \text{if } e^{b*} = 0 \\ = 1 & \text{if } e^{b*} \in (0,1) \\ > 1 & \text{if } e^{b*} = 1 \ . \end{cases} \tag{4}$$

An implication is that there will be no run when $e^{s*} = 1$ for $s \in \{g, b\}$. That is when investor withdrawal is not sensitive to the amount of securities that is put-able. Moreover, equilibrium definition highlights a sharp distinction between runs due to a bad fundamental state only, and runs *amplified* by self-fulfilling expectations. In a pure fundamental run, the thresholds $e^{g*}$ and $e^{b*}$ are equal to zero. That is, investors withdraw regardless of their expectation about other investors' withdrawals. On the other hand, for positive thresholds $e^{s*} > 0$ for $s \in \{g, b\}$, an investor will withdraw when the amount of securities that becomes put-able rises above these thresholds, and that investor expects

other investors to withdraw. In this case a run occurs and investors' expectations are *self-fulfilled*.

The discussion thus far suggests a new link between a firm's liability structure and self-fulfilling runs. In what follows we make three additional assumptions to explore this link further.[16] These assumptions are helpful to illustrate how concerns about bad fundamentals may trigger a self-fulfilling run when a large enough fraction of securities becomes put-able. These assumptions are also helpful to discuss the connection between this model and that of He & Xiong (2012).

**A1.** $\rho + \theta < r < \rho + \phi$

**A2.** $0 \leq \pi_{tn} < \frac{\rho+\phi-r}{r-\rho} \cdot (\rho + \phi + \varepsilon)$

**A3.** $\frac{r-(\rho+\theta)}{\rho+\phi+\theta-r} \cdot A < \pi_{gb} < \frac{r-\rho}{\rho+\phi-r} \cdot A$ , where $A = \rho + \phi + \theta + \varepsilon + \delta + \pi_{tn}$

We begin by establishing the basic properties of the *run* and *no run* equilibria. Assumption **A1** guarantees that *no run* is the unique symmetric equilibrium in the good fundamental state if the probability of switching from the good to bad state is zero. That is, if $\pi_{gb} = 0$ then $e^{g*} = 1$. To see this, note that if the good state is absorbing ($\pi_{gb} = 0$) and investors never withdraw in the good state, then the value of an extendible security is

$$\bar{V}^g \equiv V^g(\cdot; 1) = \frac{r + \phi + \varepsilon}{\rho + \phi + \varepsilon} \ , \tag{5}$$

which is independent of the fraction of put-able securities. Since investors' discount rate is $\rho < r$, it follows that $\bar{V}^g > 1$ and it is optimal for investors never to exercise the put, that is, always to roll-over. Moreover, for any $e$ and $e^g$

$$V^g(e; e^g) \geq V^g(1; e^g) = \frac{r + \phi + \varepsilon}{\rho + \theta + \phi + \varepsilon} > 1 \ , \tag{6}$$

which implies that extending the maturity of the security is the dominant strategy in the good fundamental state if $\pi_{gb} = 0$, and the *no run* equilibrium is unique.

Assumptions **A1** and **A2** yield a sufficient condition for the uniqueness of the symmetric *run* equilibrium in the bad fundamental state, that is, $e^{b*} = 0$.[17] To see

[16] It is straightforward to show that the set of parameters for which these assumptions hold is not empty.

[17] Note that **A2** is feasible because of the upper bound of $r$ in **A1**.

this, note that

$$V^b(e;e^b) \leq V^b(e;1) \leq \frac{r+\varepsilon+\pi_{bg}\bar{V}^g}{\rho+\phi+\varepsilon+\pi_{bg}}\ , \tag{7}$$

where

$$\bar{V}^g = \frac{r+\phi+\varepsilon}{\rho+\phi+\varepsilon} \geq V^g(e;e^g) \tag{8}$$

regardless of $\pi_{gb}$ and $e^g$. Thus, if assumptions **A1** and **A2** hold, $V^b(e;e^b) < 1$ and withdrawing (exercising the put) is a dominant strategy in the bad state.

For a low enough $e$, extending the maturity of a security is always a dominant strategy in the good fundamental state. This follows form the upper bound of $\pi_{gb}$ in assumption **A3**, which guarantees that $V^g(0;e^g) > 1\ \forall e^g \in (0,1)$. Moreover, the lower bound of $\pi_{gb}$ implies that $V^g(1;e^g) < 1$. Therefore, investors run in the good state when $e$ is high enough. By continuity, $\forall e^g \in (0,1)$, $\exists \tilde{e}^g \in (0,1)$ such that $V^g(\tilde{e}^g;e^g) = 1$, when $e^{b*} = 0$.

Under assumptions **A1**-**A3**, the existence and uniqueness of the symmetric equilibrium follows from $L(\cdot)$ being a strictly decreasing smooth function, and the proof is similar to the one in He & Xiong (2012). In particular, we can show that for a low but positive threshold $e^g$, $\tilde{e}^g > e^g$ and $V^g(\tilde{e}^g;e^g) = 1$ since the liquidation cost during a run is small. Similarly, for a high but finite threshold $e^g$, $\tilde{e}^g < e^g$ since the liquidation cost is very high. Moreover, since $e^{b*} = 0$, $V^b(e;0)$ is a strictly decreasing in $e$, and $\forall e^g \in (0,1)$ $V^g(0;e^g) = \bar{V}^g$ there exists a unique $e^{g*}$ such that $V^{g*}(e^{g*};e^{g*}) = 1$.[18] Thus, investors in this equilibrium always run in the bad state, and run in the good state if and only if $e > e^{g*}$.

To explore the differences between the above model and that of He & Xiong (2012), we set the volatility parameter $\sigma = 0$. In this special case, the liability structure of the firm is fixed as in He & Xiong (2012). Therefore, switching between the good and the bad fundamental states in our model is similar to the fluctuating asset fundamental value in their paper. And although running is the dominant strategy in the bad state, the optimality of a run in the good state depends on the persistence of the good state. That is, investors run in the good state only when there is a high enough probability of switching to the bad state. In contrast, the analysis above emphasized the link between variations in the firm's liability structure and self-fulfilling runs. In our model, a run occurs in the good state when the externality of asset liquidation due to investors' run

[18]Note equation (1) implies $\frac{de_t}{e_t(1-e_t)} = \sigma dZ_t$, thus $e = 0$ is an absorbing state. Therefore, if $e_t = 0$ there will be no run regardless of the threshold $e^g$, and $V^g(0;e^g) = \bar{V}^g$.

is high. And the size of the liquidation cost depends on the amount of securities that is subject to roll-over.

Lastly, life insurers experienced a run on their extendible securities in 2007 while their fundamentals were arguably "good," and about a year before the crisis at AIG. In line with the work of Goldstein & Pauzner (2005) and He & Xiong (2012), our model predicts that uncertainty about the possibility of switching to a bad state could have triggered a panic, resulting in a self-fulfilling run. However, it is generally difficult to rule out negative changes in unobservable fundamentals or investors' expectations about the future state of fundamentals when analyzing data on runs. We build on the contributions of Goldstein & Pauzner (2005) and He & Xiong (2012), to develop a model that suggests it is possible to exploit the exogenous variation of a firm's liability structure to make some progress in identifying the self-fulfilling component in the run on XFABN without relying on structural assumption about fundamentals. In what follows, we test the hypothesis in one convenient empirical environment.

# 4 Data

Before presenting the empirical results, we briefly describe our data and the magnitude of the run that occured in the XFABN market during 2007. The main source of data about XFABN is our database of all FABS issued by U.S. life insurers covering the period beginning when FABS were first introduced in the mid-1990s. To construct our dataset, we combined information from various market observers and participants on FABS conduits and their issuance. We then collected data on contractual terms, outstanding amounts, and ratings for each FABS issue to paint a complete picture of the market for FABS at any point in time. Finally, we added data on individual conduits and insurance companies, as well as aggregate information about the insurance sector and the broader macroeconomy. A more detailed description of our FABS database is provided in Appendix A.

Our data for XFABN were collected by hand from individual security prospectuses and the Bloomberg corporate action record. We use these sources to construct the universe of XFABN CUSIP identifiers, and pair them with their spinoffs' CUSIP identifiers. Thus, we obtain a complete panel of all XFABN outstanding, those still eligible for extensions,

and those whose holders elected to spinoff their holdings earlier than the final maturity date.

In total, we record 54 XFABN issuances during the period of our analysis, from which 106 individual spinoffs were issued. The average XFABN issuance amount is $470 million, while the average spinoff amount is $190 million, or roughly 40 percent of their parent XFABN. About 70 percent of spinoffs mature in 397 days or less, consistent with an issuance strategy that targets investment by MMFs.[19] Summary statistics for all the variables used in the analysis are displayed in Table 1.

Figure 4 shows the daily time series of outstanding XFABN and outstanding spinoffs from 2006 to 2009. The amount of XFABN issued almost tripled between 2004 and 2006, when issuance peaked at $6.4 billion. The green line shows that the amount of XFABN outstanding as of June 2007 was about $23 billion, or about 20 percent of total U.S. FABS outstanding. From August 2007, institutional investors in XFABN began to exercise their put. The same investors withdrew from the ABCP and repo markets, amid rising concerns about sub-prime mortgages in the face of a sharp drop in house prices. These concerns may plausibly have spilled over onto life insurers through their holdings of mortgage-backed securities and use of securities lending programs.

