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Self-fulfilling Runs:

Evidence from the U.S. Life Insurance Industry*

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Abstract

Is liquidity creation in 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 U.S. 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.

JEL Codes: G22, G01, G14

Keywords: Shadow banking, self-fulfilling runs, life insurance companies, funding agreement-backed securities

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Introduction

The financial crisis of 2007-2008 highlighted the vulnerability of shadow banking (e.g., asset-backed commercial paper conduits) and financial markets (e.g., repo) to runs. The crisis also showed that large non-bank financial institutions, previously thought to be on the fringes of the shadow banking sector, engaged in substantial maturity and liquidity transformation, and experienced runs.[1] Yet there remains considerable debate among regulators and academics about the actual economic mechanism behind runs on shadow banks by institutional investors.

While investor runs are a core issue for financial stability, theory suggests there are two distinct reasons for runs. In seminal theoretical work, Bryant (1980) and Diamond & Dybvig (1983) show that liquid liabilities are potentially vulnerable to swift changes in investors' beliefs about the actions of other investors.[2] When investors withdraw based on their beliefs and their action leads other investors to withdraw, then the original belief is verified and a self-fulfilling run has occured. Such a run is in contrast to a fundamental-based run, in which investors decide to withdraw based on, for example, changes in their liquidity demand, risk appetite, regulatory constraints, or information about the liquidity of an issuer.[3] In this alternative theory, a change in fundamentals is the key determinant of investor behavior and there is no self-fulfilling component. Identifying institutions and markets that are vulnerable to self-fulfilling runs is essential since they could originate shocks that propagate through the financial system and they have the potential to amplify and accelerate shocks elsewhere. In either case, vulnerability to self-fulfilling runs may require regulation that goes beyond better liquidity and solvency standards.

However, showing that institutions and markets are plausibly vulnerable to self-fulfilling runs is difficult outside of a laboratory setting.[4] The main empirical challenge

[1] For instance, while the popular press attributes the fall of AIG to its AIGFP unit that unidirectionally insured vast amount of subprime MBS before the collapse in US house prices, the trigger for the largest emergency loans from the Federal Reserve came from the run by investors on the $80 billion securities lending programs from AIG's life insurers.

[2] See also the work by Postlewaite & Vives (1987), Goldstein & Pauzner (2005) and Rochet (2004).

[3] The information about 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 Jacklin & Bhattacharya (1988), Calomiris & Gorton (1991), and Chen (1999).

[4] Garratt & Keister (2009) design an experiment that shares features of the real-world environment we describe below. See also the experiments of Madies (2006), Arifovic et al. (2013) and Kiss et al. (2012). Some classic papers have shown the importance of fundamentals to bank depositors' withdrawal decisions during the Great Depression (Gorton (1988), Calomiris & Gorton (1991), Saunders & Wilson (1996), and Calomiris & Mason (2003)). Recent empirical work outside the laboratory has sought to identify the determinants of bank runs: Graeve & Karas (2014) specify a structural vector autoregression with cross-sectional heterogeneity while Iyer &

to identifying self-fulfilling runs is that decisions by investors whether or not to run are made simultaneously. Investors may receive information about fundamentals, such as the liquidity of an issuer or their own liquidity demand, at the same time that they are forming beliefs about the likely actions of other investors. When we observe actions taken simultaneously, it is difficult empirically to separate runs due to changes in fundamentals from runs due to changes in expectations about other investors' decisions.

In this paper, we address this simultaneity problem by exploiting the contractual structure of a particular type of liquid liability issued by U.S. life insurers. Liquidity creation by U.S. life insurers emerged as a response to long-run macroeconomic and regulatory changes that affected the industry. In the traditional life insurance business model, long-term illiquid liabilities are matched with liquid assets of similar duration. The profitability of this business model relies on high returns to liquid assets and low risk-based capital requirements. So, when interest rates began falling in the late 1980s and regulatory capital requirements were increased in the early 2000s, life insurers' business model was challenged. In response, life insurers adopted new models and techniques to raise their return on equity. This includes transferring insurance liabilities (risk) to off-balance sheet captive reinsurers, and funding high-yield assets with *funding agreement-backed securities*. For more institutional details, see Appendix A.

During the early 2000s, U.S. life insurers began issuing *extendible funding agreement-backed notes* (XFABN). On pre-determined recurring *election dates*, investors in these securities decide whether or not to extend the maturity of their holding.[5] Hence, XFABN are put-able in the sense that investors have the option not to extend 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 identifiers. Therefore, XFABN are designed to appeal to short-term investors, such as prime money market funds (MMFs), whose investment decisions may be constrained by liquidity and concentration requirements.[6]

Puri (2012) use micro-level data on depositors' social networks. In relation to the shadow banking system during the 2007-2008 financial crisis, Covitz et al. (2013) document a collapse in the asset-backed commercial paper market, Gorton & Metrick (2012) identify a collapse in the repo market through a sharp rise in haircuts, while Chen et al. (2010) and Schmidt et al. (2014) study runs by investors in money market funds.

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

[6] 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.

As with other types of liquid liabilities, XFABN are vulnerable to the risk that investors jointly withdraw their funds on short notice. Investors' sudden withdrawal from XFABN by converting their holdings into short-dated bonds maturing around the same time could then create a liquidity shortfall for the insurer. This is especially likely since XFABN proceeds are invested in illiquid high-yield assets and other sources of liquidity could become unavailable at that time.[7] Importantly, illiquidity of an issuer may be of great concern to short-term investors who are sensitive to the timely redemption of their investments, even when the solvency of the issuer is not in doubt.[8] We document that, beginning in the third quarter of 2007, the market for XFABN collapsed as investors converted holdings worth about \$15 billion (in a market with over \$23 billion in outstanding securities.)

We begin our analysis by modelling investors' decisions to convert their holdings and exit the XFABN market. The main result is that, if the decision of other investors to convert their holdings affects the liquidity of the issuer, then there is a possibility of self-fulfilling runs. We also use the model to illustrate the salient challenges when using data on observed XFABN conversions to separate the self-fulfilling effect from the effect of fundamentals on investors' decisions.

Turning to our empirical analysis, the key contract characteristic we exploit is that each XFABN specifies *different* election dates. This allows us to separate the decisions of investors within each insurer, thereby avoiding the aforementioned simultaneity problem. In a reduced-form analysis of withdrawals, 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,

[7] Private observers of the insurance industry recognised early-on the liquidity risk created by combining putable liabilities with illiquid assets: "Moody's believes that the put option sometimes extended to FA holders creates liquidity concerns and event risk. ... The less liquid and lower quality the asset portfolio, the higher the potential for losses and increased probability of the FA issuer becoming troubled. The longer the duration of the assets, or higher potential for duration drift (a common issue for mortgage backed securities), the less likely a company can handle a put 'run' " (Moody's 1998).

[8] If an insurer breaches a regulatory capital threshold, it is immediately taken over by the state. This threshold is breached much sooner than insolvency occurs. Although liability holders can be reasonably certain they will not lose their investment, there will be tremendous uncertainty over *when* investors will get their money back. MMFs are sensitive to any possible disruption to timely redemption of their investments, even when those investments are relatively illiquid (Hanson et al. 2013). A MMF would 'break the buck' if on maturity the redemption of an investment were delayed by even one week.

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 in 2007, we adopt an instrumental variable approach based on the contractual structure of XFABN. Our strategy uses the pre-determined XFABN election dates together with variation over time in the fraction of securities that are eligible for conversion. The various XFABN issued by a given insurer typically have different election dates, but all information is known in advance to investors. Crucially, the election dates are determined when the security is issued, and are therefore plausibly exogenous to recent changes in fundamentals. This exogeneity allows us to construct an instrument for investors' expectations that gets us closer to identifying the effect of changes in expectations about other investors on the payoff to an individual investor. The IV estimates suggest that investors in XFABN were sensitive to changes in their expectations that other investors would withdraw. A one standard deviation (30 percentage point) increase in an investor's expectation that other investors would withdraw is associated with an increase of 3.2 standard deviations (64 percentage points) in the probability that the investor would convert her holdings.

A significant concern in this analysis is that there could be a common shock to fundamentals affecting the U.S. life industry as a whole, or a common shock to short-term investors' liquidity demand. This is especially likely since the run on XFABN in 2007 coincided with runs in the asset-backed commercial paper and repo markets, and liquidity was generally evaporating around that time. In an effort to address this concern, the IV specifications allow for common fundamental shocks by including weekly time fixed effects. Separately, we also allow for insurer-specific time-varying shocks, by including monthly-insurer fixed effects. As further controls for time-varying fundamentals, we include daily variation in the VIX, the size of the asset-backed commercial paper market, as well as insurer-specific credit default swap spreads, expected default frequencies, and stock prices. We find that our baseline IV estimate of the self-fulfilling effect is largely unaffected by these controls.

To add weight to our IV findings, we implement a series of robustness tests to assess the likelihood that alternative mechanisms unrelated to self-fulfilling expectations may be driving our main results. In particular, we test whether our findings are a consequence of time-series persistence in investors' decision to liquidate their holdings. We also examine whether issuers' choice of election dates at the time they issued their XFABN meant the market was designed to be fragile. We investigate whether other pre-determined variables might plausibly work as alternative instruments. And we present some evidence that our endogenous variable is correlated with recent market developments, while our instrument is not. Taken together, the results from these tests consistently suggest that there was a 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 behaviour 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.[9]

The remainder of the paper proceeds as follows: In Section 2 we introduce and model the XFABN issued by U.S. life insurers. Section 3 presents our data and summary statistics on these securities. Section 4 presents our main empirical results, including our IV estimates and robustness tests. We conclude in Section 5 with some remarks on broader implications and further study.

2 Model

Life insurers issue FABS and invest the proceeds in a portfolio of high 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).[10] 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

[9] There are two reasons why it is difficult to identify self-fulfilling runs in the repo and asset-backed commercial paper 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.

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

issued to the SPV is an insurance liability. This provides FABS investors seniority over regular debt holders, and implies a lower cost of funding for the insurer relative to senior unsecured debt.[11] FABS are flexible instruments that may feature different types of embedded put option to meet demands from different types of investors, including short-term investors, such as money market funds (MMFs). FABS designed for short-term investors are the extendible funding agreement backed notes (XFABN) that give investors the option to extend the maturity of their investment at predetermined regular intervals (usually once a month), and were subject to a run by investors in the summer of 2007.

In this section, we construct a model of XFABN investors' decision making to illustrate how expectations about other investors' future actions may affect an investor's decision to extend or not her holding of XFABN. We show how this effect could lead to a self-fulfilling run on XFABN. We then use the model to discuss the main challenges of identifying the self-fulfilling effect from the observationally equivalent effect of fundamentals using equilibrium outcome data.

We begin by formalizing the decision problem faced by XFABN investors.[12] Time is continuous, and there is a continuum of investors indexed by $\iota \in \boldsymbol{\iota}$, each endowed with a unit of an XFABN security $i \in \boldsymbol{I}$. Securities are issued by a single issuer and each unit i is expected to pay c units of coupons on specific dates $\underline{t}_i, \underline{t}_i + 1, \underline{t}_i + 2, \ldots, \overline{t}_i$ and a final principal payment of 1 unit at the final maturity date $\overline{t}_i + m$. Consistent with the requirements of MMFs, we assume that dividends and principal payments are not storable and must be immediately consumed to deliver utility. Investors are risk neutral, and discount the future at rate β. However, investors can only derive utility from consumption on the payment dates of their endowed security. Moreover, each investor ι might also receive an idiosyncratic shock preventing her from receiving any further utility from consumption. We will elaborate on this idiosyncratic shock below.

On any of the dividend payment dates of security i, $t_i \in \left\{\underline{t}_i, \underline{t}_i + 1, \ldots, \overline{t}_i\right\}$, an investor has the option of *converting* a fraction or all of her holding of security i to a *spinoff* bullet bond, which pays the face value of the security at date $t_i + m$. We refer to the dates on which an investor has the option to convert his investment into a short dated

[11] Moreover, since a funding agreement is an insurance obligation, issuing FABS does not affect the issuing insurer's leverage, since it appears to be selling more policies.

[12] The assumptions of the model are based on the actual contractual structure of XFABN. See Appendix D for an example of the first three pages of an XFABN prospectus; the overall prospectus totals over 900 pages.

bullet bond as *election* dates. We summarize all payments due by an issuer at time t, including predetermined payments and the payments resulting from investors converting their XFABN, by q_t.

