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Effects of Unconventional Monetary Policy on Financial Institutions
Gabriel Chodorow-Reich
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ABSTRACT

Monetary policy affects the real economy in part through its effects on financial institutions. High frequency event studies show the introduction of unconventional monetary policy in the winter of 2008-09 had a strong, beneficial impact on banks and especially on life insurance companies. I interpret the positive effects on life insurers as expansionary policy recapitalizing the sector by raising the value of legacy assets. Expansionary policy had small positive or neutral effects on banks and life insurers through 2013. The interaction of low nominal interest rates and administrative costs forced money market funds to waive fees, producing a possible incentive to reach for yield to reduce waivers. I show money market funds with higher costs reached for higher returns in 2009-11, but not thereafter. Some private defined benefit pension funds increased their risk taking beginning in 2009, but again such behavior largely dissipated by 2012. In sum, unconventional monetary policy helped to stabilize some sectors and provoked modest additional risk taking in others. I do not find evidence that the financial institutions studied formented a tradeoff between expansionary policy and financial stability at the end of 2013.

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1. Introduction

In the winter of 2008, the Federal Reserve's Federal Open Market Committee (FOMC) began using a mix of policy instruments unprecedented in its history. These expanded to include a target federal funds rate of essentially zero, purchases of Treasury bonds, Agency (Fannie Mae, Freddie Mac, and Ginnie Mae) mortgage-backed securities, Agency bonds, and explicit guidance concerning the future path of the federal funds rate. I refer to these instruments as unconventional monetary policy. The FOMC introduced these policies with the intention of reducing long-term real interest rates, which it believed would lead to a stronger economic recovery.¹ A number of studies have confirmed the policies' success in reducing long-term rates (Gagnon et al., 2010; Krishnamurthy and Vissing-Jorgensen, 2011; Campbell et al., 2012; Wright, 2012).

The introduction of new treatments raises the concern of side effects. In the aftermath of one of the worst financial crises in history, a possibly acute one involves the effect of unconventional policy on the health and stability of the financial sector. Indeed, numerous FOMC participants have cited increased risk taking by financial institutions as a potential constraint on their policy choices (Bernanke, 2013; Stein, 2013a; Fisher, 2014). Alternatively, an improving real economy spurred in part by unconventional policy may have helped to stabilize some financial institutions.

I discuss four channels through which unconventional monetary policy affects the financial sector. First, reducing the risk free rate lowers the hurdle rate for risky investment projects. This leads to increased new spending on projects with either lower mean returns or higher

¹See for example the FOMC statement announcing a new round of asset purchases in September 2012 (<http://www.federalreserve.gov/newsevents/press/monetary/20120913a.htm>).

variances. Depending on the distribution of newly-funded projects, the optimal level of real risk in the economy may change. Financial institutions carry exposure to real project risk through their role as intermediaries between borrowers and savers. Second, unconventional policy may lead some financial institutions to seek higher returns due to institutional dissatisfaction with low yields. By definition, such “reaching for yield” constitutes an increase in risk taking beyond what the end holders of the risk would prefer. Third, by promoting recovery in the real economy, unconventional policy lowers delinquency and default rates, raises profits, and possibly lowers risk aversion. Higher probability of payoff, higher profits, and less risk aversion together raise the prices of legacy assets – financial assets already on financial institutions’ balance sheets – improving solvency. These general equilibrium effects may also benefit financial companies that sell products with a positive income elasticity. Fourth, low interest rates reduce the opportunity cost of holding reserves or collateral. This may generate larger balance sheets and higher leverage at institutions facing binding collateral or reserve requirements, such as banks.

I then turn to evidence on four classes of financial institutions. I use high frequency event studies to measure the response of credit default swap (CDS) spreads, bond yields, and equity prices of life insurers and bank holding companies in narrow windows surrounding surprise announcements of policy changes. I study bank holding companies because of their importance to the financial system. For life insurers, the combination of long-term fixed income liabilities and shorter duration assets may generate a compressed or even negative interest spread at low rates and prompt reaching for yield behavior. On the other hand, many life insurers faced solvency crises in early 2009, and the legacy corporate and mortgage bonds on their balance sheets would have benefited from expansionary policy. In the event, the initial round

of expansionary policy in the winter of 2008-09 had a stabilizing and salutary effect. Life insurer and bank CDS spreads and bond yields fell and stock prices increased immediately following monetary policy announcements, with a particularly pronounced effect on life insurers. Subsequent policy announcements had smaller effects, but expansionary policy continued to benefit asset prices of life insurers and banks.