The figure contrasts the decline in the amount of XFABN outstanding (green line) with the fastest possible withdrawal that investors could have made from August 1, 2007 (black line). The gap between these two series shows that, while investors did withdraw swiftly, the run was not as immediate as it could have been. This means that there was scope for investors to form expectations about other investors' future actions—it is unlikely that everyone expected everyone else to withdraw immediately. The blue line in the figure shows the cumulative outstanding amounts of XFABN and their spinoffs. The total outstanding amount remained roughly flat throughout the run period, and declined in 2008 as the spinoffs created during the run matured. This second decline might mislead an observer of insurers' total liabilities to conclude that investors withdrew later in 2008. In fact, the run occurred almost a year earlier. The question we address in the next section is how much of the run was amplified by panic and how much was a response to the triggers.

[19]The median initial maturity at issuance for all XFABN in our sample is about 2 years, less than one-quarter of the median duration at issue of the entire sample of FABN (roughly 8 years).

# 5 Empirical results

Figure 3 shows a stylized timeline of the decision process for XFABN holders. At time $t$, holders of a particular XFABN have the option to withdraw (spinoff) and receive a payout at time $t+m$. If they choose instead to extend their holdings, the option to withdraw will move to time $t+1$. In the time between $t$ and $t+1$, holders of other XFABN may have the option to withdraw. The red dashed lines show the potential spinoffs. Our basic hypothesis for a self-fulfilling run is that investors will make decisions at time $t$ taking into account their expectations about future decisions on other XFABN between $t$ and $t+1$.

Our empirical analysis begins by establishing that there was a positive correlation between investors' decisions to convert and their expectations that holders of other XFABN will convert *in future*, while controlling for obvious economic fundamentals that might be driving the run. The unit of observation throughout our analysis is the election date $t$ of an individual XFABN $i$ issued by insurer $j$, yielding a sample of 1,129 security-election date observations from January 1, 2005 to December 31, 2010. Our main specification is summarized by Equation 9 below.

$$D_{ijt} = \gamma_0 + \gamma_1 S_{ijt+1} + \gamma_2 Q_{ijt} + \mathbf{x}'_{jt}\beta + \epsilon_{ijt} \tag{9}$$

The dependent variable, $D_{ijt}$, is the fraction of XFABN $i$ issued by insurer $j$ that is converted into a spinoff on election date $t$. The "ideal" explanatory variable is the unobservable expectation, $\boldsymbol{E}_t S_{ijt+1}$, of the fraction of all other XFABN from insurer $j$ that will be converted into spinoffs between the current election date $t$ and the next election date $t+1$. We invoke rational expectations to the extent that $S_{ijt+1}$ and $\boldsymbol{E}_t S_{ijt+1}$ are not orthogonal and are correlated. Our main explanatory variable is then the realized future spinoffs, $S_{ijt+1}$, between the current election date $t$ and the next election date $t+1$. This fraction is indexed by $i$ because it excludes decisions made in respect of the XFABN $i$ itself.

In all specifications, we control for $Q_{ijt}$, which is calculated for each issuer $j$ in reference to the maturity date $t+1+m$ of a spinoff created from XFABN $i$ at date $t$. The variable is constructed as the sum of all spinoffs created prior to election date $t$ plus fixed maturity FABS that are scheduled to mature before or on the maturity date $t+m+1$. Intuitively,

this variable is a control for the amount of claims on the insurer that are already ahead of any spinoff created by decision $D_{ijt}$.[20] We also control for a number of issuer, time, and aggregate controls, contained in the vector $\mathbf{x}_{jt}$. Throughout the empirical analysis in this paper, we specify robust standard errors.

## 5.1 Reduced form estimates

Column 1 of Table 2 reports the results from estimating Equation 9 by OLS. This specification includes in $\mathbf{x}_{jt}$ insurer fixed effects to control for persistent insurer characteristics that could affect their vulnerability to runs by institutional investors. We find that withdrawals by other XFABN holders between $t$ and $t+1$ are positively correlated with the decision to spinoff on date $t$ and the association is statistically significant at less than the one percent level. The coefficient estimate on $S_{ijt+1}$ suggests that, on average, a one standard deviation (10 percentage point) increase in investors' withdrawal from insurer $j$'s XFABN between election $t$ and $t+1$ is associated with a 0.3 standard deviation (7.6 percentage point) increase in the fraction of a particular XFABN on election date $t$ that is withdrawn.

Columns 2 and 3 of Table 2 attempt to control, at least partially, for fundamental developments in the financial sector and at individual insurers. Column 2 controls for the expansion of shadow bank liquidity creation using the one-month log difference in the amount of asset-backed commercial paper outstanding. It also attempts to control for the development of concerns about the stability of the financial system using the one-month log difference in the VIX. Column 3 of Table 2 controls for insurer-specific time-varying fundamentals using market-based measures of issuer financial health such as insurer holding company stock prices, 5-year credit default swap spreads and 1-year Moody's KMV expected default probabilities.[21] In both cases, the estimated coefficient on $S_{ijt+1}$ remains positive and significant.

Taken together, these reduced form results suggest that investors' decisions to withdraw today are related to their expectations about other investors' future

[20] In effect, $Q_{ijt}$ controls for rollover risk stemming from insurers' entire FABS program. Recall that insurers issue FABS that mature at different points in time. Consequently, an insurer could appear to be risky if it had a lot of FABS maturing between an election date $t$ and the time at which the converted XFABN is set to come due, even though the amount of outstanding XFABN may be relatively small.

[21] This specification can only be estimated on about 40 percent of the original sample, because of data availability.

withdrawals. This correlation survives controlling for measures of obvious fundamentals that could affect life insurers and the broader financial system. Of course, while the correlation is consistent with an amplification effect driven by expectations about future withdrawals, it does not imply that there was any self-fulfilling component. In particular, the likely presence of unobservable fundamentals ($\epsilon_{ijt}$) correlated with both current ($D_{ijt}$) and future decisions ($S_{ijt+1}$) prevents us from drawing inference on the importance of self-fulfilling expectations. We turn to an instrumental variable approach in an effort to purge from our main explanatory variable, $S_{ijt+1}$, the possibly confounding effect of fundamentals, and to tease out the self-fulfilling component in the run.

## 5.2 Instrumental variable approach

The unusual contractual structure of XFABN allows us to construct an instrument for $S_{ijt+1}$ that is plausibly unrelated to fundamentals. Importantly, our instrumental variable approach is not a test of self-fulfilling expectations against fundamentals, as a driving force for the run on XFABN. Rather, our test for the self-fulfilling component is conditional on the effect of fundamentals developing during the run. Hence, this approach is fully consistent with the application of global games framework to understanding runs (Goldstein 2012) and the dynamic debt run models of He & Xiong (2012) and in Section 3. We take the state of fundamentals as given and tease out the amplification effect that comes from exogenous variation in expectations about future withdrawal decisions. The source of this exogenous variation is insurers' liability structures.

Denoted by $RE_{ijt+1}$, our instrumental variable is the ratio of XFABN from issuer $j$ that is up for election between election date $t$ and $t+1$. That is, $RE_{ijt+1}$ is the maximum fraction of XFABN that can potentially be converted into short-term fixed maturity bonds between an individual XFABN $i$'s election dates $t$ and $t+1$. By definition, the space of future withdrawals between election date $t$ and $t+1$, $S_{ijt+1}$, is bounded by 0 and $RE_{ijt+1}$. The contractual terms spelled out in the publicly available XFABN prospectuses allow all investors to calculate and use $RE_{ijt+1}$ when forming expectations about $S_{ijt+1}$. For example, if no XFABN from issuer $j$ have election dates between $t$ and $t+1$, everyone knows that everyone's expectation about $S_{ijt+1}$ is trivially 0. On the other hand, if $RE_{ijt+1} > 0$, investors may form non-trivial expectations about the decision of other investors to convert their XFABN between $t$ and $t+1$.

Variation in our instrumental variable, $RE_{ijt+1}$, comes from three main sources. First, the timing of election dates generally varies across XFABN; even the periodicity of election dates can vary across securities. Second, there is often a gap between when an XFABN is issued and its first election date. And third, there is usually a gap between the last election date and the final maturity date.

We use $RE_{ijt+1}$ as an instrumental variable, rather than as a proxy for expectations directly in Equation 9. While in some simple cases, such as our highly stylized model in Section 3, $RE_{ijt+1}$ may be a sufficient statistic for expectations, investors generally use other information when forming expectations about future withdrawals. In our view, future realizations are a better proxy for expectations because they offer a more complete representation of the factors used to form expectations. Our approach separates the component of realized decisions that is correlated with a single factor determining expectations. That factor was predetermined by the contractual structure of all XFABN issued by an insurer *before* the run began.

A key concern is that, while $RE_{ijt+1}$ is pre-determined, it is not necessarily independent from changes in fundamentals *after* a run begins. On the one hand, $RE_{ijt+1}$ changes when investors begin to convert their XFABN, since an increase in $S_{ijt+1}$ necessarily implies that fewer XFABN will be up for election on future dates. Thus, if an increase in $S_{ijt+1}$ is caused by fundamentals, $RE_{ijt+1}$ could be correlated with fundamentals. On the other hand, new XFABN issuance would increase $RE_{ijt+1}$. For example, an insurer experiencing a run on its existing XFABN may try to secure funding by issuing new XFABN, rendering $RE_{ijt+1}$ positively correlated with fundamentals.