The ability of the issuer to make payments at time t is summarized by N_t, which we refer to as the state of *fundamentals*. Moreover, we assume that N_t evolves according to

$$\dot{N}_t = \alpha \cdot q_t - r_t \tag{1}$$

where r_t is the issuer's revenue stream that follows a persistent stochastic process, q_t is the total payments due on t, and $\alpha \geq 0$ is the effect of these payments on the issuer's liquidity. Specifically, the issuer could receive a liquidity shock with arrival rate $F(N_t)$, where $F(\cdot)$ is an increasing function of N_t. Once the issuer receives the liquidity shock, no further payment can be made.[13] Note that when $\alpha = 0$, the payments are unrelated to the issuer's liquidity. We assume that at time 0 expected and predetermined payments, denoted by $\tilde{q}_t^0$, are such that $E_0 r_t = \alpha \tilde{q}_t^0$. This implies that the expected liquidity of the issuer is constant when investors do not exercise their converting option and extend their XFABNs.[14]

As mentioned before, each ι investor could receive a shock at any time t preventing her from receiving any utility after time $t + m$. The arrival rate of the shock is given by $N_{\iota t}$, which follows a random walk. Both $N_{\iota t}$ and the idiosyncratic shocks are private information. As will be clear later, this idiosyncratic shock could be interpreted as a liquidity shock, forcing the investor to exercise her option to convert her XFABN into a short-dated bullet bond, with a maturity date that is earlier than the final maturity date of the original XFABN. [15]

The timeline of the model is summarized by Figure 3. Let $D_{\iota t}$ be the fraction of investor ι's holding of the security which is not extended (hence converted) on election date t, and therefore will mature at date $t + m$. It follows that at the next election date $t + 1$, investor ι must decide whether to extend the remaining $1 - D_{\iota t}$ percent of her

[13] Note that the issuer may not be insolvent upon receiving the liquidity shock. However, the order of payments would be disturbed. Since we assume the investors are hyper-sensitive about the timing of their consumption, the delayed payments would be useless for them.

[14] Intuitively, $\alpha > 0$ represents the cost of early liquidation as in the literature stemming from Diamond & Dybvig (1983).

[15] We assume that the idiosyncratic shocks are uncorrelated. However, the model allows for correlated shocks, if we interpret N_t to contain the correlated part of the liquidity shocks to the investors, in addition to issuer's liquidity shock.

security holding, with earliest maturity at $t+1+m$. Let $\boldsymbol{Q_t}$ denote the existing queue of claims on the issuer, and $\boldsymbol{N}_{\iota t} = (N_t, r_t; N_{\iota t})$ be the summary of fundamentals affecting the issuer's ability to pay that are relevant to investor ι, as well as her own (liquidity) preferences. Conditional on not receiving an idiosyncratic (liquidity) shock and on the issuer being liquid, investor ι's decision at time $t < \bar{t}_i$ is summarized by the following Bellman equation:

$$\begin{aligned} P\left(\boldsymbol{Q}_t; \boldsymbol{N}_{\iota t}\right) \; &= \max\nolimits_{D_{\iota t}\in[0,1]} \;\; c + D_{\iota t} \;\; \underbrace{e^{-m\beta}\left[1-\delta_m(\boldsymbol{Q}_t;\boldsymbol{N}_{\iota t})\right]}_{\text{Expected payoff at } m \text{ if converting}} \\ &\qquad + (1-D_{\iota t})\,\underbrace{e^{-\beta}\boldsymbol{E_t}\left\{\left[1-\delta_1(\boldsymbol{Q}_t;\boldsymbol{N}_{\iota t})\right] P\left(\boldsymbol{Q}_{t+1};\boldsymbol{N}_{\iota t+1}\right)\right\}}_{\text{Expected continuation value if extending}} \end{aligned} \tag{2}$$

where $1-\delta_m(\boldsymbol{Q_t};\boldsymbol{N}_{\iota t})$ is the expected probability that neither the investor receives the idiosyncratic shock nor the issuer receives the liquidity shock in the next m periods.[16] If the option is not exercised so that $D_{\iota t} = 0$, the investor faces a similar decision at time $t+1$ with probability $1-\delta_1(\boldsymbol{Q}_t;\boldsymbol{N}_{\iota t})$, and either she receives the idiosyncratic shock or the issuer becomes illiquid with probability $\delta_1(\boldsymbol{Q}_t;\boldsymbol{N}_{\iota t})$. Note that $P\left(\boldsymbol{Q}_{\bar{t}_i};\boldsymbol{N}_{\iota\bar{t}_i}\right) = c + e^{-m\beta}(1-\delta_m(\boldsymbol{Q}_{\bar{t}_i};\boldsymbol{N}_{\iota\bar{t}_i}))$ since there is no further election at time $\bar{t}_i$ and the final maturity of security i is at time $\bar{t}_i + m$.

Lemma 2.1 *Given equation (1), and under mild regulatory assumptions about $F(\cdot)$, the relevant part of $\boldsymbol{Q}_t$ for $[1-\delta_m(\boldsymbol{Q}_t;\boldsymbol{N}_{\iota t})]$ is $\{q_\tau\}_{\tau=t}^{t+m}$, which is the queue of payments scheduled to be made from the current period t until the maturity date of the converted bullet bond at $t+m$.*

To see this point, note that if other investors with an opportunity to exercise their option in the future choose to convert their XFABN after t, the associated final maturity payments would be scheduled for a date later than $t+m$, and thus would not affect the liquidity of the issuer in a significant way.[17] It follows that

$$\frac{\partial}{\partial q_{\tilde{t}}}[1-\delta_m(\boldsymbol{Q_t};\boldsymbol{N}_{\iota t})] \;\; \approx \;\; \begin{cases} -\alpha\int_{\tilde{t}}^{t+m} F'(N_\tau)d\tau\cdot[1-\delta_m(\boldsymbol{Q_t};\boldsymbol{N}_{\iota t})] & \text{if } \tilde{t} < t+m \\ 0 & \text{otherwise} \end{cases} \tag{3}$$

[16] Recall that we assume that the fair value of the investment is expected to be 1.

[17] In fact, since converting XFABN into bullet bond means that the issuer avoids payments of c, the payments between t and $t+m$ could potentially decrease. However, we assume c is small enough to not affect Q_t significantly.

which implies that the effect of an increase in payment $q_{\tilde{t}}$ for a $\tilde{t} \in (t, t+m]$ is negative if and only if $\alpha > 0$, since $F'(\cdot) > 0$.

Next we study the effect of idiosyncratic and issuer liquidity shocks on investors' decisions. Investor ι's decision is given by

$$D_{\iota t} \quad = \quad \begin{cases} 0 & e^{-(m-1)\beta}\left(1-\delta_1(\boldsymbol{Q}_t;\boldsymbol{N}_{\iota t})\right) \leq \boldsymbol{E_t}\left[\left(1-\delta_1(\boldsymbol{Q}_t;\boldsymbol{N}_{\iota t})\right) P\left(\boldsymbol{Q}_{t+1};\boldsymbol{N}_{\iota t+1}\right)\right] \\ 1 & \text{otherwise} \end{cases} \tag{4}$$

where we assume that indifferent investors always extend their XFABN. Since by converting her security the investor loses the stream of coupons, she only does so if she has serious concerns about receiving a liquidity shock or about the liquidity of the issuer.[18] That is, if $N_{\iota t}$ increases, so that receiving the idiosyncratic shock becomes more likely, an investor would choose to convert her holding of XFABN into a short dated bullet bond, hoping that she will receive her final payment before her idiosyncratic liquidity shock arrives and she loses her appetite for consumption. Similarly, if the issuer's liquidity deteriorates and N_t increases, the investor might prefer to convert her XFABN and receive her final payment before the payments are disrupted.

Deterioration in the issuer's liquidity affects all investors, and could lead a significant fraction of investors to *run* on XFABN. The run could result from a negative shock to r_t, or could be simply due to a disorderly liquidation of XFABN resulting from self-fulfilling expectations, or both. We call the negative shock to r_t the *fundamental effect*, and we call the effect of expectations about other investors' future actions on an investor's decision the *self-fulfilling effect*. To understand the latter effect, consider the case where investors whose election date is today believe that investors with election dates in the future will choose to withdraw. This belief induces today's decision makers to withdraw. When the resulting new additions to the payment queue induce future decision makers to withdraw on their election dates, then the belief will be self-fulfilled and a self-fulfilling run will result. Note that a small shock to r_t could be amplified and accelerated by a self-fulfilling run in an interaction between the fundamental and self-fulfilling effects.

The main result of this model can be summarized by Proposition 2.2 below, relegating the proof to the appendix.

[18] The stream of coupons have a present value of $\frac{e^{m\beta}\left(1-e^{-(\bar{t}_i-t)\beta}\right)}{(e^{\beta}-1)} \cdot c$.

Proposition 2.2 *A run on XFABN could be self-fulfilling if and only if $\alpha > 0$.*

The intuition for this result is as follows. If at time t, an investor ι expects other investors to convert their XFABN at t' between t and $t+1$, her expectation of the increase in the queue of payments between $t+m$ and $t+m+1$ would rise. While this change in expectation will not affect her expected value of converting her XFABN, captured by $1-\delta_1(\boldsymbol{Q}_t; \boldsymbol{N}_{\iota t})$, it will lower her expected value of extending the XFABN, denoted by $\boldsymbol{E}_t P_{t+1}$, giving more incentive to convert her XFABN.[19] Moreover, the addition of her spinoff to the queue of payment would in turn have a negative effect on the expected future liquidity of the issuer, inducing other investors' to convert their XFABN between t and $t+1$. This realization confirms the original expectation, giving rise to a self-fulfilling run.

This proposition highlights the feedback mechanism between expectations of other investors' decisions and fundamentals that can arise if the decision of an investor to convert her XFABN has a negative impact on the expected value of other investors ($\alpha > 0$). This mechanism would be absent if an investor's decision to convert her XFABN had no impact on the expected value of other investors ($\alpha = 0$).

So far we have assumed that information about the fundamentals is observable by all investors. However, asymmetric information could imply that uninformed investors act on the informed investors' actions if they believe these actions contain information about the fundamentals, as in Chari & Jagannathan (1988).[20] This indirect information effect could result in a positive correlation between the uninformed investors' withdrawal decisions and the previous decisions of other investors, even when $\alpha = 0$, and thus the other investors' decisions do not have any direct effect on the uninformed investors' payoff. However, as we show in Appendix B, if $\alpha = 0$ then a change in beliefs about other investors' future action has no effect on the expectation about the future liquidity of the issuer, and hence affects neither informed nor uninformed investors' decisions. Therefore, such beliefs cannot be self-fulfilled.

[19] To see the effect of a change in the queue of payment on the expected value of extending the XFABN, recall that N_{t+1+m} is determined by the law of motion in Equation (1).

[20] In the setup of Chari & Jagannathan (1988), informed investors receive a signal about the issuer's future profitability, while uninformed investors can only observe informed investors' actions. However, informed investors also experience random liquidity needs, implying that informed investors' motives for withdrawals cannot be perfectly inferred by the uninformed. Thus, withdrawals may be triggered by the uninformed investors, not because withdrawals by informed investors' decreases the value of the uninformed investors' investment as in Diamond & Dybvig (1983), but because of the possibility of low future returns due to bad fundamentals.

Corollary 2.3 *Regardless of heterogeneity in investors' information about fundamentals, a run on XFABN could be a self-fulfilling run, if and only if* $\alpha > 0$.

2.1 Mapping decisions to observables

As we will discuss in the next section, we precisely observe the aggregate fraction of XFABN that is converted at any given election date t, but do not observe individual investors' conversion decisions. A question, thus, is how to use this data to learn whether there might have been a self-fulfilling component to the run on XFABN in the summer of 2007. In this sub-section, we show how observed changes in aggregate XFABN conversion across time are related to changes in investors' expectations and fundamentals.

Given the above framework, the aggregate fraction of XFABNs converted into short-dated bullet bonds on election date t is defined as

$$D_t\left(\boldsymbol{Q}_t; \boldsymbol{N}_t\right) \;=\; \int D_{\iota t}\left(\boldsymbol{Q}_t; \boldsymbol{N}_{\iota t}\right)\, d\mu(N_{\iota t}) \tag{5}$$

where $\boldsymbol{N}_t = (N_t, r_t)$ summarizes the aggregate state of the issuer's liquidity, and $\mu(\cdot)$ denotes the distribution of the investors' idiosyncratic shocks, so that $\int d\mu(N_{\iota t}) = 1$. Furthermore, the expected increase at date t in other investors' decisions to convert their XFABN between time t and $t+1$, potentially adding to the queue of payments between $t+m$ and $t+m+1$, is defined as

$$\boldsymbol{E}_t S_{t+1} \;=\; \boldsymbol{E}_t \int_{t+m}^{t+m+1} \left(q_\tau - \tilde{q}_\tau^t\right) d\tau$$

where $\tilde{q}_\tau^t$ is the predetermined payments at time $\tau \in (t+m, t+m+1]$ known at time t.[21]

Proposition 2.4 *The partial derivative* $\frac{\partial D_t}{\partial \boldsymbol{E}_t S_{t+1}}$ *summarizes the self-fulfilling effect, and is positive if and only if* $\alpha > 0$.