Some money market funds engaged in reaching for yield in late 2007 and 2008, with disastrous consequences following the Lehman Brothers bankruptcy. A low interest rate environment could again provoke such behavior by squeezing funds' ability to cover administrative costs. Beginning in 2009, funds passed higher gross yields through into higher charged expenses nearly one-for-one, with almost no effect on the net yield received by investors. The high pass through rate suggests funds' operators understood the cost of waiving fees and the potential to avoid such costs by generating higher gross returns – reaching for yield. I exploit cross-sectional differences in administrative costs to determine whether such costs pushed funds to increase their risk-taking. I find evidence of high cost funds pursuing higher gross returns and accepting greater return variance in 2009-11, although the economic magnitudes are small. Moreover, such behavior vanishes by 2013, as the compression in yields across asset classes left little room for funds to reach for yield.

Finally, I analyze risk-taking by private defined benefit pension funds. Underfunded pension plans have the temptation to reach for yield to avoid making larger contributions. Low interest rates may exacerbate this problem by decreasing the expected return absent additional risk taking. Also, funds with a shorter duration of liabilities following a market downturn have less time to smooth their shortfall, and so may try to reach for yield. I use a difference-in-

difference framework with these dimensions of heterogeneity and before and after 2009. Funds with shorter liability duration or worse funding status in 2009 had relative increases in their loadings on the market excess return, and in the variance of their returns over 2009-12. Again, however, the reaching for yield appears mostly to have dissipated by 2012. Here as well, the positive effect of unconventional monetary policy on the stock market and the overall economy improved the solvency position of defined benefit pension funds and their sponsors, helping to counteract any deleterious effect of low interest rates on reaching for yield.

In interpreting these results, it helps to review why policy makers might care about the health of the financial sector, and to clarify a distinction between financial institution risk taking and financial sector stability. Financial institution risk taking involves an active decision by managers to change their risk profile. Low interest rates may spur increased risk taking through the hurdle rate effect, or through reaching for yield. The combined gross assets of life insurers, private defined benefit pension funds, money market funds, and regulated banks exceeded \$24 trillion at the end of 2013. Their attitude toward risk has the potential to affect the market price of risk in the economy. Policy makers may care directly about limiting reaching for yield if it causes risk premia to fall below their first-best level. Conversely, in an application of the theory of the second best, an increase in reaching for yield by some institutions may improve welfare if other distortions (for example, insufficient capital in the financial sector) have resulted in too little risk taking in the economy.

The effect of monetary policy on financial sector stability combines changes in risk taking, in leverage, and the general equilibrium effects on legacy asset prices and the economic environment. Recent theoretical work emphasizes the sharply non-linear effect of financial sector

capital on risk premia and lending (He and Krishnamurthy, 2013; Brunnermeier and Sannikov, 2014). In these models, large contractions in financial sector capital cause capital constraints to bind or set off adverse feedback loops. For example, in a fire sale, an institution's need to delever puts downward pressure on the mark-to-market price of assets held at other institutions, which may then set off further deleveraging (Shleifer and Vishny, 2011). The rapid economic collapse following the Lehman Brothers bankruptcy highlights these non-linear dynamics, as well as providing a direct link between the health of the financial sector and the Federal Reserve's employment mandate (Chodorow-Reich, 2014). For financial stability concerns, higher risk matters regardless of whether it stems from first-best reallocation of resources toward riskier projects or from reaching for yield or higher leverage, particularly if the additional risk concentrates in systemically important financial firms. As a corollary, policy makers might worry less about spurring reaching for yield behavior if unconventional policy simultaneously reduces financial institution risk by improving legacy asset values.