To eliminate the possible effect of issuance or spinoffs during the run on our instrumental variable, we calculate $RE_{ijt+1}$ with a three month lag, $RE\_ex3m_{t+1}$. That is, we construct what investors three months before election date $t$ thought would be the fraction of XFABN from issuer $j$ up for election between election date $t$ and $t+1$. Since the majority of XFABN in the sample are converted between August 1, 2007 and October 31, 2007, this lag length removes the potential bias associated with any conversion or new issuance during the run.[22] Through pre-determined and lagged variation, we eliminate the direct and indirect effects, respectively, of fundamentals on our instrumental variable.

[22] We explore the robustness of this assumption in section 5.3.

### 5.2.1 Instrumental variable estimates

Columns 4 and 5 of Table 2 report our baseline instrumental variable (IV) results estimated using a two-stage least square procedure. In the first-stage regression, reported in column 4, we instrument for the dependent variable, $S_{ijt+1}$, using $RE\_ex3m_{ijt+1}$. The regression includes the controls from the specification in column 1 of Table 2. Consistent with the discussion above, the first-stage results suggest there is a large positive association between $S_{ijt+1}$ and $RE\_ex3m_{ijt+1}$ that is significant at less than the one percent level. The column also reports that the instrument passes the Stock & Yogo (2005) weak instrument test. From column 4 of Table 2, a one standard deviation (31 percentage point) increase in $RE\_ex3m_{ijt+1}$ is associated with a 0.37 standard deviation (4 percentage point) increase in $S_{ijt+1}$.

Column 5 shows the second-stage regression results, including the IV coefficient on the predicted value of $S_{ijt+1}$ from the first-stage estimation. The coefficient estimate is not statistically different from its OLS counterpart in the reduced form specification (column 1). The magnitude suggests that a one standard deviation (10 percentage point) increase in the XFABN conversion rate between $t$ and $t+1$ expected by investors at election date $t$ raises the probability that investors convert their XFABN at election date $t$ by 0.91 standard deviations (22 percentage points).

In dollar terms, the IV coefficient implies that a one standard deviation (7.2 percent) increase in expected future XFABN withdrawals between election dates $t$ and $t+1$ is associated with $38 million of additional withdrawals from the median outstanding XFABN on date $t$. As an alternative economic interpretation, we estimate the overall contribution of the self-fulfilling component to total withdrawals during the run. To compute this estimate, we first calculate the model-implied expected future withdrawals, $\hat{S}_{ijt+1}$, between election dates $t$ and $t+1$ from the first-stage regression. We then multiply this figure by the estimated IV coefficient from the second-stage regression and by the amount of XFABN up for election on date $t$. This yields a model-implied estimate of the dollar amount of each XFABN withdrawn due to self-fulfilling expectations on each election date. We compare the sum of these estimates with the sum of actual withdrawals that occurred between June 30, 2007 and December 31, 2008. The calculation suggests that 41 percent of the observed $18 billion withdrawn during that period can be attributed to the self-fulfilling component. These estimates suggest that self-fulfilling expectations

played a significant role in the run on XFABN.

## 5.3 Robustness of the IV coefficient estimate

In this subsection, we test the robustness of our findings to omitted or latent variables, to the construction of our instrumental variable, and to sample selection bias. The results of these tests are summarized in Table 3.

A significant concern about our baseline analysis is that there could be a common shock to fundamentals affecting the U.S. life insurance industry as a whole. This is especially likely since the run on XFABN coincided with the runs in asset-backed commercial paper and repo markets, and quickly evaporating liquidity in general. In an effort to address this concern, Columns 1 and 2 of Table 3 control further for common shocks to the industry by adding week fixed effects. The week fixed effects absorb any aggregate variables, including the amount of ABCP outstanding, VIX, and aggregate market returns. Intuitively, this test assumes that news about fundamentals are either broadly good or broadly bad for a whole week. On the first day of the week in which fundamentals are bad, if $RE\_ex3m_{ijt+1}$ is high, many investors will run. On the second day, if $RE\_ex3m_{ijt+1}$ is low, few investors will run. Our identification strategy could be challenged if, systematically and within each week, good news about fundamentals coincided with days when $RE\_ex3m_{ijt+1}$ were low and bad news coincided with days when $RE\_ex3m_{ijt+1}$ were high. However, we argue that this is a highly unlikely scenario since fundamentals were generally worsening across financial markets throughout the run period. The second-stage coefficient estimate on expected future spinoffs between $t$ and $t+1$, $S_{ijt+1}$, remains statistically significant at less than the 5 percent level, and is not statistically different from its counterpart in column 5 of Table 2.

A further substantial concern is that the three-month lag is insufficient to properly eliminate potential effects of the run on the instrumental variable. We investigated the robustness of our estimate to alternative lag lengths, removing developments over longer time horizons (the results are available on request). Broadly speaking, we find that the instrument remains strong, in the Stock and Yogo sense, and the IV coefficient estimate is little changed with lags up until 24 months, and thereafter becomes weak As an alternative to the lagged instruments, we also fixed the date on which the instrumental variable is calculated at June 1, 2007, for all election dates thereafter. Intuitively, this calculation

eliminates any possible developments in issuance or spinoffs during the run period that might possibly affect the instrumental variable. The results of this robustness test are reported in columns 3 and 4 of Table 3. The second-stage coefficient estimate on expected future spinoffs between $t$ and $t+1$, $S_{ijt+1}$, is statistically significant at less than the 1 percent level.

The inclusion of week fixed effects alleviates some of the concerns that withdrawals are simply a response to an aggregate shock to the insurance industry or to short-term institutional investors. Using an instrument measured on a single day before the start of the run helps alleviate some of the concerns that the withdrawal could be driven by other aggregate and idiosyncratic latent fundemental effects. However, it remains plausible that withdrawals could be driven by systematic changes in fundamentals that affect demand. For example, deteriorating fundamentals could have weighed on institutional investors causing them to exercise their put options around the same time. Columns 3 and 4 of Table 3 address this concern by including the lagged dependent variable, $D_{ijt-1}$, in the baseline IV specification. Intuitively, $D_{ijt-1}$ should capture group behavior unrelated to expectations about future withdrawals. The coefficient on $D_{ijt-1}$ is statistically insignificant, adding weight to the argument that withdrawals are unlikely to be driven by a common shock.

Another potentially important omitted variable that could be correlated with our instrument is the time until next rollover date. Longer election cycles could be associated with a greater amount of XFABN up for election between two election dates. Consequently, an insurer with longer XFABN election cycles may be experiencing greater withdrawal because the probability that investors or the insurer are, for example, hit by a liquidity shock in the interim period is greater. That said, columns 3 and 4 of Table 3 suggest that controlling for the number of days between rollover date has little effect on the IV coefficient estimate.

Our robustness tests have so far addressed the construction of the instrumental variable and potential omitted variables. An alternative concern is that the sample is improperly selected. With little variation in withdrawals during the non-run period, the standard errors estimated using both run and non-run periods may potentially be biased downwards, inflating the statistical significance of the estimated coefficients. As a robustness check, reported in columns 7 and 8 of Table 3, we restrict the sample to

the run period from June 31, 2007 to December 31, 2008. This reduces our sample size by about 65 percent. Nevertheless, the second-stage IV coefficient estimate on expected future spinoffs between $t$ and $t+1$, $S_{ijt+1}$, remains statistically significant at less than the 1 percent level.

## 5.4 Robustness to alternative mechanisms

In a second set of tests, reported in Table 5, we explore whether alternative mechanisms might explain our findings: time-series persistence in the instrumental variable, fragility of the market by design, and the firesale of assets.

A first concern is that the IV estimate of the coefficient on $S_{ijt+1}$ is driven by time-series persistence in the instrumental variable $RE\_ex3m_{ijt+1}$, rather than expectation about future XFABS conversion by investors. To test this hypothesis, we consider the lag of our instrument $RE\_ex3m_{ijt}$, defined as the fraction of XFABS that is up for election between the previous election date $t-1$ and the current election date $t$. Table 4 suggests that there may indeed be significant time-series persistence, with a correlation coefficient of about 0.6 between $RE\_ex3m_{ijt+1}$ and $RE\_ex3m_{ijt}$. Columns 1 and 2 of Table 5 report the first and second stage regression results using $RE\_ex3m_{ijt}$ as an instrument for $S_{ijt+1}$, respectively. The results suggest that $RE\_ex3m_{ijt}$ is a weak instrument for $S_{ijt+1}$. Moreover, the coefficient of $S_{ijt+1}$ treated by $RE\_ex3m_{ijt}$ in the second stage is not statistically different from zero. This result suggests that, despite some persistence in the instrumental variable over time, lagged values of the instrument, $RE\_ex3m_{ijt}$, are not a good instrument for expectations about future XFABN withdrawals.

A second concern is that insurers deliberately designed their XFABN securities to be fragile. That is, insurers may have offered a liability structure that would itself respond to bad fundamentals. By so doing, they could encourage investment and lower further their cost of funding. To test the hyopothesis that the liability structure was designed to be fragile, we define $RE@I_{ijt+1}$ as the fraction of XFABN that will be up for election between election dates $t$ and $t+1$, computed when XFABN $i$ was issued. Table 5 suggests that the correlation between $RE\_ex3m_{ijt+1}$ and $RE@I_{ijt+1}$ is only 0.35. Unsurprisingly, $RE@I_{ijt+1}$ is a poor instrument, as reported in column 3 and 4 of Table 5. This finding suggests that it is unlikely that insurers designed their institutional spread margin business to be fragile.