That is, at any election date t, the direct effect of a change in an investor's expectation about other investors' decision to convert their XFABN in the future, on her decision to convert her XFABN at t captures the self-fulfilling effect.

[21] Note that converting XFABN brings payments by the issuer to an earlier due date, reducing predetermined payments. That is, $\tilde{q}_\tau^t \leq \tilde{q}_\tau^0$. Conversely, when investors convert their XFABN with final maturity $\bar{t}'$ at time $t' \in (t, t+1]$ to a short-dated bullet bond maturing at time $\tau = t' + m$, q_τ increases while $\tilde{q}_{\bar{t}'}^{t'}$ decreases.

While we observe D_t and S_{t+1}, the individual investor's expectation, $\boldsymbol{E}_t S_{t+1}$, is unobservable. We invoke rational expectations to the extent that S_{t+1} and $\boldsymbol{E}_t S_{t+1}$ are not orthogonal and are correlated. However, variation in S_{t+1} could be the result of a shock to r, thereby reflecting the liquidity of the issuer, N. And, since these shocks to fundamentals are persistent, the observed variation in D_t could also be the result of a shock to fundamentals. More formally, the effect of a change in observable S_{t+1} on a change in D_t can be expressed as

$$\begin{aligned}
&\frac{dD_t}{dS_{t+1}} \\
&= \int \frac{dD_{\iota t}\left(\boldsymbol{Q}_t; \boldsymbol{N}_{\iota t}\right)}{dS_{t+1}}\, d\mu(N_{\iota t}) \\
&= \int \left[\int_t^{t+1} \frac{dD_{\iota t}\left(\boldsymbol{Q}_t; \boldsymbol{N}_{\iota t}\right)}{dq_{\tau+m}} d\tau\right] d\mu(N_{\iota t}) \\
&= \int \left[\int_t^{t+1} \left\{\frac{\partial D_{\iota t}\left(\boldsymbol{Q}_t; \boldsymbol{N}_{\iota t}\right)}{\partial E_t q_{\tau+m}} \cdot \frac{\partial E_t q_{\tau+m}}{\partial q_{\tau+m}} + \frac{\partial D_{\iota t}\left(\boldsymbol{Q}_t; \boldsymbol{N}_{\iota t}\right)}{\partial N_t} \cdot \frac{\partial N_t}{\partial N_\tau} \cdot \frac{\partial N_\tau}{\partial q_{\tau+m}}\right\} d\tau\right] d\mu(N_{\iota t}) \\
&= \int \int_t^{t+1} \left[\underbrace{\frac{\partial D_{\iota t}\left(\boldsymbol{Q}_t; \boldsymbol{N}_{\iota t}\right)}{\partial E_t q_{\tau+m}}}_{\substack{\text{self-fulfilling}\\ \text{effect}}} \left(\frac{\partial q_{\tau+m}}{\partial E_t q_{\tau+m}}\right)^{-1} + \underbrace{\frac{\partial D_{\iota t}\left(\boldsymbol{Q}_t; \boldsymbol{N}_{\iota t}\right)}{\partial N_t} \left(\frac{\partial N_\tau}{\partial N_t} \cdot \frac{\partial q_{\tau+m}}{\partial N_\tau}\right)^{-1}}_{\substack{\text{fundamental}\\ \text{effect}}}\right] d\tau\, d\mu(N_{\iota t})
\end{aligned} \tag{6}$$

where, as shown before, $\frac{\partial D_{\iota t}}{\partial N_t} \geq 0$, and $\frac{\partial q_{\tau+m}}{\partial N_\tau} \geq 0$ from $\frac{\partial D_{\iota \tau}}{\partial N_\tau} \geq 0$. Note that even if $\alpha = 0$, so that $\frac{\partial D_{\iota t}(\boldsymbol{Q}_t; \boldsymbol{N}_{\iota t})}{\partial E_t q_\tau} = 0$, a run on XFABN can occur since it could be that $\frac{dD_t}{dS_{t+1}} > 0$ from the fundamental effect.

Therefore, the self-fulfilling effect cannot be identified from the effect of fundamentals without adequately controlling for the possibly confounding effect of fundamentals. The rest of the paper attempts to make some progress in identifying the self-fulfilling effect in the run on XFABN.

3 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.[22] Our data for each

[22] 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

XFABN was collected by hand from individual security prospectuses and the Bloomberg corporate action record. Each XFABN prospectus specifies the initial maturity date, the election window during which the periodic election dates occur, and when the maturity date of the XFABN may be extended.[23] If extended, the XFABN maturity date is re-set to the election date plus some term pre-specified in the prospectus. Holders may continue to extend the duration of their security throughout the election window on the pre-specified election dates.

When partial or whole conversions occur within the extension window, a new security identifier (CUSIP) is created and assigned to the spinoff amount. We use prospectus information and Bloomberg corporate action records to construct the universe of XFABN CUSIP identifiers, and pair them with their spinoffs' CUSIP identifiers. This new security spinoff is no longer eligible for extension and has a fixed maturity date. The remaining portion of the security is eligible for extension throughout the election window and retains its original CUSIP identifier. 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 65 XFABN issuances during the period, from which 115 individual spinoffs were issued. The average XFABN note is $450 million at issuance, while spinoffs are on average $170 million, or almost 40 percent of their parent XFABN, when created. About 65 percent of spinoffs mature in 397 days or less, consistent with an issuance strategy that targets investment by money market funds.[24] Summary statistics for all the variables used in the analysis are displayed in Table 2.

Figure 4 shows the daily time series of outstanding XFABN and outstanding spinoffs from 2006 to 2009. The amount of XFABN issued almost tripled from 2004 to 2006, when issuance peaked at $6.4 billion, before falling sharply during the second half of the

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. A more detailed description of our FABS database, including funding agreement-backed notes and funding agreement-backed commercial paper, is provided in Appendix C.

[23] 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 D 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.

[24] 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).

financial crisis. The amount of XFABN outstanding as of June 2007 was about $23 billion, or just over 19 percent of total U.S. FABS outstanding. Issuance of XFABN since 2013 shows signs of recovery, but remains well below pre-crisis levels.

4 Empirical results

The discussion in Section 2 suggests that investors' decision on election date t to convert their holdings of XFABN should be positively associated with other investors' decisions to convert their holdings of other XFABN before the next election date. Our empirical strategy in this section begins by establishing that there is a positive correlation between investor's 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. However, this correlation does not tell us whether the run is due to self-fulfilling expectations, fundamentals, or both. In the second part of our analysis, we try to draw sharper inference on the possibility that there was a self-fulfilling component using an instrumental variable (IV) approach.

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 1,467 security-election date observations from January 1, 2005 to December 31, 2010. We pay close attention to individual election dates and election windows that make each security eligible or not for conversion into a short-dated bullet bond. Our main specification is summarized by Equation 7 below.

$$D_{ijt} = \gamma_0 + \gamma_1 S_{ijt+1} + \gamma_2 Q_{jt} + \mathbf{x}'_{jt}\beta + \epsilon_{ijt} \tag{7}$$

The dependent variable, D_{ijt}, is the fraction of XFABN i issued by insurer j that is converted on election date t. The main explanatory variable, S_{ijt+1}, is the fraction of all XFABN from insurer j that are converted between the current election date t and the next election date $t+1$. This fraction, S_{ijt+1}, is calculated for each election date t of each individual security i issued by j and excludes decisions made in respect of the XFABN i itself. As discussed above, S_{ijt+1} is an equilibrium outcome determined by self-fulfilling expectations as well as fundamentals, and is therefore likely to be endogenous. In all specifications, we control for Q_{jt}, the fraction of all XFABN from issuer j that were converted prior to election date t, a number of issuer and time specific and aggregate controls, contained in the vector $\mathbf{x}_{jt}$. The error term ϵ_{ijt} likely contains unobserved fundamentals, which we deal with in Section 4.2. Throughout the empirical analysis in this paper, we specify robust standard errors.

4.1 Reduced form estimates

We begin our analysis by estimating the basic correlation between S_{ijt+1} and D_{ijt} in a reduced form specification, controlling directly for the possibly confounding effect of observable fundamentals. The reduced form results are contained in Table 3.

Column 1 of Table 3 reports the results of a regression of D_{ijt}, the fraction of XFABN i issued by insurer j that is converted on election date t, on S_{ijt+1}, the fraction of all XFABN from insurer j that are converted between the current election date t and the next election date $t+1$, and Q_{jt}, the fraction of all XFABN from issuer j that were converted prior to election date t. Consistent with our discussion in Section 2, we find that conversion by other XFABN holders between t and $t+1$ is positively correlated with conversion on date t and is statistically significant at less than the one percent level. Column 2 of Table 3 adds insurer fixed effects to control for persistent insurer characteristics that could affect their propensity to be run on by XFABN investors. The coefficient on S_{ijt+1} and the R^2 are not substantially different from the specification in column 1 of Table 3, suggesting the basic correlation between S_{ijt+1} and D_{ijt} is not simply driven by concerns about individual insurers. The coefficient suggests that, on average, a one standard deviation (20 percentage point) increase in investors' conversion of insurer j's XFABN between election t and $t+1$ is associated with a 0.8 standard deviation (25 percentage point) increase in the fraction of a particular XFABN on election date t that is converted.

Column 3 of Table 3 investigates whether the correlation between D_{ijt} and S_{ijt+1} could be due to a persistent autocorrelation process for S_{ijt+1}, by decomposing Q_{jt} into S_{ijt} and Q_{jt-1}.[25] Finding evidence of autocorrelation in S_{ijt+1}, while controlling for Q_{jt-1} might cast doubt on the likelihood that coordination played a significant role in the run on XFABN. For example, if news about bad fundamentals started circulating just before election date t, one would expect D_{ijt} to be highly correlated with the most recent

[25] Recall from Section 2 that $Q_{jt-1} = \{q_\tau\}_{\tau=t-1}^{t-1+m}$ is updated to $Q_{jt} = \{q_\tau\}_{\tau=t}^{t+m}$ by adding $S_{ijt} = \{q_\tau - \tilde{q}_\tau^t\}_{\tau=t+m}^{t+1+m}$ to the queue of payments.

decisions to convert XFABN issued by the same insurer, summarized by S_{ijt}. The results reported in column 3 show that the coefficient on S_{ijt} is positive but insignificant, while the coefficient on Q_{jt} remains positive and significant at the one percent level.[26] This suggests that, consistent with the argument of Section 2, the overall size of the queue of payments and future developments that might affect the queue appear to be important for D_{ijt}, while recent developments up to t that are summarized by S_{ijt} are not.

Column 4 of Table 3 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. The specification of column 4 controls for the amount of fixed maturity FABS Q_t^{FABS} and ΔQ_t^{FABS} that mature before or on date $t+1$.[27] The coefficient on Q_t^{FABS} is positive and significant, suggesting that a particular XFABN is more likely to be converted at election date t when a large fraction of fixed maturity FABNs is known to mature in the year or so after t. However, the coefficient on S_{ijt+1} remains materially unchanged and statistically significant at the one percent level.

Column 5 of Table 3 controls for the expansion of shadow bank liquidity creation from 2005 to early 2007. It also attempts to control for the rapid development of concerns about the stability of the financial system from mid-2007 that could be a determinant of the runs on XFABN. Specifically, variables measuring the VIX and the amount of asset-backed commercial paper outstanding are added to the reduced form regression. Recall that the run on XFABN was around the same time as the run on ABCP in August 2007 (Covitz et al. 2013) and the run on repo in September 2007 (Gorton & Metrick 2012), but more than a year before the collapse of AIG. Column 6 of Table 3 adds to column 5 quarterly fixed effects to control for any common shock to the industry.[28] Column 7

[26] However, we expect that S_{ijt+1} should be correlated with S_{ijt}, and the coefficient on S_{ijt} in a simple regression of D_{ijt} on S_{ijt} with or without Q_{jt} is indeed significant at the one percent level. The results are available on request.

[27] To be precise, Q_t^{FABS} refers to the amount of outstanding fixed maturity FABS that are maturing before date t and ΔQ_t^{FABS} refers to the amount of outstanding fixed maturity FABS that will mature between t and $t+1$. Note that controlling for rollover risk from fixed maturity FABS requires data on the universe of FABN, not only XFABN. See Appendix C for more details on our FABS database.

[28] Note that since S_{ijt+1} and D_{ijt} are zero when no run is occurring, a quarterly fixed effect is the highest frequency possible in our specification given the number of parameters to estimate and the number of insurer observations per quarter.

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.[29] In all three specifications, the estimated coefficient on S_{ijt+1} remains positive and significant, albeit somewhat smaller when including the time fixed effects. All these results suggest that the most obvious signs of deteriorating fundamentals during the onset of the global crisis cannot account for the basic correlation between S_{ijt+1} and D_{ijt}.