With this guidance in mind, I draw three conclusions regarding the effects of unconventional policy on financial institutions. First, the expansionary policy of the winter of 2008-09 had an important component of financial rescue, particularly for life insurers. The subsequent designation of a large life insurer (Prudential) as a systemically important institution accentuates the value of helping life insurers' balance sheets to recover. Second, a low interest rate environment does pose challenges to money market funds and pension funds. Some of these funds will reach for yield given the opportunity. Third, both life insurers and banks continued to benefit from expansionary monetary policy in 2013, and I find no evidence of money market funds or pension funds reaching for yield in 2012 or 2013. At least in the economic environment

that prevailed at the end of 2013, there does not seem to be a trade-off between expansionary policy and the health or stability of the financial institutions studied.

The paper's results also relate to a literature on the role of financial institutions in transmitting monetary policy. One strand of this literature emphasizes the relationship between the stance of monetary policy and banks' cost of funds and hence loan supply schedules (Bernanke and Blinder, 1992; Gertler and Gilchrist, 1994; Kashyap and Stein, 2000). More recent work posits a risk taking or risk premia channel where a reduction in the monetary policy rate causes financial institutions to increase their risk taking, resulting in lower risk premia and amplifying the magnitude of the interest rate cut (Adrian and Shin, 2010; Borio and Zhu, 2012; Hanson and Stein, 2012). The evidence of some money market funds and pension funds increasing risk taking in 2009-11 provides empirical support for the risk taking channel, albeit in the special environment of near zero nominal interest rates. Finally, in Brunnermeier and Sannikov (2011) monetary easing works by recapitalizing financial institutions, similar to the legacy asset channel described above. The positive effects on life insurers during winter 2008-09 give support to this recapitalization view of monetary policy.

The next section characterizes the theoretical effects of unconventional monetary policy on financial institutions. Section 3 presents the event studies of life insurance companies and bank holding companies. Sections 4 and 5 analyze the responses of money market funds and pension funds, respectively. Section 6 concludes.

2. Theoretical channels

The policy instruments of a sustained low federal funds rate, forward guidance, and large scale asset purchases or quantitative easing (QE) affect the economy by lowering long-term real interest rates. It is useful to distinguish an expectations channel from a portfolio balance channel. Each of the three instruments may trigger the expectations channel by lowering the public's expectation of the path of policy rates. Through the expectations hypothesis of the term structure, long-term nominal interest rates then fall. Additionally, forward guidance and QE may generate an expectation of a lower policy rate after the zero lower bound no longer binds, causing consumption to boom in that future state and raising spending immediately through the Euler equation. These two effects generate a third effect of the expectations channel, a rise in expected inflation. Lower long-term nominal interest rates and higher inflation together imply a decline in long-term real interest rates. The portfolio balance channel arises only with QE. Here investors value certain types of securities beyond their risk-adjusted payoff structure (for example, satisfying regulatory requirements or due to habit or market segmentation). The central bank can then affect interest rates other than the short-term policy rate by changing the portfolio of assets private investors must hold in equilibrium.

I next discuss four channels through which low interest rates affect financial institutions. The concept distance to default provides a useful organizing framework. The distance to default DD_t of a firm is

$$DD_t = \left[\frac{V_{A,t} - V_A^*}{V_{A,t}} \right] \frac{1}{\sigma_{A,t}}, \quad (1)$$

where $V_{A,t}$ denotes the present value of the firm's assets (including intangible assets), V_A^* the

asset boundary at which the firm will default, and $\sigma_{A,t}$ the standard deviation of the firm's (log) assets. The asset boundary V_A^* depends in general on the size of the firm's liabilities and the strictness of debt holders in enforcing positive net worth covenants. The expression has its origins in the Merton (1974) model of credit risk, and today underlies academic and industry measures such as Moody's KMV.

DD_t measures the distance between a firm's current assets and its default barrier, in units of standard deviation. Higher DD_t indicates a lower probability of default. In the language of the introduction, changes in $\sigma_{A,t}$ summarize the effect of monetary policy on financial institution risk taking, while financial sector stability depends on the distribution of DD_t .