Lastly, while an asset fire sale could be a source of bias in the estimate of the self-fulfilling effect, it is unlikely to be significant in the XFABN market. In principle, if life insurers had participated in a fire sale of assets funded by XFABN then institutional investors might have worried that the losses incurred by insurers could affect their repayment, and this fundamental effect could have contributed to the run. However, XFABN issuers had access to a backstop - the Federal Home Loan Banks.[23] As shown in Figure 5, FABS issuers accessed funding from the third quarter of 2007 by issuing funding agreements, collateralized by their real estate-linked assets, directly to one of the twelve Federal Home Loan Banks. In fact, nearly all of the increase in the Federal Home Loan Bank advances to the insurance industry from 2007 was to FABS issuers. Moreover, as shown in Figure 1 of Ashcraft et al. (2010), the cost of funding from Federal Home Loan Banks remained low and stable between June 2007 and June 2008, while the cost of funding implied by the one-month LIBOR and asset-backed commercial paper AA-rated 30 day interest rate surged, as the repo and asset-backed commercial paper markets experienced runs. Thus, the Federal Home Loan Banks played a key role in re-intermediating term funding to life insurers experiencing runs by institutional investors, such as money market funds.[24] The availability of low-cost, stable Federal Home Loan Bank funding during the run and at the time the converted XFABN came due obviated the need for XFABN issuers to participate in asset fire sales.

Importantly, while the FHLB did provide a backstop to FABS issuers and greatly mitigated the risk of fire sale, there was considerable uncertainty at the time about the survival of the FHLB system. This uncertainty stemmed from the aggressive lending by FHLBs to thousands of member banks during the real estate boom, many of which became troubled when house prices collapsed. For example, IndyMac increased its borrowings from the Federal Home Loan Bank of San Francisco more than 500 percent from the end of 2004 through early 2008, before failing in July 2008; and Countrywide gambled for resurrection during 2007 by borrowing about $50 billion from the Federal Home Loan

[23] To be a member of an Federal Home Loan Banks, a life insurer needs to have at least 10 percent of its assets linked to real estate and can obtain advances in proportion to its membership capital that are fully collateralized by real estate-linked and other eligible assets.

[24] This goes beyond the point noted by Ashcraft et al. (2010) that "at the outset of the financial crisis, money market investors ran away from debt [e.g. asset-backed commercial paper] issued or sponsored by depository institutions and into instruments guaranteed explicitly or implicitly by the U.S. Treasury. As a result, the Federal Home Loan Bank System was able to re-intermediate term funding to member depository institutions through advances."

Bank of Atlanta before its near collapse in 2008 (Coy 2008). The uncertainty about the availability of a backstop to FABS issuers around the time of the run did nothing to reassure short-term institutional investors.

# 6 Conclusion

Shadow banking consists of institutions operating outside the regulated banking sector and linking together to form a chain of financial intermediation. While shadow banking facilitates greater risk sharing in the economy, different links in the financial intermediation chain could be vulnerable to self-fulfilling runs. These links could originate shocks that propagate through the financial system, or could amplify and accelerate shocks originated elsewhere. In this paper, we provide evidence of self-fulfilling beliefs affecting institutional investors' decisions to run on issuers of short-term instruments.

We first establish in a model the connection between a firm's liability structure and self-fulfilling runs. We build on Goldstein & Pauzner (2005) and He & Xiong (2012) to show that variation in a firm's liability structure, orthogonal to fundamentals, plays a critical role in the self-fulfilling component to a run on the firm. This theoretical result suggests that we can potentially exploit exogenous variation of a firm's liability structure to make some progress in identifying the self-fulfilling component in a run, without relying on structural assumption about fundamentals.

We take the insight we obtain from the model to the data, exploiting unusual liabilities issued by U.S. life insurers since the early 2000s. In particular, we exploit the contractual structure of a particular type of put-able instrument issued by U.S. life insurers to access short-term funding markets, extendible funding agreement-backed notes (XFABN). These securities offer exogenous variation in insurers' liability structures, through the contractual terms that allowed investors to withdraw only on certain pre-determined dates. We find robust evidence that the run on U.S. life insurers' XFABN in the second half of 2007 had a significant self-fulfilling component.

Our findings suggest that there may have been a significant self-fulfilling component to other contemporaneous runs by institutional investors. While the market for XFABN is small relative to the asset-backed commercial paper (ABCP) and repo markets, the same short-term institutional investors participate in them. Identifying self-fulfilling runs on

ABCP and repo is difficult because these instruments do not have the same contractual structure as XFABN and runs in these markets triggered confounding asset firesales. Nevertheless, the behavior of short-term institutional investors is likely to have been similar across short-term funding markets in the second half of 2007.

Our results also have implications for the regulation of non-bank financial institutions. A large regulatory effort since the 2008-09 financial crisis has focused on strengthening the liquidity and solvency standards of non-bank financial institutions. However, if the self-fulfilling effect identified in this paper was a culprit for the disruptions to financial intermediation by the shadow banking sector during the crisis, more emphasis should be given to addressing the risk of self-fulfilling runs.

Finally, this paper informs the debate on the systemic risk posed by asset managers to financial markets. For example, while efforts have been made to mitigate the risk of runs *on* MMFs by adapting tools from traditional banking regulations–e.g., suspension of convertibility–the vulnerability of the financial system to runs *by* MMFs on the issuers of short-term liabilities remains largely unaddressed. Moreover, the wide and constantly evolving array of liabilities and assets on institutional investors' balance sheets implies that tools from traditional banking regulation, such deposit insurance and asset monitoring by regulators, may be impractical or infeasible for dealing with runs by institutional investors.

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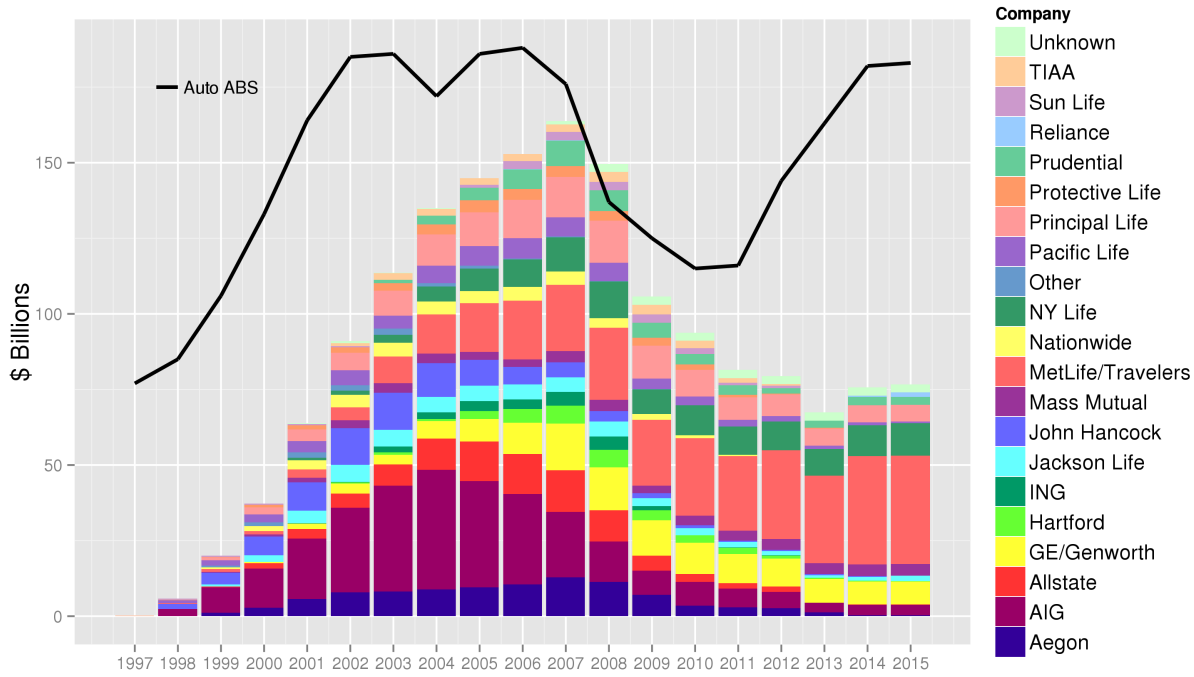
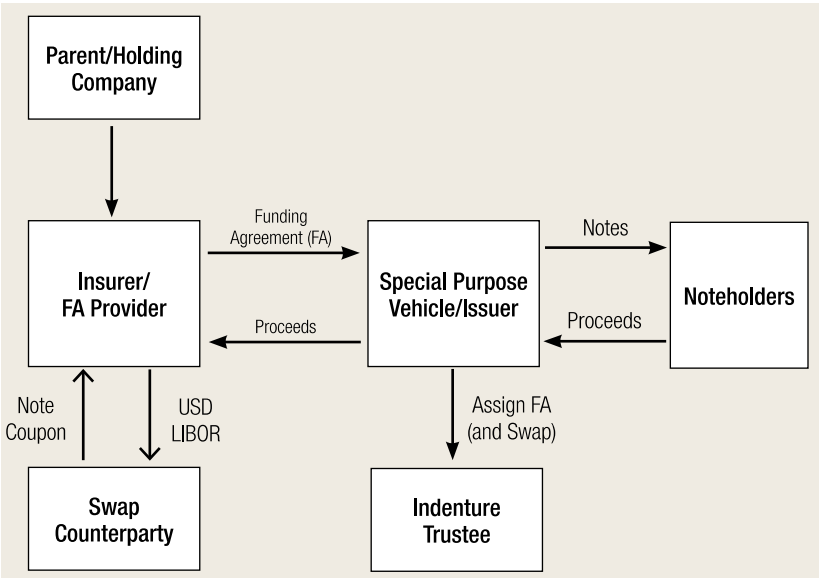
# Figures and Tables

**Figure 1: FABS and Auto ABS Amount Outstanding**




Source: authors' calculations based on data collected from Bloomberg Finance LP, and Moody's ABCP Program Index. Data as of October 31, 2015.