Taken together, the results in Table 3 indicate that there is a robust correlation between the probability that an investor would convert her holdings (D_{ijt}) and the investor's expectations about other investors' likelihood of withdrawal (S_{ijt+1}). This correlation survives controlling for obvious fundamentals that could affect life insurers and the broader financial system. Of course, the correlation does not imply that there was any self-fulfilling component. In particular, the likely presence of unobservable fundamentals prevents us from drawing inference on the importance of self-fulfilling expectations. We next 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.

4.2 Instrumental variable approach

The goal of this analysis is to better estimate the effect of changes in investors' expectations about S_{ijt+1} on D_{ijt}. As discussed above, the effect of expectations about other investors' conversions between t and $t+1$ on the conversion decision is ultimately a function of the externality leading to a self-fulfilling run.[30] That is, if investors' decision to convert their XFABN between two election dates t and $t+1$ had no impact on the payoffs of other XFABN investors deciding to convert their XFABN at election date t, then investors' expectations about other investors (conditional on the state of fundamentals at t) should have no impact on their own conversion decision.

Before presenting the results, we discuss how the unusual contractual structure of XFABN can be used to construct an instrument for S_{ijt+1} that is plausibly unrelated to fundamentals. We then show how this instrument can be used to estimate investors'

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

[30] In the language of the model discussed in Section 2, $\partial f\left(\boldsymbol{Q_t}; \boldsymbol{N}_{\iota t}\right)/\partial q_{\tilde{t}}$ for $\tilde{t} \in (t, t+m]$

expectations about the conversion decisions of other investors between t and $t+1$, and thereby estimate the effect of changes in $E_t S_{ijt+1}$ on D_{ijt}. Importantly, we are not testing self-fulfilling expectations against fundamentals. Rather, our test for the self-fulfilling component is conditional on the effect of fundamentals.

4.2.1 Constructing an instrumental variable from XFABN

Recall that S_{ijt+1} is calculated for each election date t of each individual security i issued by j and excludes decisions made in respect of the XFABN i itself. Now, consider the *ratio of electable* XFABN, RE_{ijt+1}, defined as the fraction 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 be converted into short-term fixed maturity bonds between an individual XFABN i's election dates t and $t+1$. For each XFABN, election details are spelled out in the XFABN prospectuses available to all investors, so that RE_{ijt+1} can be used by all investors to form expectations about S_{ijt+1}. For example, if there is no XFABN from issuer j up for election between t and $t+1$, everyone would know investor's expectation about S_{ijt+1} to be trivially 0. On the other hand, if $RE_{ijt+1} > 0$, these investors may form non-trivial expectations about the decision of other investors to convert their XFABN between t and $t+1$, and their position in the queue of payments.

The ratio of electable RE_{ijt+1} provides a link between investors' ex-ante expectation $\mathbf{E}_t S_{ijt+1}$ and investors' ex-post decisions D_{ijt} and S_{ijt+1}. By definition, RE_{ijt+1} and S_{ijt+1} are bounded below by 0, and S_{ijt+1} is bounded above by RE_{ijt+1}. Furthermore, note that while S_{ijt+1} tends to be 0 when there is no run, RE_{ijt+1} fluctuates over time according the set of possibly non-overlapping election cycles from all XFABN issued by insurer j. Consequently, the greater the number of XFABN outstanding with non-overlapping election cycles, the greater the fluctuations in RE_{ijt+1}. Moreover, because RE_{ijt+1} is the upper bound for S_{ijt+1}, the two variables tend to co-move positively during a run, as $S_{ijt+1} = RE_{ijt+1}$ if all investors choose to convert their XFABN.

In normal times, RE_{ijt+1} is pre-determined by the contractual structure of all outstanding XFABN. However, RE_{ijt+1} is not necessarily independent from changes in fundamentals once a run occurs. On the one hand, RE_{ijt+1} mechanically decreases 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} would be negatively correlated with fundamentals. On the other hand, RE_{ijt+1} could increase with an increase in XFABN issuance. For example, an insurer experiencing a run on its XFABN may try to secure new funding by issuing additional XFABNs, so that RE_{ijt+1} would be positively correlated with fundamentals.

Thus, we construct an instrument for S_{ijt+1} that retains the variation of RE_{ijt+1} that is predetermined by the XFABN contractual structure and positively correlated with S_{ijt+1}, but we remove any innovations to RE_{ijt+1} that might arise from conversion and new issues during the run period. Since the majority of XFABN in the sample are converted between August 1, 2007 and October 31, 2007, we remove any changes of RE_{ijt+1} from the three months leading up to each election date t (RE_ex3m_{ijt+1}). Using the variation in RE_ex3m_{t+1} as an instrument for S_{ijt+1} yields estimates of the effect of the expectation of investor liquidation decisions $\mathbf{E}S_{ijt+1}$ on investors' own liquidation decisions D_{ijt} that are less likely to be biased by latent fundamental effects. Moreover, the variation of RE_ex3m_{ijt+1} during the run is likely orthogonal to latent fundamental effects contributing to the conversion decision.

Importantly, RE_ex3m_{ijt+1} is not a "sunspot", or coordination device for investor expectations, in the sense of Shell (1987). Rather, our empirical environment provides a variable that is correlated with investor expectations, but independent of latent fundamental effects. To see this in a simple way, consider two possible distributions of beliefs about S_{ijt+1} represented in Figure 6. When the overall distribution of beliefs is close to 0, as in the case $g^A(.)$, then the expectations will always be close to zero and independent of RE_ex3m_{ijt+1}. But, as the case $g^B(.)$ shows, sometimes the expectation of S_{ijt+1} may be a function of RE_ex3m_{ijt+1}. While we have no idea what (real or sunspot) variables are driving the entire distribution of beliefs to change, we can nevertheless potentially instrument for changes in the expectations about S_{ijt+1} using RE_ex3m_{ijt+1}.

4.2.2 Instrumental variable estimates

Table 4 contains our main instrumental variable (IV) results estimated using a two stage least square procedure. The first-stage regression, reported in column 1 of Table 4, regresses S_{ijt+1}, the fraction of all XFABN from issuer j that is converted between election date t and $t+1$ on RE_ex3m_{ijt+1}, the fraction of XFABN from issuer j that is up for election between election date t and $t+1$. The regression includes the baseline controls from the specification in column 4 of Table 3. 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} significant at less than the one percent level. The first stage results also show that the instrument passes the Stock & Yogo (2005) weak instrument test. From column 1 Table 4, a one standard deviation (10 percentage point) increase in RE_ex3m_{ijt+1} is associated with a 0.3 standard deviation (9 percentage point) increase in S_{ijt+1}.

Column 2 of Table 4 reports the second stage regression results, with the coefficient obtained from treating S_{ijt+1} with RE_ex3m_{ijt+1}. The IV coefficient estimate is larger, but not statistically different than its OLS counterpart in the reduced form specification (column 4 of Table 3). The magnitude of the IV coefficient suggests that a one standard deviation (30 percentage point) increase in the XFABN conversion rate between t and $t+1$ predicted by investors at election date t raises the probability that investors convert their XFABN at election date t by 3.2 standard deviations (64 percentage points).

A significant concern in this analysis is that there could be a common shock to fundamentals affecting the U.S. life 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 3 and 4 of Table 4 control further for common shocks to the industry by adding weekly time fixed effects.[31] Columns 3 and 4 of Table 4 also control for the expansion in shadow bank liquidity creation from 2005 to early 2007, and the rapid development of concerns about the stability of the financial system from mid-2007 that could be a determinant of the runs on XFABN, by including the VIX and the amount of ABCP outstanding.

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 the fraction of electable XFABN is high, many investors will run. On the second day, if the fraction of electable XFABN is low, few investors will run. Our identification strategy could be challenged if, systematically and within each week, good news about

[31] Note that unlike the reduced form specification of Table 3 for which quarterly time fixed effect were the highest frequency possible, the IV regression allows us to use a higher frequency because the value of S_{ijt+1} treated by RE_ex3m_{ijt+1} has much greater variation over the entire sample period.

fundamentals coincided with days when the fraction of electable XFABN were low and bad news coincided with days when the fraction of electable XFABN were high. However, we argue that this is an unlikely scenario since, fundamentals were worsening across capital markets during this period.

As a further robustness check on fundamentals, Columns 5 and 6 of Table 4 allow for high-frequency idiosyncratic shocks by including monthly-insurer fixed effects. Columns 7 and 8 of Table 4 add daily variation in market-based measures of issuer financial health such as insurer holding company stock prices, 5-year CDS spreads and 1-year Moody's KMV Expected Default Probabilities.[32] In all these specifications, the estimated IV coefficient (S_{ijt+1} treated by RE_ex3m_{ijt+1}) remains positive and highly significant giving us some confidence that our estimate of the coordination failure effect is not biased in obvious ways by latent fundamental effects.

4.3 Robustness to alternative mechanisms

As discussed above, investors' decisions to convert their XFABN could be shaped by the joint and largely unobservable variation in $\boldsymbol{E}_t S_{ijt+1}$ and N_t. Our instrumental variable approach uses the variation in RE_ex3m_{ijt+1} to help purge the possibly confounding effect of N_t on D_{ijt} from the equilibrium outcome S_{ijt+1}. In this sub-section, we perform a number of tests to examine further the property of our instrument, and the robustness of our proposed mechanism to alternative explanations. The results of these tests are summarized in Table 6.

A first concern is that the IV estimate of the coefficient on S_{ijt+1} discussed above is driven by the 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 RE_{ijt}, defined as the fraction of XFABS that is up for election between election date $t-1$ and the current election date t. Table 6 suggests that there is indeed a significant time-series persistence, with a correlation coefficient of 0.82 between RE_ex3m_{ijt+1} and RE_{ijt} (and 0.85 between RE_{ijt+1} and its lag RE_{ijt}), respectively. Columns 1 and 2 of Table 6 report the first and second stage regression results using RE_{ijt} as an instrument for S_{ijt+1}, respectively. Although there is a statistically significant relationship between this alternative instrument and the endogenous variable S_{ijt+1} in the first stage, the results

[32] This specification can only be estimated on about 40 percent of the original sample.

suggest that RE_{ijt} is a weak instrument for S_{ijt+1}. Moreover, the coefficient of S_{ijt+1} treated by RE_{ijt} in the second stage is not statistically significant from zero. This result is consistent with the hypothesis that RE_ex3m_{ijt+1} can be used to form expectation about future XFABN conversion, while RE_{ijt} cannot.

A second concern is that the XFABN market could be fragile by design, which would render our instrument RE_ex3m_{ijt+1} correlated with fundamentals. To test this hypothesis, we define $RE@I_{ijt+1}$ as the *anticipated* fraction of XFABS that will be up for election between election date t and $t+1$, computed when the XFABN is issued. Table 6 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 6. This finding suggests that it is unlikely that insurers designed their institutional spread margin business to fail.

A third concern is that there could be a mechanical relationship between the predetermined variables of the model and the liquidation decisions. To test this hypothesis, we investigate whether Q_{jt} mechanically affects investors' decisions to convert their XFABN. That is, we instrument the endogenous variable S_{ijt+1} with Q_{jt}, the fraction of XFABN that has been converted up until XFABN i's election date t and that is known to come due before any amount of XFABN i converted at t comes due. Note that while Q_{jt} is predetermined, it is not independent from fundamentals and has a direct effect on D_{ijt}. Column 1 of Table 6 shows that the coefficient estimates on $Q_{jt}-S_{ijt}$ and S_{ijt} in the reduced form specification are positive and jointly significant at less than the one percent level. However, the 2SLS results reported in column 5 and 6 of Table 6 show that the coefficient estimate on S_{ijt+1} instrumented with $Q_{jt} - S_{ijt}$ and S_{ijt} is insignificant. More generally, this test helps shed some light on how erroneously using Q_{jt} as an instrument for S_{ijt+1}, a variable with a direct effect on D_{ijt}, might bias our results.

A fourth concern is that RE_ex3m_{ijt+1} could have a direct effect on the dependent varaible D_{ijt}. We investigate this issue by testing whether S_{ijt+1} might a proxy for RE_{ijt+1}, rather than a proxy for $\boldsymbol{E}_t S_{ijt+1}$. Whether S_{ijt+1} is a proxy for RE_{ijt+1} would imply RE_ex3m_{ijt+1} could have a direct effect on D_{ijt}, which would invalidate our instrumental variable strategy. In this case, the estimated reduced form coefficient on S_{ijt+1} would not capture part of the effect of $\boldsymbol{E}_t S_{ijt+1}$ on D_{ijt}, but instead capture the effect of RE_{ijt+1} on D_{ijt} through its effect on S_{ijt+1}. We investigate this possibility by adding our instrument RE_ex3m_{ijt+1} to the baseline reduced-form specification. The results in column 7 of Table 6 suggests that the coefficient estimate on S_{ijt+1} is not statistically different from its counterpart in column 4 of Table 3, suggesting that S_{ijt+1} has a plausibly direct effect on D_{ijt}.

Lastly, while an asset fire sale could bias our estimate of the self-fulfilling effect, it is unlikely to be of great concern to institutional investors 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.[33] 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.[34] 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.