2.1. Real spending

Lowering long-term real interest rates stimulates riskless spending as households substitute intertemporally, firms discount future profits at a lower rate, and a commitment to future expansionary policy generates a positive wealth effect. These effects form the textbook channel of monetary policy (Werning, 2012).

Reducing the risk free interest rate also stimulates spending on risky projects. Project risk comes from uncertainty over, inter alia, consumer taste shocks, future technology, future tax policy, and regulation. In corporate finance, investment decisions depend on whether the expected return from a project exceeds the project's hurdle rate. The hurdle rate depends on both the cost of capital and the project's riskiness. When the risk free interest rate declines, newly viable projects have either lower expected returns or higher risk. If projects on the margin of funding mostly have higher risk, total project risk in the economy will rise. If instead the marginal projects have lower expected returns and lower variance than the average project,

total risk will fall. A change in project risk maps into a change in $\sigma_{A,t}$ in equation (1).

A small model illustrates the channel. Consider a two period economy consisting of a representative consumer, a producer, and a monetary authority. The producer passively provides output in exchange for money, at a price normalized to 1. The consumer enters period 0 with real money balances Y_0 , and may purchase output from the producer or make deposits at the monetary authority at a safe gross real interest rate R^f .² Purchased output can be consumed immediately or invested in a project with risky return. The space of projects indexed by expected return μ and variance σ^2 characterize the investment opportunities. There are $K(\mu, \sigma)$ independent projects with the same (μ, σ^2) , each of which can receive either one unit of investment or no investment. Importantly, investment projects do not have scalability – increasing investment by more than K requires accepting either a lower mean return or higher project variance. Let $A(\mu, \sigma) = 1$ if the project receives investment and 0 otherwise, where all (ex-ante identical) projects with the same (μ, σ) either receive or do not receive funding. The consumer chooses allocations to maximize utility from consumption C_0 and C_1 ,

$$U_0 = u(C_0) + \beta E_0 [u(C_1)], \quad (2)$$

subject to the period budget constraints

$$Y_0 = C_0 + A^f + A^p \quad (3)$$

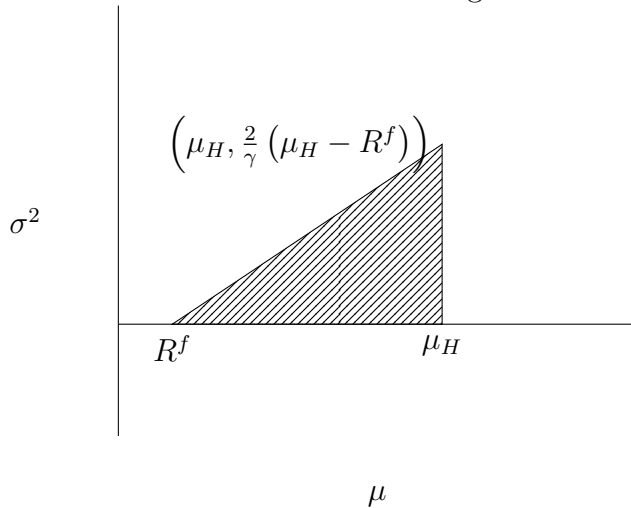
$$C_1 = R^f A^f + R^p A^p, \quad (4)$$

²The model could easily accommodate demand constrained producers as in a standard New Keynesian model. R^f has the literal interpretation of interest paid on reserves at the monetary authority, with two caveats. First, R^f is a real rather than nominal return. Implicitly, agents have perfect foresight over the path of inflation. Second, in this simple two period economy, R^f encompasses all of the policy instruments described above.

where A^f denotes the allocation to the safe deposit, A^p the portfolio of risky assets, and R^p the (endogenous) return on the risky portfolio. C_0 and A^p require purchased output, and hence constitute real spending. Deposits A^f do not utilize real resources.