**Figure 2: Typical FABS Structure**




Source: A.M. Best Methodology Note, 2011, "Rating Funding Agreement-Backed Securities Programs". http://www.ambest.com/ratings/fundagreementmethod.pdf

**Figure 3:** Timeline for XFABN election date decisions

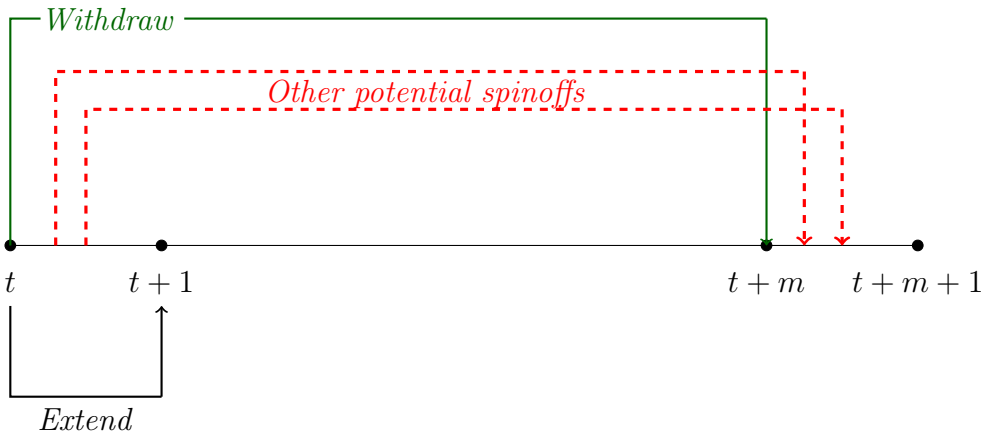
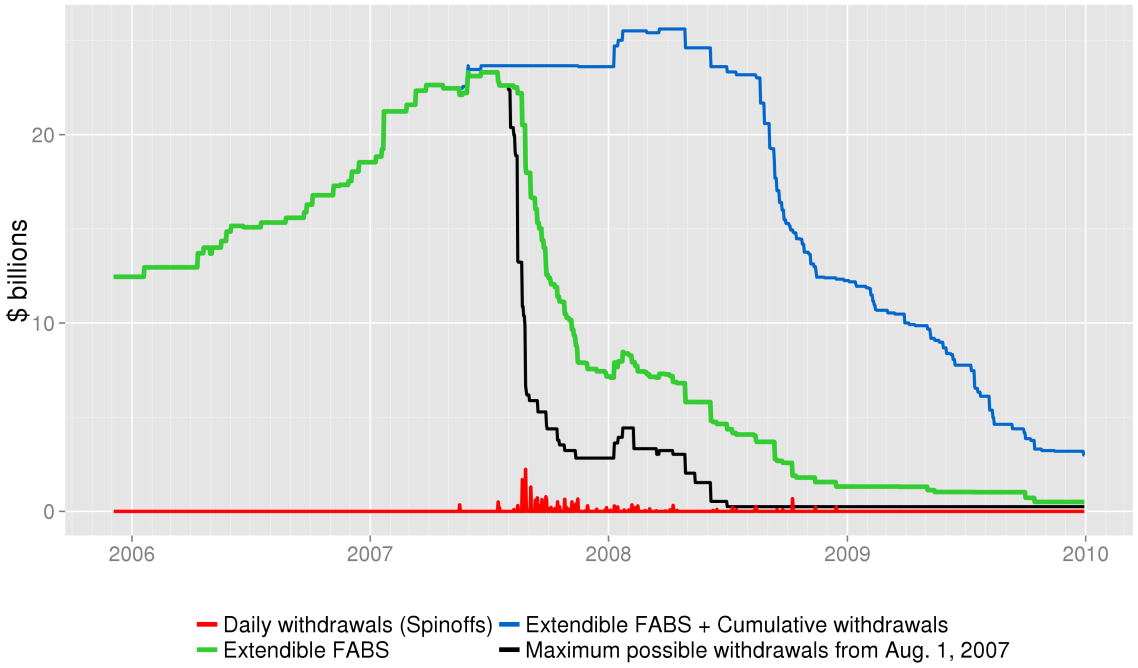
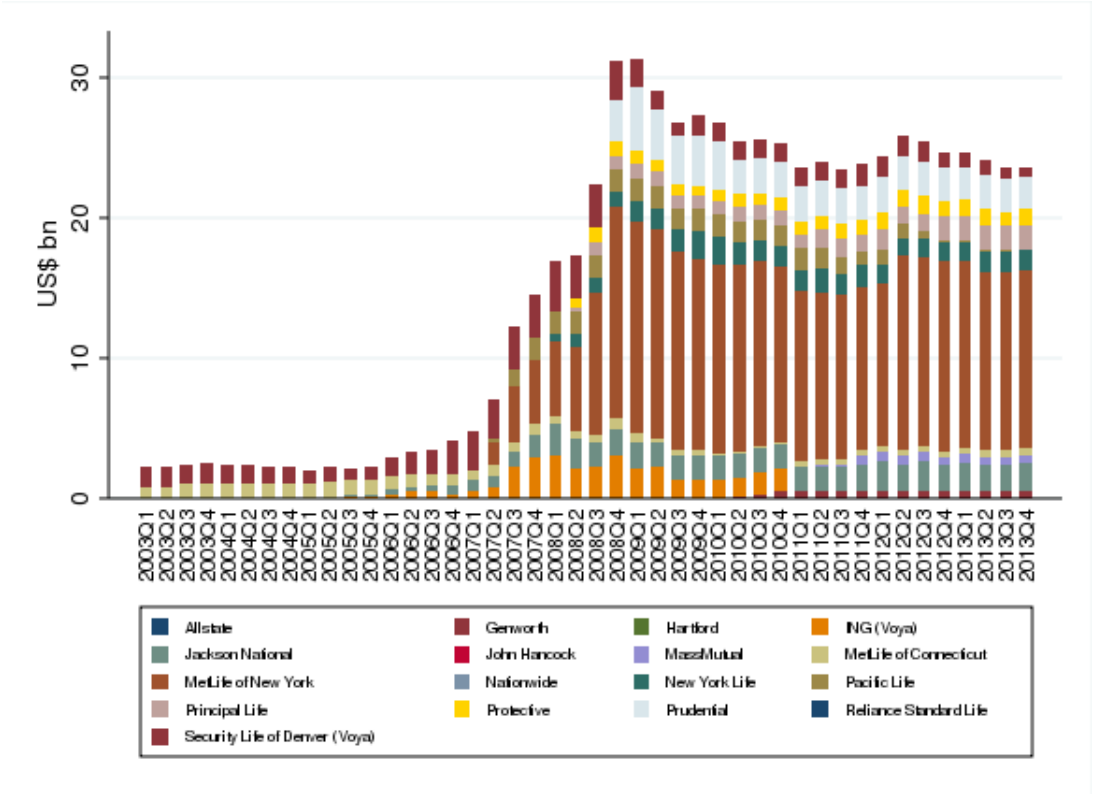



**Figure 4: Run on Extendible FABN**



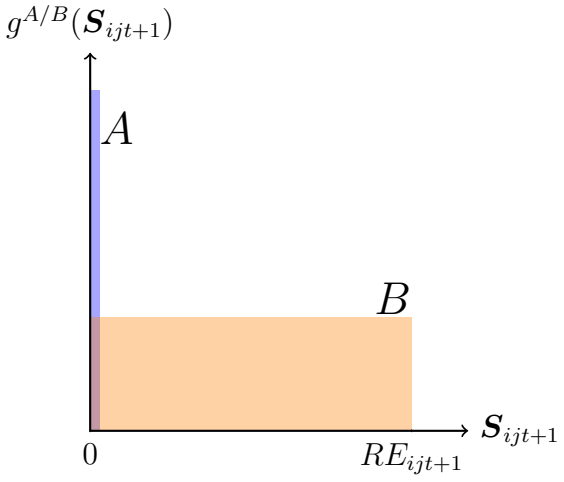

Source: authors' calculations based on data collected from Bloomberg Financial LP.

**Figure 5: FHLB Advances to FABS Issuers**




Source: authors' calculations based on the Federal Home Loan Bank database, provided by the FHLB Office of Finance.

**Figure 6: $RE_{ijt+1}$ is not necessarily a sunspot**




This figure illustrate how $RE_{ijt+1}$ is not necessarily a sunspot. Consider two distribution of beliefs $g^A(\boldsymbol{S}_{ijt+1})$ and $g^B(\boldsymbol{S}_{ijt+1})$, such that $\boldsymbol{E}_t^A \boldsymbol{S}_{ijt+1} = 0$. Shocks, real or sunspot, may switch the distribution from $A$ to $B$. However, indentification only requires $\boldsymbol{E}_t \boldsymbol{S}_{ijt+1} \not\perp RE_{ijt+1}$ *during the run*, and is uninformative about what causes the distribution to shift.