5 Conclusion

In this paper, we exploit the contractual structure of a particular type of tradable liability issued by U.S. life insurers, extendable funding agreement-backed notes (XFABN), to

[33] 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.

[34] 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."

identify the effect of self-fulfilling beliefs on institutional investors' decisions to run on non-bank financial institutions. We find robust evidence that the run on U.S. life insurers' XFABN that began in the third quarter of 2007 had a self-fulfilling component.

Our results have several implications for research and macroprudential regulation. First, a large regulatory effort since the 2008-09 financial crisis focuses on strengthening the liquidity and solvency standards of non-bank financial institutions. However, if the self-fulfilling component identified in this paper is one of the culprits for the disruptions in non-bank financial intermediation during the crisis, more emphasis should be given to addressing the risk of self-fulfilling 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 decision-making behaviour is likely to have been similar across markets, our study offers some evidence that there may have been a self-fulfilling component to the runs by institutional investors in those larger shadow banking markets.

Second, the Federal Home Loan Bank System provided an important backstop to U.S. life insurers during the 2008-09 financial crisis, possibly preventing the run on XFABN from turning into a fire sale of relatively illiquid assets around the time Fannie Mae and Freddie Mac were taken into conservatorship by the U.S. Treasury. For instance, about three quarters of the surge in Federal Home Loan Bank advances to insurance companies between 2007Q4 and 2008Q4 can be attributed to XFABN issuers at the time their spinoffs came due. However, the run on XFABN demonstrates that this backstop failed to provide effective insurance. Thus, a question is whether the ineffectiveness of the backstop was the outcome of a general lack of understanding of its existence, or evidence that it is not effective in preventing runs on liquid liabilities issued by non-banks.

Lastly, U.S. financial institutions are increasing their reliance on new products such as "extendible" or "evergreen" repo in response to new rules requiring them to report longer-term financing. These repo transactions closely resemble the key features of the XFABN market studied in this paper. Understanding the vulnerability of these markets to self-fulfilling runs is important for all policymakers concerned about financial stability.

References

Allen, F. & Gale, D. (1998), 'Optimal Financial Crises', *Journal of Finance* **53**(4), 1245–1284.

Arifovic, J., Hua Jiang, J. & Xu, Y. (2013), 'Experimental evidence of bank runs as pure coordination failures', *Journal of Economic Dynamics and Control* **37**(12), 2446–2465.

Ashcraft, A., Bech, M. & Frame, W. (2010), 'The Federal Home Loan Bank System: The Lender of Next-to-Last Resort?', **42**(4), 551–583.

Briys, E. & De Varenne, F. (2001), 'Insurance: from underwriting to derivatives', *Springer US* .

Bryant, J. (1980), 'A model of reserves, bank runs, and deposit insurance', *Journal of Banking & Finance* pp. 335–344.

Calomiris, C. W. & Gorton, G. (1991), 'The origins of banking panics: models, facts, and bank regulation', *Financial markets and financial crisis* pp. 109–174.

Calomiris, C. W. & Mason, J. R. (2003), 'Fundamentals, panics, and bank distress during the depression', *American Economic Review* pp. 1615–1647.

Chari, V. V. & Jagannathan, R. (1988), 'Banking panics, information, and rational expectations equilibrium.', *Journal of Finance* **43**, 749–760.

Chen, Q., Goldstein, I. & Jiang, W. (2010), 'Payoff complementarities and financial fragility: Evidence from mutual fund outflows', *Journal of Financial Economics* **97**(2), 239–262.

Chen, Y. (1999), 'Banking panics: The role of the first-come, first-served rule and information externalities', *Journal of Political Economy* **107**(5), 946–968.

Covitz, D., Liang, N. & Suarez, G. (2013), 'The evolution of a financial crisis: Collapse of the asset-backed commercial paper market', *The Journal of Finance* **68**(3).

DeAngelo, H., DeAngelo, L. & Gilson, S. C. (1994), 'The collapse of first executive corporation junk bonds, adverse publicity, and the 'run on the bank' phenomenon', *Journal of Financial Economics* **36**(3), 287–336.

Diamond, D. W. & Dybvig, P. H. (1983), 'Bank runs, deposit insurance, and liquidity', *Journal of Political Economy* **91**(3), 401–419.

Fitch (2006), 'Fundamentals of Asset-Backed Extendible Notes', *Asset-Backed Special Report* .

Garratt, R. & Keister, T. (2009), 'Bank runs as coordination failures: An experimental study', *Journal of Economic Behavior & Organization* **71**(2), 300–317.

Goldstein, I. & Pauzner, A. (2005), 'Demand-Deposit Contracts and the Probability of Bank Runs', *Journal of Finance* **60**, 1293–1327.

Gorton, G. (1988), 'Banking panics and business cycles', *Oxford economic papers* pp. 751–781.

Gorton, G. & Metrick, A. (2012), 'Securitized banking and the run on repo', *Journal of Financial Economics* **104**(3), 425–451.

Graeve, F. & Karas, A. (2014), 'Evaluating Theories of Bank Runs with Heterogenity Restrictions', *Journal of the European Economic Association* .

Hanson, S. G., Scharfstein, D. S. & Sunderam, A. (2013), 'An Evaluation of Money Market Fund Reform Proposals', *Working paper. Harvard Business School* .

Holsboer, J. H. (2000), 'The Impact of Low Interest Rates on Insurers', *The Geneva Papers on Risk and Insurance* **25**(1), 38–58.

Iyer, R. & Puri, M. (2012), 'Understanding bank runs: the importance of depositor-bank relationships and networks', *The American Economic Review* **102**(4), 1414–1445.

Jacklin, C. J. & Bhattacharya, S. (1988), 'Distinguishing panics and information-based bank runs: Welfare and policy implications.', *The Journal of Political Economy* pp. 568–592.

Kiss, H. J., Rodriguez-Lara, I. & Rosa-García, A. (2012), 'On the effects of deposit insurance and observability on bank runs: an experimental study', *Journal of Money, Credit and Banking* **44**(8), 1651–1665.

Koijen, R. S. & Yogo, M. (2014), 'Shadow Insurance', *National Bureau of Economic Research* (WP19568).

Madies, P. (2006), 'An Experimental Exploration of Self-Fulfilling Banking Panics: Their Occurrence, Persistence, and Prevention', *Journal of Business* **79**(4), 1831–1866.

Moody's (1998), 'Funding Agreements - The New Frontier of Stable Value', *Moody's Investors Service Global Credit Research Special Comment (April)* .

Postlewaite, A. & Vives, X. (1987), 'Bank Runs as an Equilibrium Phenomenon', *Journal of Political Economy* **95**(3), 485–491.

Rochet, J.-C. (2004), 'Macroeconomic shocks and banking supervision', *Journal of Financial Stability* **1**(1), 93–110.

Saunders, A. & Wilson, B. (1996), 'Contagious bank runs: evidence from the 1929–1933 period', *Journal of Financial Intermediation* **5**(4), 409–423.

Schmidt, L. D., Timmermann, A. G. & Wermers, R. (2014), 'Runs on money market funds', *CEPR Discussion Paper No. DP9906* .

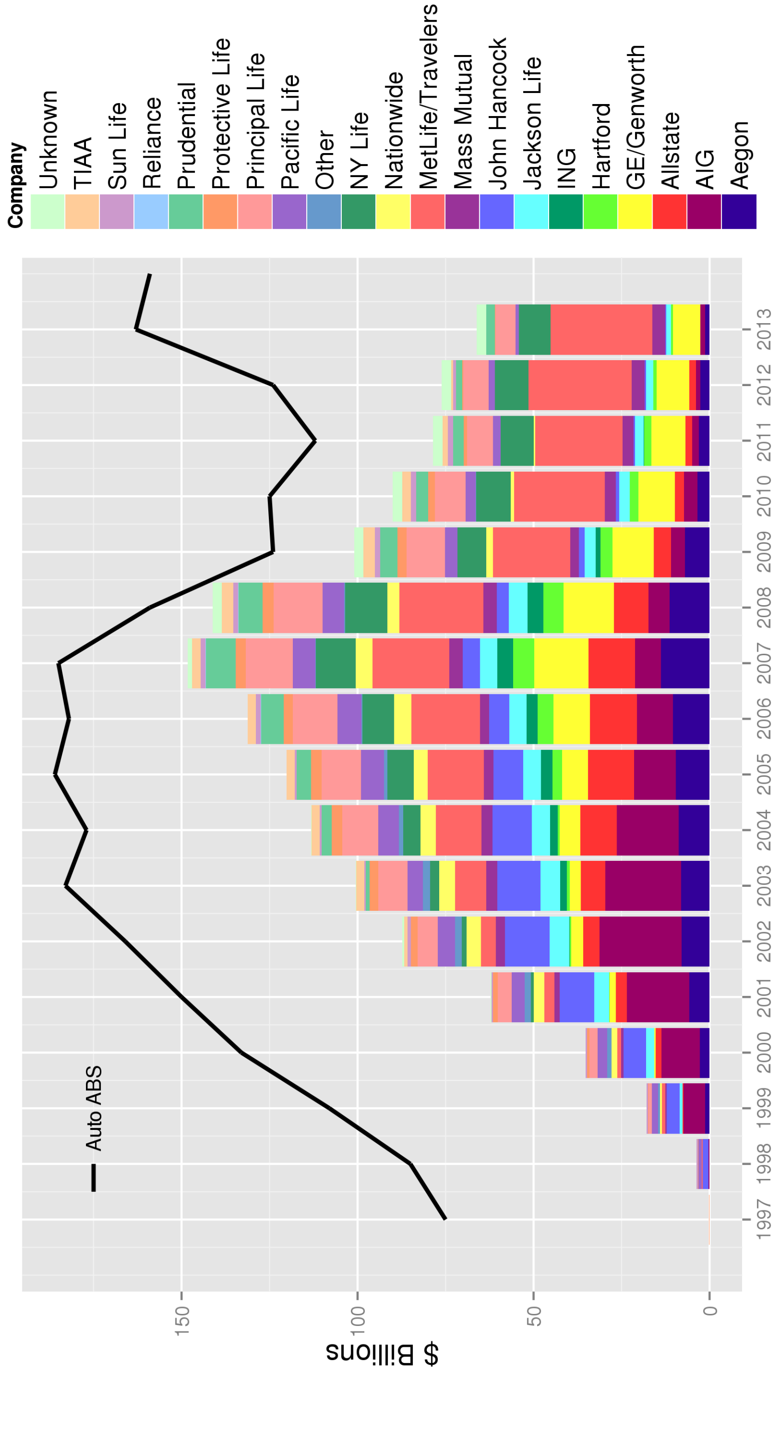
SEC (2010), 'Money Market Fund Reform to 17 CFR Parts 270 and 274', *Release No. IC-29132; File Nos. S7-11-09, S7-20-09* .

Shell, K. (1987), 'Sunspot equilibrium', *The New Palgrave: A Dictionary of Economics (J. Eatwell, M. Milgate, and P. Newman, eds.)* **4**, 549–551.

Stock, J. & Yogo, M. (2005), *Testing for Weak Instruments in Linear IV Regression*, Cambridge University Press, New York, pp. 80–108.