Appendix B shows that with parametric assumptions on the utility function (CARA) and the distribution of returns on projects (independent normal), the consumer's problem simplifies to a mean variance tradeoff where projects receive funding if their expected excess return $\mu - R^f$ exceeds a multiple $\gamma/2$ of their variance, where $\gamma > 0$ is the coefficient of absolute risk aversion. This gives rise to a mean-variance frontier, on and below which every asset receives funding. The frontier has slope $2/\gamma$ in (μ, σ^2) space, and has a right bound at the economy's maximum expected return μ_H . If the consumer makes strictly positive riskless deposits, $A^f > 0$, then $(R^f, 0)$ must lie on the frontier. Figure 1 illustrates the set of funded projects in (μ, σ^2) space.

Figure 1: Set of funded projects



Expansionary monetary policy – a decline in the riskfree rate R^f – generates a parallel shift out of the mean-variance frontier. Immediately, total spending on risky assets A^p increases. Moreover, spending on riskier projects rises, in the sense that at every mean return projects with higher variance now receive funding. The increased spending on risky projects does not,

however, necessarily imply an increase in the total riskiness of the economy, because spending on projects with low returns and low risk also rises. Whether the variance of the total investment portfolio $(\sigma^p)^2$ rises or falls depends on the relative densities of high risk, high return and low risk, low return projects on the margin of funding, i.e. on the distribution of $K(\mu, \sigma)$.³

If the change in real spending does tilt toward riskier projects, the financial system will have exposure to the additional risk through its role in intermediating between savers and borrowers. Notably, this change in risk-taking does not require any departure from the first-best allocation of resources. As a corollary, changes in the risk quantity or pricing of new lending cannot alone determine optimality. At least some increase in the asset risk of financial institutions may constitute an *intended* channel of unconventional monetary policy.

2.2. Reaching for yield

Low interest rates may also spur risk taking by financial institutions beyond what the ultimate holders of the risk would prefer. Investment management poses a classic principle-agent problem, in which the incentives of managers may not align perfectly with the objectives of shareholders and debt holders (Jensen and Meckling, 1976; Rajan, 2005). Chairman Bernanke referenced these concerns in his May 2013 Congressional testimony:

“the Committee is aware that a long period of low interest rates has costs and risks... one that we take very seriously, is the possibility that very low interest rates, if maintained too long, could undermine financial stability. For example, investors or portfolio managers dissatisfied with low returns may reach for yield by taking on more credit risk, duration risk, or leverage.”⁴

³For example, if $K(\mu, \sigma) = 1 \forall \mu, \sigma$, one can show that both μ^p and $(\sigma^p)^2$ unambiguously decline. Even so, risk in the financial system might still increase if not all institutions hold the same portfolio.

⁴Testimony to the Joint Economic Committee (<http://www.federalreserve.gov/newsevents/testimony/bernanke20130522a.htm>).

The definition of reaching for yield varies across authors. I use it to mean increases in risk taking for reasons other than the end-holder’s risk preferences. In the language of the model in section 2.1, reaching for yield is an increase in the slope of the funding frontier without a change in the risk aversion coefficient γ . The additional risk, corresponding to higher $\sigma_{A,t}$ in equation (1), may come from shifting investments into higher risk asset classes (i.e. equities instead of investment grade debt), choosing higher yield investments within an asset class, or by increasing leverage. The following sections give explicit examples of why some financial institutions might reach for yield (see also Stein, 2013a).

2.3. General equilibrium effects

The general equilibrium effects of low interest rates on financial institutions come because low interest rates also boost aggregate demand. Higher real spending raises profits of nonfinancial firms. As well, a decline in unemployment leads to lower loan delinquency and charge-off rates. Higher profits and lower default probabilities raise state-contingent payoffs and hence asset values. Asset values may rise further if the discount rate used to discount risky future profits falls, as for example consumption-based asset pricing models would predict.

Higher asset prices raise the value of legacy assets held by financial institutions, a phenomenon Brunnermeier and Sannikov (2011) refer to as “stealth recapitalization.” Increases in legacy asset prices correspond to an increase in $V_{A,t}$ in equation (1). The resulting rise in net worth increases distance to default. If proximity to bankruptcy encourages risk-shifting behavior, the increase in net worth will also reduce the amount of risk taking by financial institutions, resulting in lower asset volatility $\sigma_{A,t}$ as well.