**Table 1: Descriptive Statistics**

This table displays descriptive statistics for the main variables used in the analysis in the sample extending from January 1, 2005 to December 31, 2010. When an XFABN is not extended, it is "spunoff" into a new security with a separate CUSIP identifier.

| | Obs. | Median | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|---|
| Number of XFABN | 54 | . | . | . | . | . |
| Number of spinoffs | 106 | . | . | . | . | . |
| Number of election dates across all XFABN | 1129 | . | . | . | . | . |
| Number of days between election dates | 1076 | 31 | 47.3 | 35.9 | 28 | 365 |
| Issuance amount of XFABN (USD million) | 53 | 350 | 468.4 | 333.3 | 100 | 2000 |
| Issuance amount of spinoffs (USD million) | 106 | 134.5 | 191.5 | 193.3 | .2 | 1338.5 |
| Maturity of spinoffs (days) | 53 | 367 | 504.7 | 215 | 302 | 1006 |
| Fraction of XFABN that is converted into spinoff ($D_{ijt}$) | 768 | 0.0 | 0.1 | 0.3 | 0 | 1 |
| Spinoffs created during election period as a fraction of all XFABN ($S_{ijt+1}$) | 914 | 0.0 | 0.0 | 0.1 | 0 | 1 |
| Fraction of all XFABN that can potentially be turned into spinoffs ($RE\_ex3m_{ijt+1}$) | 1128 | 0.44 | 0.44 | 0.35 | 0 | 1 |
| Maturing FABS ($Q_{ijt}$) | 1076 | 0.2 | 0.18 | 0.15 | 0 | 1 |

Source: authors' calculations based on data collected from Bloomberg Finance LP.

This table summarizes the main reduced form results on the run on U.S. life insurers that occurred in the summer of 2007. The unit of observation is the election date $t$ of an individual XFABN $i$ issued by insurer $j$, and the sample extends from January 1, 2005 to December 31, 2010. The dependent variable $D_{ijt}$ is the fraction of XFABN $i$ issued by insurer $j$ that is converted into a fixed maturity bond at election date $t$. The main, potentially endogenous explanatory variable $S_{ijt+1}$ is the fraction of all XFABN from insurer $j$ that is converted between the current election date $t$ and the next election date $t+1$. The variable $Q_{ijt}$ is calculated as the fraction of XFABN from insurer $j$ that were converted prior to election date $t$ plus the fixed maturity FABN scheduled to mature between $t$ and $t+1$. Columns 1 through 5 include insurer fixed effects. Column 2 includes the one-month log change in VIX and the amount of U.S. ABCP outstanding. Column 3 includes sponsoring insurer stock price, 5-year CDS, and 1-year EDF. Column 4 and 5 summarize the main instrumental variable results on the run on U.S. life insurers that occurred in the summer of 2007. In this specification, we instrument $S_{ijt+1}$ with $RE\_ex3m_{ijt+1}$, calculated as the maximum fraction of XFABN that can be converted into short-term fixed maturity bonds between an individual XFABN $i$'s election dates $t$ and $t+1$, removing any changes stemming conversion or new issue in the three months leading up to election date $t$. Robust standard errors are reported in parentheses. ***, **, and * represent statistical significance at the 1%, 5%, and 10% level, respectively.

| *Dep. var.:* $D_{ijt}$ | (1) Reduced Form | (2) VIX & ABCP | (3) Financial Health | (4) Instrumental Variable First Stage | (5) Instrumental Variable Second Stage |
|---|---|---|---|---|---|
| $S_{ijt+1}$ (endogenous) | 0.731*** | 0.429*** | 0.497** | | 2.124*** |
| | (0.144) | (0.143) | (0.231) | | (0.396) |
| $RE\_ex3m_{ijt+1}$ | | | | 0.125*** | |
| | | | | (0.0160) | |
| $Q_{ijt}$ | 0.743*** | 0.673*** | 1.052*** | 0.108** | 0.505*** |
| | (0.168) | (0.156) | (0.362) | (0.0429) | (0.177) |
| $\Delta_{1m} \ln(\text{VIX}_t)$ | | -0.0438 | -0.103** | | |
| | | (0.0367) | (0.0501) | | |
| $\Delta_{1m} \ln(\text{ABCP outstanding}_t)$ | | -1.793*** | -2.197*** | | |
| | | (0.334) | (0.463) | | |
| 5 Year CDS Spread (bps) | | | -0.000102 | | |
| | | | (0.000235) | | |
| 1 Year Expected Default Frequency (%) | | | -0.0139 | | |
| | | | (0.0499) | | |
| Stock Price ($) | | | 0.000325 | | |
| | | | (0.00187) | | |
| Observations | 747 | 747 | 312 | 747 | 747 |
| Adjusted $R^2$ | 0.204 | 0.283 | 0.398 | 0.272 | -0.086 |
| Insurer FE | Y | Y | Y | Y | Y |
| Robust KP Wald F-stat | | | | | 61.17 |
| Stock-Yogo Critical Value 10% | | | | | 16.38 |

Source: authors' calculations based on data collected from Bloomberg Finance LP, Markit and Center for Research in Security Prices (CRSP) via Wharton Research Data Services (WRDS), Moody's Analytics: KMV, Federal Reserve Bank of St Louis, Federal Reserve Economic Data (FRED).

**Table 3: Robustness of the IV Coefficient Estimate**

This table investigates the robustness of the IV coefficient estimate to additional controls. The unit of observation is the election date $t$ of an individual XFABN $i$ issued by insurer $j$, and the sample extends from January 1, 2005 to December 31, 2010. The dependent variable $D_{ijt}$ is the fraction of XFABN $i$ issued by insurer $j$ that is converted into a fixed maturity bond at election date $t$. The endogenous variable $S_{ijt+1}$ is the fraction of all XFABN from insurer $j$ that is converted between the current election date $t$ and the next election date $t+1$. The variable $Q_{ijt}$ is calculated as the fraction of XFABN from insurer $j$ that were converted prior to election date $t$ plus the fixed maturity FABN scheduled to mature between $t$ and $t+1$. The main instrumental variable is $RE\_ex3m_{ijt+1}$. Columns 1 and 2 include weekly time fixed effects. Columns 3 and 4 use the instrument measured as of June 1, 2007 ($RE\_Jun07_{ijt+1}$). Columns 5 and 6 include the lagged dependent variable $D_{ijt-1}$. Columns 7 and 8 include the number of days until the next rollover date. Columns 9 and 10 restrict the sample to the run period extending from June 31, 2007 to December 31, 2008. Robust standard errors are reported in parentheses. ***, **, and * represent statistical significance at the 1%, 5%, and 10% level, respectively.

| *Dep. var.:* $D_{ijt}$ | Week FE | | $RE\_Jun07_{ijt+1}$ | | $D_{ijt-1}$ | | Days to rollover | | Run period | |
|---|---|---|---|---|---|---|---|---|---|---|
| | First stage | Second stage | First stage | Second stage | First stage | Second stage | First stage | Second stage | First stage | Second stage |
| $S_{ijt+1}$ (endogenous) | | 1.606** | | 3.236*** | | 2.029*** | | 2.095*** | | 2.657*** |
| | | (0.641) | | (0.644) | | (0.417) | | (0.373) | | (0.960) |
| $RE\_ex3m_{ijt+1}$ | 0.0672*** | | | | 0.124*** | | 0.140*** | | 0.131*** | |
| | (0.0175) | | | | (0.0176) | | (0.0182) | | (0.0319) | |
| $RE\_Jun07_{ijt+1}$ | | | 0.0584*** | | | | | | | |
| | | | (0.0101) | | | | | | | |
| $Q_{ijt}$ | 0.0616 | 0.519*** | 0.0541 | 0.315 | 0.103** | 0.501*** | 0.152*** | 0.497*** | 0.0387 | 1.164** |
| | (0.0680) | (0.171) | (0.0409) | (0.195) | (0.0448) | (0.179) | (0.0507) | (0.185) | (0.0707) | (0.490) |
| $D_{ijt-1}$ | | | | | 0.0553 | 0.112 | | | | |
| | | | | | (0.0450) | (0.113) | | | | |
| Days-to-rollover | | | | | | | -0.000474*** | 0.000118 | | |
| | | | | | | | (0.000168) | (0.000466) | | |
| Observations | 747 | 747 | 747 | 747 | 704 | 704 | 747 | 747 | 266 | 266 |
| Adjusted R-squared | 0.414 | 0.136 | 0.225 | -0.735 | 0.278 | -0.011 | 0.283 | -0.075 | 0.435 | -0.464 |
| Insurer FE | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Weekly FE | Y | Y | N | N | N | N | N | N | N | N |
| Robust KP Wald F-stat | | 14.72 | | 33.64 | | 49.37 | | 59.4 | | 16.82 |
| Stock-Yogo Critical Value 10% | | 16.38 | | 16.38 | | 16.38 | | 16.38 | | 16.38 |

Source: authors' calculations based on data collected from Bloomberg Finance LP, Markit and Center for Research in Security Prices (CRSP) via Wharton Research Data Services (WRDS), Moody's Analytics: KMV, Federal Reserve Bank of St Louis, Federal Reserve Economic Data (FRED).