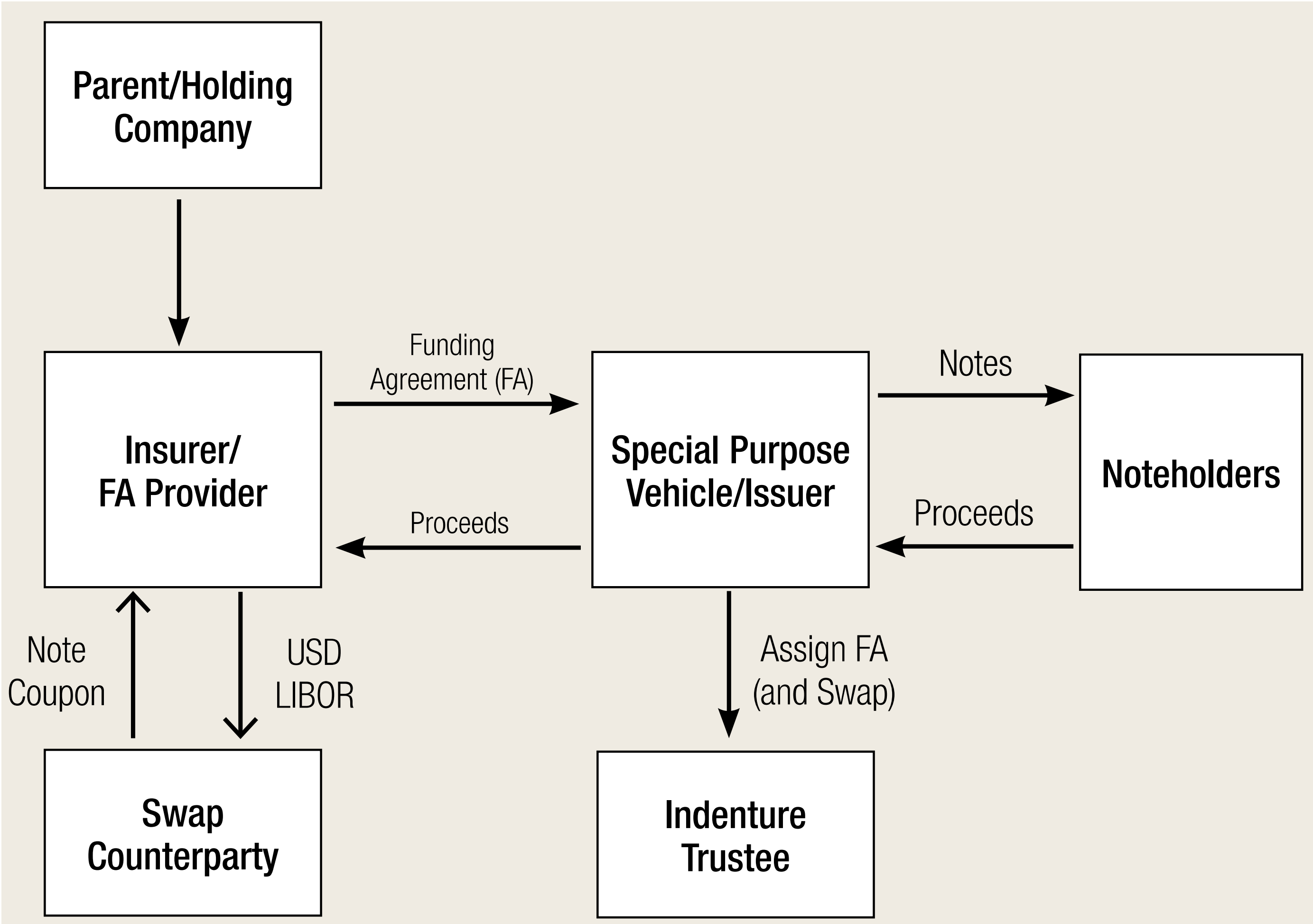
Tables and Figures

Figure 1: FABS and Auto ABS Amount Outstanding



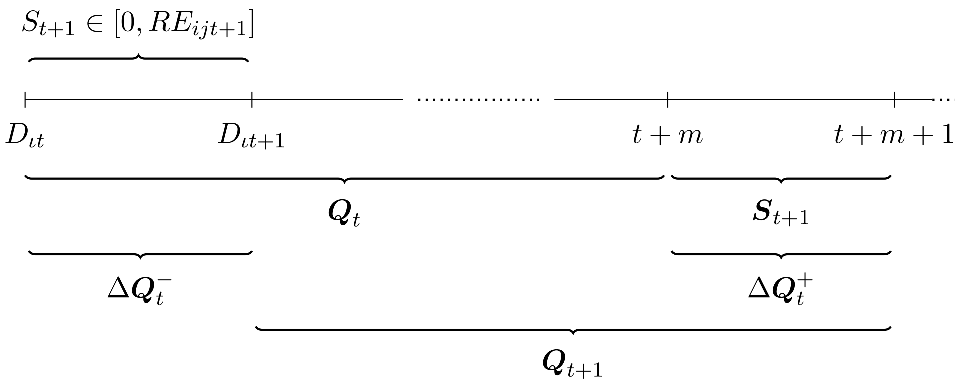
Source: authors' calculations based on data collected from Bloomberg Finance LP, and Moody's ABCP Program Index.

Figure 2: Typical FABS Structure



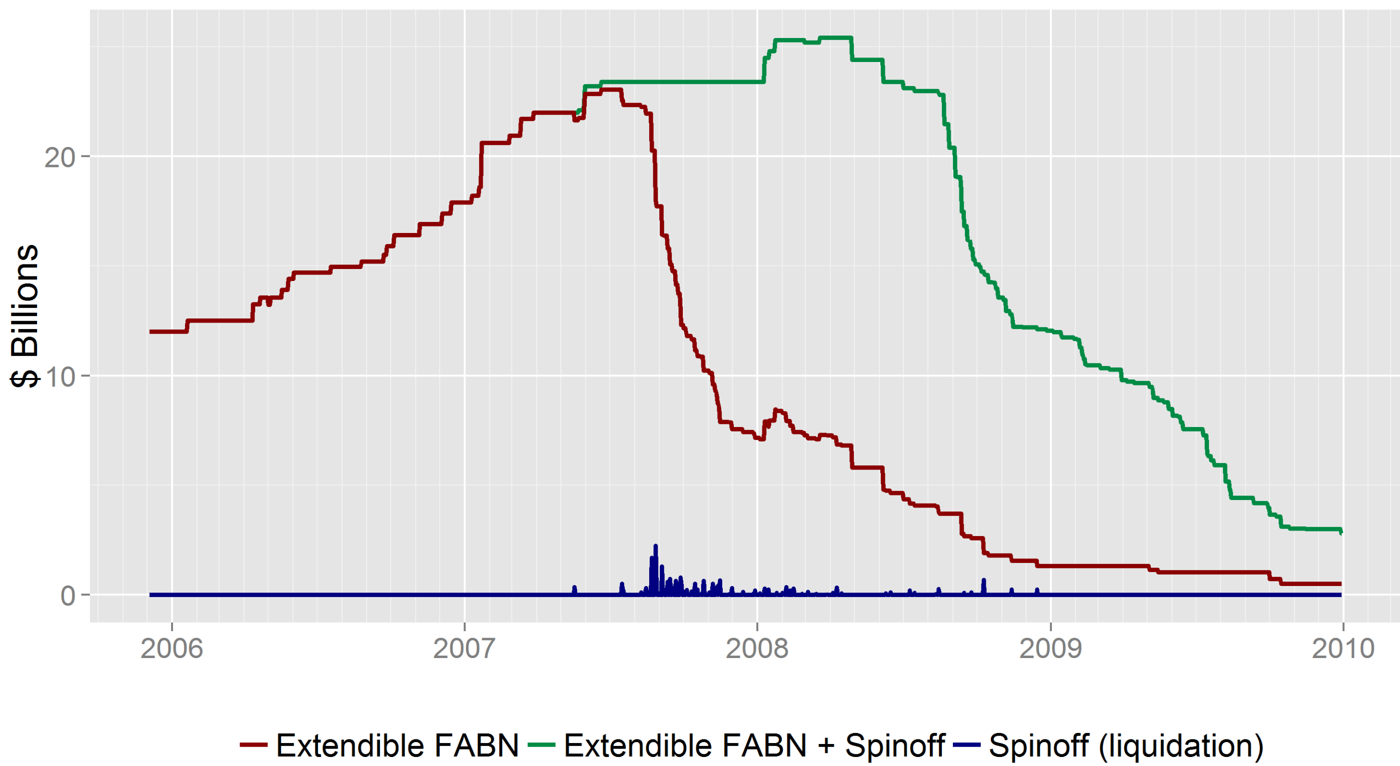
Source: A.M. Best Methodology Note, 2011, "Rating Funding Agreement-Backed Securities Programs". http://www.ambest.com/ratings/fundagreementmethod.pdf

Figure 3: Timeline for XFABN elections



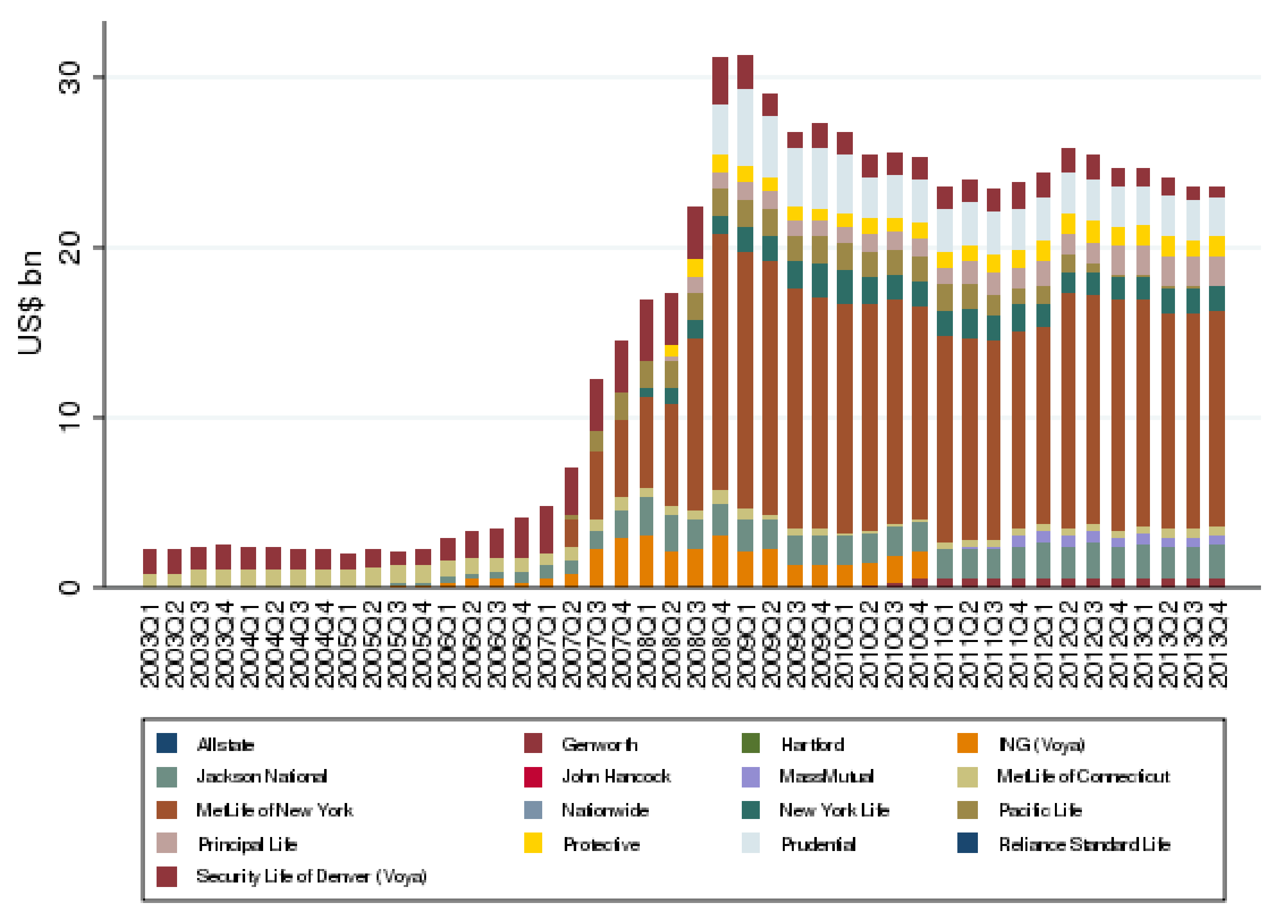
$D_{\iota t}$	Current extension decision	$t+m$	Maturity date of $D_{\iota t}$ spinoff
$D_{\iota t+1}$	Next extension decision	$t+m+1$	Maturity date of $D_{\iota t+1}$ spinoff
$\boldsymbol{S}_{t+1}$	Fraction of other XFABN that are spunoff	RE_{ijt}	Fraction of XFABN that are up for election
$\boldsymbol{Q}_t$	Maturing FABS during $[t, t+m]$	$\Delta\boldsymbol{Q}_t^+$	Other predetermined maturing FABS
$\boldsymbol{Q}_{t+1}$	Maturing FABS during $[t+1, t+m+1]$	$\Delta\boldsymbol{Q}_t^-$	Maturing FABS before the next election

Figure 4: Run on Extendible FABN



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

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.

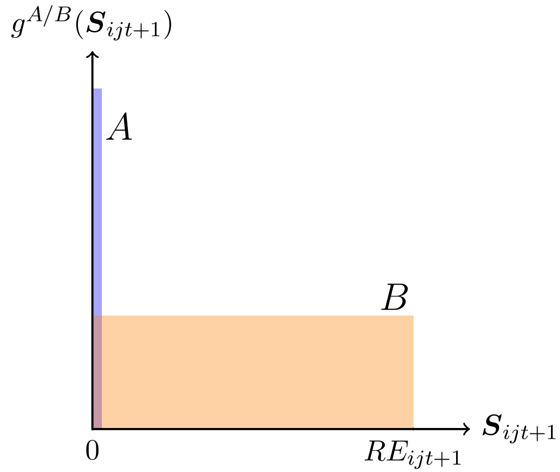


Table 1: U.S. Issuers of Funding Agreement-Backed Securities (FABS)

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.