Increased aggregate demand may also benefit financial firms if demand for financial products has a positive income elasticity. For example, life insurers’ income from life insurance premiums tends to fall when the unemployment rate rises.⁵

⁵Specifically, at an annual frequency the cyclical component (HP cycle divided by HP trend, smoothing parameter 6.25) of life insurance premiums and the cyclical component of the unemployment rate have a correlation coefficient of -0.56 over the period 1985-2012, with a pvalue against no correlation of 0.002. The correlation remains negative and marginally significant excluding the years 2008-12. Data on life insurance premiums come from American Council of Life Insurers (2013).

2.4. Leverage

Finally, the corporate finance literature has highlighted reasons why low interest rates may affect leverage decisions apart from reaching for yield motivations. The channel mostly concerns banks. A decline in the safe interest rate reduces the cost of holding required reserves or collateral. For banks facing binding collateral constraints or reserve requirements, the decline in the opportunity cost leads to larger total portfolios and higher leverage (Stein, 2012; Dell’Ariccia et al., 2014; Drechsler et al., 2013).⁶ Brunnermeier and Sannikov (2014) describe a related phenomenon stemming from the low volatility environment induced by low interest rates. As low realized volatility feeds into banks’ value at risk models, banks respond by increasing leverage. In the Merton model, leverage corresponds to the entire first term $\left[\frac{V_{A,t} - V_A^*}{V_{A,t}} \right]$.

2.5. Summary

Unconventional monetary policy affects the risk held by financial institutions by changing the hurdle rate for risky projects, through general equilibrium effects on asset values and product demand, and by possibly causing some institutions to reach for yield or expand leverage. Project risk and reaching for yield affect $\sigma_{A,t}$, the forward standard deviation of asset returns. Raising the price of legacy assets increases $V_{A,t}$, while leverage affects the entire first term of equation (1).

I next turn to an empirical assessment of the effects of unconventional policy on four classes of financial institutions: life insurance companies, bank holding companies, money market funds, and pension funds. The analysis of life insurers and banks examines the total effect of unconventional policy on these institutions. For money market funds and pension funds, I narrow the focus to reaching for yield behavior and the effect on forward volatility $\sigma_{A,t}$.⁷

⁶The increase in leverage can exceed the first-best increase. In Stein (2012), a fire sale externality makes one bank’s expanded leverage negatively affect the asset values of another bank in the event of a deleveraging shock. Because banks do not internalize the effect of their own leverage decision on the collateral constraints of other banks, the fire sale externality can lead to an increase in leverage beyond the social optimum.

⁷For money market funds, absence of a capital buffer makes $\sigma_{A,t}$ a near sufficient statistic for the likelihood of the money market version of default (“breaking the buck”).

3. Life insurance companies and bank holding companies

I measure the effect of unconventional policy on life insurance companies and bank holding companies using event studies. Event studies permit the identification of the causal effect of a monetary policy surprise on asset prices.⁸ Identification requires (1) a window narrow enough that aggregate shocks other than the monetary policy shock do not affect the asset price during the window, and (2) a window wide enough to allow markets to process the new information.

I compile a data set of CDS, bond, and equity prices of life insurers and bank holding companies, and Treasury prices. Single label CDS data come from Bloomberg generic quotes for contracts with a five year tenor (contract horizon), written in U.S. dollars, and with an MR restructuring clause.⁹ I obtain end of day quotes for Tokyo, London, and New York, each corresponding to the last trade before 5:15pm local time. The bond price data come from the FINRA TRACE database, which contains transaction-level data for over-the-counter bond transactions collected by FINRA per the rule 6200 series. The equity data come from the TAQ database of tick-by-tick transactions from the consolidated tape of stocks traded on the NYSE. GovPx provides tick-by-tick indicative bid and ask prices on Treasury securities from five inter-dealer brokers. The life insurer sample contains an unbalanced panel of all life insurers in the top 30 by assets, excluding AIG, and with outstanding equity (13 firms), debt (11 firms), or CDS (4 firms) securities. The 13 life insurers in the equity sample together held 45% of total life insurer assets at the end of 2012. The bank holding company sample contains an unbalanced panel of all bank holding companies with publicly-traded equity (305 firms) or bonds (46 firms), and the CDS spreads for eight of the largest bank holding companies.