**Table 4: Correlations Between Alternative Instruments**

This table explores the correlations between variables that are closely related to the instrumental variable $RE\_ex3m_{ijt+1}$ used in the main analysis of Table 3. The instrumental variable $RE\_ex3m_{ijt+1}$ is the maximum fraction of XFABN that can be converted into short-term fixed maturity bonds between an individual XFABN $i$'s election dates $t$ and $t+1$, removing any changes stemming conversion or new issue in the three months leading up to election date $t$; $RE\_ex3m_{ijt}$ is the same variable measued between election date $t-1$ and the current election date $t$; $RE_{ijt+1}$ is the maximum fraction of XFABN that can be converted into short-term fixed maturity bonds between an individual XFABN $i$'s election dates $t$ and $t+1$; $RE@I_{ijt+1}$ is the anticipated fraction of XFABN that will be up for election between election date $t$ and $t+1$ when the XFABN is issued; and $\Delta\_3mVIX_t$ is three month change in VIX.

| | $S_{ijt+1}$ | $RE\_ex3m_{ijt+1}$ | $RE_{ijt+1}$ | $RE\_ex3m_{ijt}$ | $RE@I_{ijt+1}$ | $\Delta_{3m}VIX_t$ |
|---|---|---|---|---|---|---|
| $S_{ijt+1}$ | 1 | | | | | |
| $RE\_ex3m_{ijt+1}$ | 0.37 | 1 | | | | |
| $RE\_ijt+1$ | 0.37 | 0.83 | 1 | | | |
| $RE\_ex3m_{ijt}$ | 0.10 | 0.57 | 0.57 | 1 | | |
| $RE@I_{ijt+1}$ | 0.15 | 0.54 | 0.56 | 0.52 | 1 | |
| $\Delta_{3m}VIX_t$ | 0.04 | 0.03 | -0.03 | -0.04 | 0.00 | 1 |

Source: authors' calculations based on data collected from Bloomberg Finance LP.

**Table 5: Further Robustness Tests**

This table investigates the robustness of the results in Table 3 to alternative mechanisms. All regressions include the controls included in the baseline reduced form regression – column 4 of Table **??**. Columns 3 and 4 instrument $S_{ijt+1}$ with $RE_{ijt}$, the fraction of XFABN that is up for election between election date $t-1$ and the current election date $t$. Columns 5 and 6 instrument $S_{ijt+1}$ with $RE@I_{ijt+1}$, the anticipated fraction of XFABN that will be up for election between election date $t$ and $t+1$ when the XFABN is issued. Column 7 includes $RE\_ex3m_{ijt+1}$ to the baseline reduced form regression (column 4 of Table **??**). Columns 8 and 9 instrument $S_{ijt+1}$ with $Q_{ijt}$, the fraction of XFABN from insurer $j$ that were converted prior to election date $t$. Robust standard errors are reported in parentheses. ***, **, and * represent statistical significance at the 1%, 5%, and 10% level, respectively.

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| *Dep. var.:* $D_{ijt}$ | Lagged IV | | RE at issue | | IV as a proxy |
| | First stage | Second stage | First stage | Second stage | |
| $S_{ijt+1}$ (endogenous) | | -0.274 | | 1.842 | 0.549*** |
| | | (1.864) | | (1.677) | (0.143) |
| $RE\_ex3m_{ijt+1}$ | | | | | 0.197*** |
| | | | | | (0.0429) |
| $RE\_ex3m_ijt$ | 0.0116 | | | | |
| | (0.00761) | | | | |
| $RE@I_{ijt+1}$ | | | 0.0173 | | |
| | | | (0.0118) | | |
| $Q_{ijt}$ | 0.227*** | 1.152** | 0.200*** | 0.698* | 0.674*** |
| | (0.0657) | (0.492) | (0.0698) | (0.389) | (0.158) |
| Observations | 642 | 642 | 554 | 554 | 747 |
| Adjusted R-squared | 0.211 | 0.079 | 0.149 | 0.040 | 0.241 |
| Insurer FE | Y | Y | Y | Y | Y |
| Robust KP Wald F-stat | | 2.32 | | 2.15 | |
| Stock-Yogo Critical Value 10% | | 16.38 | | 16.38 | |

Source: authors' calculations based on data collected from Bloomberg Finance LP.

**APPENDIX FOR ONLINE PUBLICATION ONLY**

# A FABS database

Our FABS database was compiled from multiple sources, covering the period beginning when FABS were first introduced in the mid-1990s to early 2014. To construct our dataset on FABS issuers, we combined information from various market observers and participants on FABS conduits and their issuance. We then collected data on contractual terms, outstanding amounts, and ratings for each FABS issue to obtain a complete picture of the supply of FABS at any point in time. Finally, we added data on individual conduits and insurance companies, as well as aggregate information about the insurance sector and the broader macroeconomy.

FABS are issued under various terms to cater to different investors demand. The most common type of FABS are funding agreement-backed notes (FABN), which account for more than 97 percent of all US FABS. We first identify all individual FABN issuance programs using market reports and other information from A.M. Best, Fitch, and Moody's. FABN conduits are used only to issue FABN with terms that match the funding agreement (FA) issued by the insurance company. This FA originator-FABN conduit structure falls somewhere between the more familiar stand-alone trust and master trust structures used for traditional asset-backed securities, such as auto loan, credit card, and mortgage ABS.[25]

A substantial fraction of FABN are issued with different types of embedded put options, including Putable FABN and Extendible FABN. Extendible FABN gives investors the option to extend the maturity of their FABN (usually once a month), and are designed to for money market funds subject to Rule 2a-7. Furthermore, in the same way that there are structural similarities between FABN and ABS, funding agreement backed commercial paper (FABCP) is structurally reminiscent of ABCP. In a FABCP program, the life insurer transfers FAs from the general account or separate account to a commercial paper conduit, which then issues FABCP to investors. Much like Extendible

[25]While a stand-alone trust issues a single ABS deal (with multiple classes) based on a fixed pool of receivables assigned to the SPV, the master trust allows the issuer/SPV to issue multiple securities and to alter the assigned pool of collateral. Although the FABN conduit may issue multiple securities, similar to a master trust, the terms of each security are shared with the unalterable FA backing the asset, similar to the fixed pool of collateral for a stand-alone trust.

FABN, FABCP are designed for short term investors such as money market funds. The FAs typically have a longer maturity than the associated CP, so a liquidity backstop is required in case the CP cannot be rolled over. Unlike more traditional ABCP programs for which a third party financial institution provides the liquidaity backstop, the liquidity backstop for FABCP is usually the sponsoring insurance company.

We link these FABS programs to the insurance companies originating the FAs used as collateral. In total, as shown in Table 6, we find that FABS programs associated with over 130 conduits, backed by FAs from 30 life insurers in the United States. Of these, there are four FABCP conduits (two of which are currently active) operated by two insurance conglomerates using FAs from five different insurers. We then use our list of FABS conduits to search Bloomberg and gather information on every FABN issue. For each FABN, we collected Bloomberg and prospectus data on contractual terms and amount outstanding to construct a complete panel of new FABN issuances and amount outstanding at a daily frequency.

We have records of 2,040 individual FABN issues, with the first issuance recorded in 1996 and about 70 new issues recorded in the first half of 2014. FABN issuance grew rapidly during the early 2000s, peaking at over $47 billion in 2006. We also collected data on FABCP, relying on end of quarter data from Moody's ABCP Program Review since individual security information is not available.[26] Total FABCP outstanding was less than $3 billion until 2008, growing to just under $10 billion at the end of 2013 after MetLife entered the market in late 2007. As described in the introduction, at its peak in 2007, the total outstanding value of the FABS market collateralized with FA from US based life insurers reached almost $150 billion, or more than 80 percent of the Auto ABS market (Figure 1).

Lastly, we match our data to a wide variety of firm-level, sector-level, and broader economic environment data. Since these data are usually available only at a quarterly frequency, we aggregate our data for most of the analysis in this paper. We include several data-series about the FA-sponsoring life insurers, including balance sheet and statutory filings information from SNL Financial and AM Best, CDS spreads from Markit, credit ratings from S&P, and expected default frequencies (EDF) from Moody's KMV.

[26]Individual issuance data on FABCP are available from DTCC but are confidential and unavailable to us.

## Table 6: U.S. Issuers of Funding Agreement-Backed Securities (FABS)

This table shows the number and type of conduits used by U.S. life insurers to issue FABS and and their ultimate parent company.[a]

| Funding agreement issuer name | Parent company name | No. of FABN conduits | | No. of FABCP conduits |
|---|---|---|---|---|
| | | Multiple issue | Single issue[b] | |
| AIG SunAmerica Life Insurance Company[c] | AIG/SunAmerica | 3 | 15 | |
| Monumental Life Insurance Company | Aegon | 3 | . | |
| Allstate Life Insurance Company | Allstate | 5 | . | |
| GE Capital Assurance Company | Ge Capital | . | 10 | |
| Genworth Life Insurance Company[d] | Genworth | 2 | 40 | |
| Hartford Life Insurance Company | Hartford | 2 | 5 | |
| ING USA Annuity and Life Insurance Company | Voya Financial[e] | 1 | . | |
| Security Life of Denver Insurance Company | Voya Financial[f] | 1 | . | |
| Jackson National Life Insurance Company | Jackson National | 2 | . | |
| John Hancock Life Insurance Company | John Hancock | 2 | . | |
| Massachusetts Mutual Life Insurance Company | MassMutual | 2 | . | |
| MetLife Insurance Company of Connecticut[g] | MetLife | 4 | . | 1[h] |
| Metropolitan Life Insurance Company | MetLife | 1 | 2 | |
| Nationwide Life Insurance Company | Nationwide | 2 | . | |
| New York Life Insurance Company | New York Life | 2 | . | |
| Pacific Life Insurance Company | Pacific Life | 2 | 1 | |
| Principal Life Insurance Company | Principal Life | 5 | . | |
| Protective Life Insurance Company | Protective Life | 3 | 2 | |
| Prudential Insurance Company of America | Prudential | 1 | 1 | |
| Reliance Standard Life Insurance Company | Reliance | 2 | . | |
| Sun Life Assurance Company of Canada (USA) | Sun Life Financial | 2 | 2 | |
| Teachers Insurance and Annuity Association of America | TIAA | 1 | . | |
| Travelers Life and Annuity | Travelers | 2 | . | |
| Transamerica Life Insurance Company | Aegon | . | . | 3[i] |
| Transamerica Occidental Life Insurance Company[j] | Aegon | . | . | |
| Other[k] | | 1 | 23 | |
| Unknown[l] | | . | 31 | |
| Total | | 51 | 132 | 4 |