Table 2: Descriptive Statistics: Runs on Extendible FABN

This table displays descriptive statistics for extendible funding agreement-backed notes (XFABN) in our database where the funding agreement provider is known. There are a further eight XFABN and seven spinoffs that are issued by unknown insurer(s) under Premium Asset Trust and Structured Repackaged Asset Trust structures. Each XFABN has periodic election dates on which the holders of the security may opt to lengthen the term of the XFABN. 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	57	.	.	.	.	.
Number of spinoffs	110	.	.	.	.	.
Number of election dates across all XFABN	1316	.	.	.	.	.
Number of days between election dates	1260	31.0	45.4	36.1	28	366
Issuance amount of XFABN (USD million)	56	400.0	497.8	349.9	100	2000
Issuance amount of spinoffs (USD million)	110	134.5	193.7	198.2	.2	1338.5
Maturity of spinoffs (days)	56	367.0	497.4	211.3	302	1006
Fraction of XFABN that is converted into spinoff (D_{ijt})	942	0.0	0.1	0.2	0	1
Spinoffs created during election period as a fraction of all XFABN (S_{ijt+1})	1098	0.3	0.3	0.3	0	1
Fraction of all XFABN that can potentially be turned into spinoffs (RE_ex3m_{ijt+1})	1098	0.0	0.0	0.1	0	1
Predetermined maturing FABS (Q_{jt}^{FABS})	1260	0.2	0.2	0.1	0	1
New predetermined maturing FABS (ΔQ_{jt}^{FABS})	1260	0.0	0.0	0.0	0	.21

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

Table 3: Runs on Extendible FABN: Reduced Form Results

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 explanatory variables are S_{ijt+1} the fraction of all XFABN from insurer j that is converted between the current election date t and the next election date $t+1$, and Q_{jt} the fraction of XFABN from insurer j that were converted prior to election date t. Columns 2 through 7 include insurer fixed effects. Column 3 decomposes Q_{jt} into a most recent and older component $Q_{jt} - S_{ijt}$ and S_{ijt}, respectively. Column 4 includes the amount of fixed maturity FABS Q_{jt}^{FABS} and ΔQ_{jt}^{FABS} that matures before or on the date at which an XFABN converted at date t is set to come due divided by total FABS. Column 5 includes the VIX and the amount of U.S. ABCP outstanding. Column 6 includes quarterly time fixed effects. Column 7 includes sponsoring insurer stock price, 5-year CDS, and 1-year EDF. Robust standard errors are reported in parentheses. ***, **, and * represent statistical significance at the 1%, 5%, and 10% level, respectively.

Dep. var.: D_{ijt}	(1) No control	(2) Insurer Fixed Effect	(3) Flexible Queue	(4) FABS Rollover risk	(5) VIX & ABCP	(6) Time Fixed Effect	(7) Financials Health
S_{ijt+1}	0.884***	0.891***	0.857***	0.832***	0.735***	0.339**	0.476**
	(0.129)	(0.144)	(0.150)	(0.149)	(0.156)	(0.158)	(0.241)
Q_{jt}	0.000607***	0.000618***					
	(0.000110)	(0.000139)					
$Q_{jt} - S_{ijt}$			0.000553***	0.000481***	0.000308	0.000383*	0.000417
			(0.000170)	(0.000175)	(0.000209)	(0.000204)	(0.000818)
S_{ijt}			0.00921	0.00852	0.00959	0.00756*	0.103
			(0.00563)	(0.00556)	(0.00597)	(0.00456)	(0.106)
Q_{jt}^{FABS}				0.349***	0.330***	0.470***	0.825*
				(0.119)	(0.116)	(0.156)	(0.422)
ΔQ_{jt}^{FABS}				-0.117	-0.131	-0.141	-0.0808
				(0.302)	(0.295)	(0.293)	(0.617)
VIX					0.00411***	-0.00428	-0.00450
					(0.00139)	(0.00293)	(0.00535)
ABCP outstanding (USD bn)					1.75e-05	-0.00105***	-0.00124**
					(3.17e-05)	(0.000319)	(0.000539)
5-Year CDS Spread (bps)							-0.000214
							(0.000635)
1-Year EDF (%)							-0.00711
							(0.106)
Stock Price ($)							-0.000490
							(0.00317)
Observations	921	921	921	921	921	921	383
Adjusted R-squared	0.172	0.187	0.191	0.202	0.219	0.300	0.365
FA provider FE	N	Y	Y	Y	Y	Y	Y
Quarter FE	N	N	N	N	N	Y	Y

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: Runs on Extendible FABN: Instrumental Variable Results

This table summarizes the main instrumental variable 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 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 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. All regressions include the controls included in the baseline reduced from regression (Column 4 of Table 3). Columns 3 through 8 include the VIX and the amount of U.S. ABCP outstanding. Columns 3 and 4 include weekly time fixed effects. Columns 5 through 8 include insurer specific month time fixed effects. Columns 7 and 8 include sponsoring insurer stock price, 5-year CDS, and 1-year EDF. Robust standard errors are reported in parentheses. ***, **, and * represent statistical significance at the 1%, 5%, and 10% level, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dep. var.: D_{ijt}	Baseline		Week FE		Issuer x Month FE		RE_{ijt+1}	
	First stage	Second stage	First stage	Second stage	First stage	Second stage	First stage	Second stage
S_{ijt+1} (endogenous)		2.142***		2.207***		3.513***		2.326***
		(0.472)		(0.686)		(1.310)		(0.762)
RE_ex3m_{ijt+1}	0.0946***		0.0739***		0.0490**		0.0691***	
	(0.0136)		(0.0190)		(0.0191)		(0.0242)	
$Q_{jt} - S_{ijt}$	-0.000216**	0.000849***	-0.000326**	0.00131***	-0.0231	0.133	-0.0146	-0.00452
	(9.14e-05)	(0.000246)	(0.000132)	(0.000395)	(0.0232)	(0.0872)	(0.00916)	(0.0425)
S_{ijt}	0.00678*	-0.00214	0.00555	0.00579	-0.184**	0.455	-0.323***	0.772***
	(0.00356)	(0.00882)	(0.00517)	(0.0119)	(0.0751)	(0.372)	(0.0526)	(0.290)
Q_{jt}^{FABS}	0.0542**	0.226*	0.0528	0.405**	-0.102	0.982***	-0.112	0.204
	(0.0274)	(0.129)	(0.0742)	(0.203)	(0.0652)	(0.293)	(0.106)	(0.264)
ΔQ_{jt}^{FABS}	0.166	-0.413	0.245	-0.481	0.0961	-0.0891	0.133	1.166**
	(0.120)	(0.359)	(0.199)	(0.508)	(0.127)	(0.562)	(0.239)	(0.513)
VIX			-0.00261	0.00348	0.00531	-0.0309***	0.00526*	-0.00742
			(0.00464)	(0.0147)	(0.00334)	(0.0113)	(0.00295)	(0.00771)
ABCP outstanding (USD bn)			0.000469	0.00443	-0.000545	0.000614	-0.000113	-0.00168
			(0.00168)	(0.00384)	(0.000469)	(0.00163)	(0.000409)	(0.00114)
5-Year CDS Spread (bps)							-0.00233	0.0218***
							(0.00158)	(0.00569)
1-Year EDF (%)							0.0451	-0.992***
							(0.120)	(0.315)
Stock Price ($)							-0.00354	0.0329**
							(0.00492)	(0.0132)
Observations	921	921	921	921	921	921	383	383
Adjusted R-squared	0.284	-0.027	0.340	-0.152	0.694	-0.479	0.871	0.486
FA provider FE	Y	Y	Y	Y	Y	Y	Y	Y
Weekly FE	N	N	Y	Y	N	N	N	N
Issuer-Month FE	N	N	N	N	Y	Y	Y	Y
Robust KP Wald F-stat		48.64		15.12		6.57		8.14
Stock-Yogo Critical Value 10%		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 5: 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 4. 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_{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_{ijt} is the fraction of XFABN that is up for election between election date $t-1$ and the current election date t; and $RE@I_{ijt+1}$ is the anticipated fraction of XFABN that will be up for election between election date t and $t+1$ when the XFABN is issued.

	S_{ijt+1}	RE_ex3m_{ijt+1}	RE_{ijt+1}	RE_{ijt}	$RE@I_{ijt+1}$	$\Delta_{3m}VIX_t$
S_{ijt+1}	1					
RE_ex3m_{ijt+1}	0.36	1				
RE_{ijt+1}	0.33	0.95	1			
RE_{ijt}	0.24	0.82	0.85	1		
$RE@I_{ijt+1}$	0.01	0.35	0.34	0.36	1	
$\Delta_{3m}VIX_t$	0.07	0.02	0.01	-0.06	0.00	1

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

Table 6: Runs on Extendible FABN: Robustness Tests

This table investigates the robustness of the results in Table 4 to alternative mechanisms. All regressions include the controls included in the baseline reduced form regression – column 4 of Table 3. 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 3). Columns 8 and 9 instrument S_{ijt+1} with Q_{jt}, 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)	(6)	(7)	(8)	(9)
Dep. var.: D_{ijt}	RE_{ijt}		RE_{ijt+1} at issue		Placebo test		RE_ex3m_{ijt+1} as a	RE_{ijt+1} Bias	
	First stage	Second stage	First stage	Second stage	First stage	Second stage	proxy for S_{ijt+1}	First stage	Second stage
S_{ijt+1} (endogenous)		0.685		0.279		-0.158	0.725***		2.582***
		(0.923)		(2.873)		(0.817)	(0.148)		(0.612)
RE_ex3m_{ijt+1}					0.0946***	0.211**	0.134***		
					(0.0136)	(0.0927)	(0.0416)		
RE_{ijt}	0.0386***								
	(0.0138)								
$RE@I_{ijt+1}$			0.0102						
			(0.0138)						
RE_{ijt+1}								0.0732***	
								(0.0119)	
$Q_{jt} - S_{ijt}$	-0.000274**	0.000392	-0.000278***	0.000325	-0.000216**		0.000543***	-0.000225**	0.000972***
	(0.000111)	(0.000298)	(9.54e-05)	(0.000823)	(9.14e-05)		(0.000166)	(9.34e-05)	(0.000289)
S_{ijt}	0.00768*	0.00729	0.00817**	0.0130	0.00678*		0.00748	0.00723**	-0.00572
	(0.00428)	(0.00890)	(0.00365)	(0.0240)	(0.00356)		(0.00507)	(0.00360)	(0.0105)
Q_{jt}^{FABS}	0.0893***	0.383**	0.0928***	0.401	0.0542**	0.436***	0.303**	0.0581**	0.185
	(0.0328)	(0.149)	(0.0295)	(0.302)	(0.0274)	(0.120)	(0.119)	(0.0282)	(0.135)
ΔQ_{jt}^{FABS}	0.168	-0.116	0.226*	0.00794	0.166	-0.159	-0.177	0.167	-0.512
	(0.131)	(0.357)	(0.129)	(0.703)	(0.120)	(0.350)	(0.292)	(0.123)	(0.401)
Observations	868	868	921	921	921	921	921	921	921
Adjusted R-squared	0.230	0.216	0.226	0.161	0.284	0.099	0.220	0.261	-0.207
FA provider FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Robust KP Wald F-stat		7.86		.55		8.44			37.63
Stock-Yogo Critical Value 10%		16.38		16.38		19.93			16.38

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

A Institutional Background

Liquidity creation 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 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, 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 high returns to savers and challenged the traditional business model of life insurers. Unlike 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 aggresive 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.[35] For their part, life insurers redressed the balance of their portfolios towards safer and more liquid assets.

[35] 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.

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. Faced with the prospect of persistently low interest rates, life insurers realized they 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 to important changes in life insurance regulation.[36] In particular, insurance industry state regulators adopted the NAIC Model Regulation 830 (Regulation XXX) in January 2000 and Actuarial Guideline 38 (Regulation AXXX) in January 2003, requiring life insurers to hold higher statutory reserves in connection with term life insurance policies and universal life insurance policies with secondary guarantees. However, higher risk-based capital requirements necessarily imply a lower return on equity, as larger reserves must be backed by safe, low-yield assets.[37]

Life insurers responded to higher capital requirements and falling interest rates by finding innovative ways to increase their return on equity. One way – the subject of this paper – is to fund a larger portfolio of high yield assets with funding agreement-backed securities (FABS), which is known in the industry as an "institutional spread business."[38] Another way is to reduce risk-based capital requirement by shifting insurance risk off-balance sheet to captive reinsurers. [39]

In a typical FABS structure shown in Figure 2, a hypothetical life insurer sells a single funding agreement (FA) to a special purpose vehicle (SPV). The SPV funds the FA by issuing smaller denomination FABS to institutional investors, who are the noteholders.[40] Importantly, FABS issuance programs inherit the ratings of the sponsoring insurance company, and note holders are treated *pari passu* with other insurance obligations since

[36] Life insurers themselves responded to rising interest rate risk by adopting asset liability management (ALM) tools from banking, including risk limit setting, investment strategies, consistent measures of risk, and sophisticated financial hedging instruments (Holsboer 2000).

[37] The new statutory reserve requirements are typically higher than the reserves 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).

[38]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.

[39]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.

[40]FABN have coupon and maturities matching those of the underlying FA. FABN may feature different types of embedded put and call option. FABN are typically medium-term fixed income securities, but FA may also be issued to an ABCP conduit to create short-term funding agreement backed commercial papers (FABCP).

the FA issued to the SPV that back the FABS is an insurance liability. This provides FABS noteholders seniority over regular debt holders. The proceeds from FABS issuances are then invested in assets with higher yields than the funding cost.[41]

B Proofs

Proof of Proposition 2.2 As shown in equation (3), an increase in investor ι's expectation of new spinoffs between her current and next election dates that could increase $q_{t'}$ for $t' \in (t+m, t+m+1]$ will not affect $(1-\delta_m(\boldsymbol{Q}_t; \boldsymbol{N}_{\iota t}))$ significantly. However, the change in $q_{t'}$ could significantly affect $P\left(\boldsymbol{Q}_{t+1}; \boldsymbol{N}_{\iota t+1}\right)$ since:

$$\frac{\partial \boldsymbol{E}_t P\left(\boldsymbol{Q}_{t+1}; \boldsymbol{N}_{\iota t+1}\right)}{\partial \boldsymbol{E}_t q_{t'}} = \boldsymbol{E}_t \sum_{t"=t+1}^{\bar{t}_i} e^{-(t"+m)\beta} \left[\prod_{\theta=t+1}^{t"-1} (1-D_{\iota\theta})\right] D_{\iota t"} \cdot \frac{\partial(1-\delta_m(\boldsymbol{Q}_{\boldsymbol{t}"}; \boldsymbol{N}_{\iota t"}))}{\partial q_{t'}}$$

$$\approx -\alpha \boldsymbol{E}_t \sum_{t"=t+1}^{\bar{t}_i} e^{-(t"+m)\beta} \left[\prod_{\theta=t+1}^{t"-1} (1-D_{\iota\theta})\right] D_{\iota t"} \int_{t'}^{t"+m} F'(N_\tau) d\tau \cdot (1-\delta_m(\boldsymbol{Q}_{\boldsymbol{t}"}; \boldsymbol{N}_{\iota t"})) \quad (8)$$

which is negative if and only if $\alpha > 0$, since $F'(\cdot) > 0$.

Consider now the case of an investor ι who is indifferent between setting $D_{\iota t}$ equal to 0 or 1, which from equation (4) means that $e^{-(m-1)\beta}(1-\delta_m(\boldsymbol{Q}_t; \boldsymbol{N}_{\iota t})) = \boldsymbol{E}_t\left[(1-\delta_1(\boldsymbol{Q}_t; \boldsymbol{N}_{\iota t}))\, P\left(\boldsymbol{Q}_{t+1}; \boldsymbol{N}_{\iota t+1}\right)\right]$. In this case, and using equation (3), an increase in expected $q_{t'}$ for $t' \in (t+m, t+m+1]$ would not affect $f(Q_t; \boldsymbol{N}_{\iota t})$. However, it follows from equation (8) that such a change in expectation would decrease $\boldsymbol{E}_t\left[(1-\delta_1(\boldsymbol{Q}_t; \boldsymbol{N}_{\iota t}))\, P\left(\boldsymbol{Q}_{t+1}; \boldsymbol{N}_{\iota t+1}\right)\right]$ if and only if $\alpha > 0$. It follows that an increase in expected $q_{t'}$ for $t' \in (t+m, t+m+1]$ would cause an initially indifferent investor to withdraw and convert her XFABN to a short-dated bullet bond. This withdrawal, in turn, would add to the payment queue $\boldsymbol{Q}$, which would make other investors making decision in the future more likely to withdraw.

[41] Life insurers earn a spread in two ways using using FABS funding: One way is to directly invest the proceeds from FABS in mortgages, other loans, and high-yield securities (corporate bonds and private label ABS). Another way is to invest the FABS proceeds in highly liquid U.S. Treasury securities and agency ABS (e.g., mortgages and student loans) that are lent against cash collateral to securities borrowers. The cash collateral is, in turn, reinvested in high-yield securities, including corporate bonds and private label ABS. The latter likely minimizes capital charges at the sponsoring insurer because the lent, highly liquid securities (i.e., the agency ABS and US Treasuries) remain on the FABS-sponsoring insurer's balance sheet, increasing its capital relative to its risk-weighted assets.

To see how an increase in the payment queue changes investors' likelihood to withdraw, consider again an investor indifferent between withdrawal and extending his XFABN. As before, new additions to the queue increase $q_{t'}$ for a $t' \in (t+m-1, t+m]$. From equation (3), the effect of this increase on $1-\delta_m(\boldsymbol{Q}_t; \boldsymbol{N}_{\iota t})$ would be relatively small, since t' is relatively close to $t+m$ and therefore $\int_{t'}^{t+m} F'(N_\tau)d\tau \cdot (1-\delta_m(\boldsymbol{Q}_t; \boldsymbol{N}_{\iota t}))$ cannot be too large. On the other hand, it follows from equation (8) that the effect of new additions to the payment queue on $\boldsymbol{E}_t P\left(\boldsymbol{Q}_{t+1}; \boldsymbol{N}_{\iota t+1}\right)$ would be larger. To see this, note that the time between t' and $t" + m$ for $t" \in \{t+1, t+2, \dots, \bar{t}_i\}$ is longer than between t' and $t+m$, which implies that the increase in $q_{t'}$ has a larger effect on the expected liquidity of the issuer, captured by $\int_{t'}^{t"+m} F'(N_\tau)d\tau \cdot (1-\delta_m(\boldsymbol{Q}_{t"}; \boldsymbol{N}_{\iota t"}))$. Thus, although an increase in $q_{t'}$ for $t' \in (t+m-1, t+m]$ could decrease $(1-\delta_m(\boldsymbol{Q}_t; \boldsymbol{N}_{\iota t}))$ slightly, its effect on $\boldsymbol{E}_t P\left(\boldsymbol{Q}_{t+1}; \boldsymbol{N}_{\iota t+1}\right)$ is larger and would induce an otherwise indifferent investor to withdraw.

Lastly, note that the coordination failure effect in run is present if and only if $\alpha > 0$. That is if $\alpha = 0$, the decision of other investors has no implication for $\boldsymbol{N}_{\iota t} = (N_t, r_t; N_{\iota t})$. Thus, investor ι's value at time t given by equation (2) could be simply written as $P\left(\boldsymbol{N}_{\iota t}\right)$, which is independent from the queue of payments $\boldsymbol{Q}_t$. On the other hand, there could be coordination failure among investors causing a disorderly conversion of XFABN if $\alpha > 0$.

Proof of Corollary 2.3 We generalize Proposition 2.2 to an environment with asymmetric information, akin to the environment studied by Chari & Jagannathan (1988). Asymmetric information could imply that uninformed investors act on the informed investors' actions if they believe these actions contain information about the fundamentals, even when $\alpha = 0$. That is, although $\alpha = 0$ means adding more claims to the queue does not affect the liquidity of the issuer, N_t, decisions of the other (possibly informed) investors to withdraw and add to the queue of claims could contain information for an uninformed investor, who does not observe the fundamentals, r_t and N_t.

Let's assume that there are two types of investors, informed and uninformed. Informed investors observe the variables governing the issuer's liquidity, (N_t, r_t), while uninformed investors do not. Therefore, while the the Bellman equation governing the informed investors' value function and decision, $P^{inf}\left(\boldsymbol{Q}_t; \boldsymbol{N}_{\iota t}\right)$ and $D^{inf}\left(\boldsymbol{Q}_t; \boldsymbol{N}_{\iota t}\right)$, remains similar to equation (2) and equation (4), the uninformed investors do not observe the fundamentals (N_t, r_t) and hence their value function and decision, $P^{un}\left(\boldsymbol{Q}_t; N_{\iota t}\right)$ and

$D^{un}(\boldsymbol{Q}_t; N_{\iota t})$, are only functions of $N_{\iota t} \subset \boldsymbol{N}_{\iota t}$, in addition to the publicly observable $\boldsymbol{Q}_t$. If $\alpha = 0$, then the withdrawal decision of the agents has no bearing on the liquidity of the issuer. Hence the informed investors' value function and decision are independent of the queue. That is, with $\alpha = 0$, we have $P^{inf}(\boldsymbol{Q}_t; \boldsymbol{N}_{\iota t}) = P^{inf}(\boldsymbol{N}_{\iota t})$ and $D^{inf}(\boldsymbol{Q}_t; \boldsymbol{N}_{\iota t}) = D^{inf}(\boldsymbol{N}_{\iota t})$. However, unlike the environment with symmetric information, even with $\alpha = 0$, uninformed investors' decisions depend on $\boldsymbol{Q}_t$, which contains the informed investors' *previous* actions and in turn is informative about the fundamentals, (N_t, r_t).

If $\alpha = 0$, similar to the environment with symmetric information, even uninformed investors would not change their current decision because of a change in their belief about other investors' future actions. That is, although a change in the observed queue, $\boldsymbol{Q}_t$, contains information about the fundamentals and thus affects uninformed investors' decisions at time t, with $\alpha = 0$, a change in belief about the other investors' future action has no effect on the expectation about the future liquidity of the issuer, and thus affects neither informed nor uninformed investors' decisions at time t. Since neither type of investors change their current decision as a result of the belief change, the future queue remains unchanged and therefore even the uninformed investors will not change their decisions in the future. In short, their belief will not be fulfilled.

Proof of Proposition 2.4 For ease of exposition, we assume away the effect of the coupon c. Since $D_{\iota t}$ is an indicator function for $e^{-(m-1)\beta}(1 - \delta_m(\boldsymbol{Q}_t; \boldsymbol{N}_{\iota t}))$ being larger than $\boldsymbol{E}_t\left[(1 - \delta_1(\boldsymbol{Q}_t; \boldsymbol{N}_{\iota t}))\, P\left(\boldsymbol{Q}_{t+1}; \boldsymbol{N}_{\iota t+1}\right)\right]$ in equilibrium, and D_t is the summary of those decisions defined by equation (5), it follows that

$$\frac{\partial D_t}{\partial \boldsymbol{E}_t \boldsymbol{S}_{t+1}} \approx \mu'(N_\iota^*) \cdot \frac{-\left(1 - \delta_1(\boldsymbol{Q}_t; \boldsymbol{N}_{\iota t})\right) \int_{t+m}^{t+m+1} \frac{\partial}{\partial \boldsymbol{E}_t q_{t'}} \boldsymbol{E}_t\left[P\left(\boldsymbol{Q}_{t+1}; \boldsymbol{N}_{\iota t+1}\right)\right] dt'}{\frac{\partial e^{-(m-1)\beta}(1-\delta_m(\boldsymbol{Q}_t; \boldsymbol{N}_{\iota t}))}{\partial N_{\iota t}} - \frac{\partial \boldsymbol{E}_t\left[(1-\delta_1(\boldsymbol{Q}_t; \boldsymbol{N}_{\iota t})) P\left(\boldsymbol{Q}_{t+1}; \boldsymbol{N}_{\iota t+1}\right)\right]}{\partial N_{\iota t}}}\Big|_{N_{\iota t}=N_\iota^*} \quad (9)$$

where at $N_{\iota t} = N_\iota^*$ we have that $e^{-(m-1)\beta}(1 - \delta_m(\boldsymbol{Q}_t; \boldsymbol{N}_{\iota t})) = \boldsymbol{E}_t\left[(1 - \delta_1(\boldsymbol{Q}_t; \boldsymbol{N}_{\iota t}))\, P\left(\boldsymbol{Q}_{t+1}; \boldsymbol{N}_{\iota t+1}\right)\right]$. Thus, $\mu'(N_\iota^*)$ is the probability density of the set of investors who are indifferent between extending and converting their XFABN.

The rest of the expression in the right hand side of equation (9) denotes how much the decision of these otherwise indifferent investors would change as a result of an increase in the expectation that other investors' would convert their XFABN in $t' \in (t, t+1]$.

Note that the denominator of the right hand side of equation (9) denotes the effect of an increase in the propensity that an investor receives an idiosyncratic shock, which is positive. The numerator of equation (9) denotes the self-fulfilling effect, as spelled out in equation (8), which is positive if and only if $\alpha > 0$.

C 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.[42]

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.[43]

[42]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.

[43]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

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 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 1, 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.[44] 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

the security, thereby making them structurally similar to put-able notes.

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

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.

D 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 6^{th} 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. Interest Payment Dates will be the 6^{th} 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 Plus 0.18% from and including July 6, 2012 to but excluding July 6, 2013 Plus 0.20% from and including July 6, 2013 to but excluding July 6, 2014 Plus 0.25% from and including July 6, 2014 to but excluding July 6, 2015 Plus 0.25% from and including July 6, 2015 to but excluding July 6, 2016 Plus 0.25% from and including July 6, 2016 to but excluding July 6, 2017 (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