[a]Source: numerous industry reports from Moody's Analytics, A.M. Best Company, ©2015 Standard & Poor's Financial Services LLC ("S&P"), Fitch Research.
[b]Includes *Premium Asset Trust Series* and *Structured Repackaged Asset Trust Series* issuing structures.
[c]Merged with General American Life in 2013, which is part of AIG Life and Retirement Group.
[d]Formerly GE Capital Assurance Company; IPO-ed as Genworth on May 24, 2004.
[e]Formelry ING U.S.; IPO-ed in 2013, renamed Voya Financial on April 11, 2014.
[f]Formelry ING U.S.; IPO-ed in 2013, renamed Voya Financial on April 11, 2014.
[g]Formerly Travelers Life and Annuity; aquired by MetLife on July 1, 2005.
[h]FABCP collaterized by FA from Metropolitan Life Insurance Company and MetLife Insurance Company of Connecticut.
[i]FABCP collaterized by FA from Transamerica Life Insurance Company and Transamerica Occidental Life Insurance Company.
[j]Merged with Transamerica Life Insurance Company on October 1, 2008.
[k]Includes Beneficial Life, Federal Kemper, Hanover Insurance Group, MBIA, Mutual of Omaha, Scottish Annuity & Life Insurance Co., and XL Life.
[l]Unmatched series issued under Premium Asset Trust and Structured Repackaged Asset Trust structure.

# B XFABN Prospectus (first three pages)

**FINAL TERMS**

Final Terms No. 2011-5 dated June 7, 2011

**Metropolitan Life Global Funding I**

Issue of $800,000,000 Extendible Notes due 2017
secured by a Funding Agreement FA-32515S issued by

**Metropolitan Life Insurance Company**

under the $25,000,000,000 Global Note Issuance Program

This Final Terms should be read in conjunction with the accompanying Offering Circular dated September 8, 2010 as supplemented by (i) a first base prospectus supplement dated as of November 24, 2010 (the "**First Base Prospectus Supplement**"), (ii) a second base prospectus supplement dated as of April 5, 2011 (the "**Second Base Prospectus Supplement**") and (iii) a third base prospectus supplement dated as of May 27, 2011 (the "**Third Base Prospectus Supplement**") (as so supplemented, the "**Offering Circular**") relating to the $25,000,000,000 Global Note Issuance Program of Metropolitan Life Global Funding I (the "**Issuer**").

**PART A — CONTRACTUAL TERMS**

Terms used herein and not otherwise defined herein shall have the meanings ascribed in the Offering Circular, which constitutes a base prospectus for the purposes of the Prospectus Directive (Directive 2003/71/EC) (the "**Prospectus Directive**"). This document constitutes the Final Terms of the Notes described herein for the purposes of Article 5.4 of the Prospectus Directive and must be read in conjunction with the Offering Circular. Full information regarding the Issuer and the offer of the Notes is only available on the basis of the combination of these Final Terms and the Offering Circular. The Offering Circular is available for viewing in physical format during normal business hours at the registered office of the Issuer located at c/o U.S. Bank Trust National Association, 300 Delaware Avenue, 9th Floor, Wilmington, DE 19801. In addition, copies of the Offering Circular and these Final Terms will be available in physical format free of charge from the principal office of the Irish Paying Agent for Notes listed on the Irish Stock Exchange and from the Paying Agent with respect to Notes not listed on any securities exchange. In addition, the Offering Circular is published on the website of the Central Bank of Ireland at www.centralbank.ie.

| | | |
|---|---|---|
| 1. | (i) Issuer: | Metropolitan Life Global Funding I |
| | (ii) Funding Agreement Provider: | Metropolitan Life Insurance Company ("**Metropolitan Life**") |
| 2. | Series Number: | 2011-5 |
| 3. | Tranche Number: | 1 |
| 4. | Specified Currency or Currencies: | U.S. Dollar ("**$**" or "**USD**") |
| 5. | Aggregate Principal Amount: | $800,000,000 |
| 6. | (i) Issue Price: | 100.00% of the Aggregate Principal Amount |
| | (ii) Net proceeds: | $798,400,000 (after payment of underwriting commissions and before payment of certain expenses) |
| | (iii) Estimated Expenses of the Issuer: | $55,000 |
| 7. | Specified Denominations: | $100,000 and integral multiples of $1,000 in excess thereof |
| 8. | (i) Issue Date: | June 14, 2011 |

| | | |
|---|---|---|
| | (ii) Interest Commencement Date (if different from the Issue Date): | Not Applicable |
| | Maturity Date: | |
| | — Initial Maturity Date: | July 6, 2012, or, if such day is not a Business Day, the immediately preceding Business Day, except for those Extendible Notes the maturity of which is extended on the initial Election Date in accordance with the procedures described under "Extendible Notes" below. |
| | — Extended Maturity Dates: | If a holder of any Extendible Notes does not make an election to extend the maturity of all or any portion of the principal amount of such holder's Extendible Notes during the notice period for any Election Date, the principal amount of the Extendible Notes for which such holder has failed to make such an election will become due and payable on any later date to which the maturity of such holder's Extendible Notes has been extended as of the immediately preceding Election Date, or if such later date is not a Business Day, the immediately preceding Business Day. |
| | — Final Maturity Date: | July 6, 2017, or, if such day is not a Business Day, the immediately preceding Business Day. |
| 9. | Election Dates: | The 6th calendar day of each month, from July 6, 2011, through, and including, June 6, 2016, whether or not any such day is a Business Day. |
| 10. | Closing Date: | June 14, 2011 |
| 11. | Interest Basis: | Floating Rate |
| 12. | Redemption/Payment Basis: | Redemption at par |
| 13. | Change of Interest or Redemption/Payment Basis: | Not Applicable |
| 14. | Put/Call Options: | Not Applicable |
| 15. | Place(s) of Payment of Principal and Interest: | So long as the Notes are represented by one or more Global Certificates, through the facilities of The Depositary Trust Company ("**DTC**") or Euroclear System ("**Euroclear**") and Clearstream Luxembourg, *société anonyme* ("**Clearstream**") |
| 16. | Status of the Notes: | Secured Limited Recourse Notes |
| 17. | Method of distribution: | Syndicated |
| **Provisions Relating to Interest (If Any) Payable** | | |
| 18. | Fixed Rate Notes Provisions: | Not Applicable |
| 19. | Floating Rate Note Provisions: | Applicable |

| | |
|---|---|
| (i) Interest Accrual Period(s)/Interest Payment Dates: | Interest Accrual Periods will be successive periods beginning on, and including, an Interest Payment Date and ending on, but excluding, the next succeeding Interest Payment Date; *provided*, that the first Interest Accrual Period will commence on, and include, June 14, 2011, and the final Interest Accrual Period of any Extendible Notes will end on, but exclude, the Maturity Date of such Extendible Notes.<br><br>Interest Payment Dates will be the 6th day of each January, April, July and October beginning on October 6, 2011; subject to adjustment in accordance with the Modified Following Business Day Convention, provided that the final Interest Payment Date for any Extendible Notes will be the Maturity Date of such Extendible Notes and interest for the final Interest Accrual Period will accrue from, and including, the Interest Payment Date immediately preceding such Maturity Date to, but excluding, such Maturity Date. |
| (ii) Business Day Convention: | Modified Following Business Day Convention, except as otherwise specified herein |
| (iii) Interest Rate Determination: | Condition 7.03 will be applicable |
| — Base Rate: | USD 3-Month LIBOR, which means that, for purposes of Condition 7.03(i), on the Interest Determination Date for an Interest Accrual Period, the Calculation Agent will determine the offered rate for deposits in USD for the Specified Duration which appears on the Relevant Screen Page as of the Relevant Time on such Interest Determination Date; *provided* that the fall back provisions and the rounding provisions of the Terms and Conditions will be applicable. The Base Rate for the first Interest Accrual Period will be interpolated between USD 3-Month LIBOR and USD 4-Month LIBOR. |
| — Relevant Margin(s): | Plus 0.125% from and including the Issue Date to but excluding July 6, 2012<br><br>Plus 0.18% from and including July 6, 2012 to but excluding July 6, 2013<br><br>Plus 0.20% from and including July 6, 2013 to but excluding July 6, 2014<br><br>Plus 0.25% from and including July 6, 2014 to but excluding July 6, 2015<br><br>Plus 0.25% from and including July 6, 2015 to but excluding July 6, 2016<br><br>Plus 0.25% from and including July 6, 2016 to but excluding July 6, 2017<br><br>(if any such day is not a Business Day the new Relevant Margin will be effective in accordance with the Modified Following Business Day Convention) |
| — Initial Interest Rate: | The Base Rate plus 0.125%, to be determined two Banking Days in London prior to the Issue Date |