Single label CDS spreads provide a market price tied to an institution's likelihood of default. When quoted in basis points, the CDS spread, or premium, gives the required annual payment

⁸See Nakamura and Steinsson (2013) for the effect of conventional and Gagnon et al. (2010) and Krishnamurthy and Vissing-Jorgensen (2011) for the effect of unconventional policy on interest rates. English et al. (2012) and International Monetary Fund (2013, chapter 3) extend the methodology to the study of the effect on commercial bank stock prices, and Kiley (2013) and Gilchrist and Zakrajsek (2012) examine the effect on corporate borrowing rates and default risk, respectively.

⁹MR stands for modified restructuring. Contracts with an MR clause give the protection buyer some recourse in the event of a credit event other than outright default. The five year tenor and the MR clause characterize the most liquid contracts for the reference entities studied.

for a contract that will pay \$10,000 if the reference institution triggers a default clause during the contract horizon. Holding the price of risk fixed, an increase in the spread thus indicates a decline in the distance to default and an increase in the default probability of the reference entity. The spread between the bond yield and the Treasury yield measures the bond risk premium. The equity response gives the stock market's perception of the effect of the surprise on the institution's future net income, suitably discounted. The liquidity in equity markets permits the narrowest windows of the assets studied and the inclusion of the largest number of firms.

For all three assets, the response reflects the combination of the effects described in section 2, as well as any change in the economy wide price of risk induced by the monetary policy action. That is, I do not separate movements in the bond or CDS premium into the change in default probability (the quantity of risk) and the excess premium (the price of risk) (see Gilchrist and Zakrajsek, 2012, for further discussion). Furthermore, market beliefs about the effects of unconventional policy may diverge from the true effects. In this regard, I present some evidence of actual events unfolding in a manner consistent with the market expectation, and that markets did not substantially change their views in 2013 even with the addition of four years of data on the effects of unconventional policy.

Table 1 lists the monetary policy surprise dates, grouped into four policy programs. QE1 consists of the initial round of asset purchases announced in late 2008 and lasting through 2009. QE2 corresponds to purchases announced in November 2010. QE3 consists of purchases begun in September 2012 and still ongoing as of March 2014. FG contains dates related to forward guidance. Through 2012, the dates form a subset of the announcement dates listed in International Monetary Fund (2013). With the exception of the initial announcement on November 25, 2008, which occurred before normal trading hours, I keep all dates used in Krishnamurthy and Vissing-Jorgensen (2011). Because my interest lies in identifying the conditional response of financial institution asset prices to monetary policy surprises, however, I exclude some other announcements which do not move the five-year Treasury.¹⁰ Each of the included announcements from

¹⁰For example, the International Monetary Fund (2013) list includes November 3, 2010, when the FOMC announced a new round of asset purchases. Market participants widely expected this announcement, and the Treasury barely reacted on impact. As a result, I include two dates, August 10 and September 21, 2010, when FOMC statements raised expectations of future purchases and Treasury prices rose, but exclude the November 3 announcement itself. As in Krishnamurthy and Vissing-Jorgensen (2011), my focus on conditional responses to

2013 had an identifiable Federal Reserve communication and a discrete change in the Treasury yield at the time of the announcement.

Table 1: Unconventional monetary policy announcement dates

Episode	Date	Time	Event	Effect on 5yr Treasury note ^a (Basis points)
QE1	December 1, 2008	1:45pm	Bernanke speech	-9.2
QE1	December 16, 2008	2:21pm	FOMC statement	-16.8
QE1	January 28, 2009	2:15pm	FOMC statement	3.1
QE1	March 18, 2009	2:17pm	FOMC statement	-22.8
QE1	September 23, 2009	2:16pm	FOMC statement	-8.9
QE2	August 10, 2010	2:14pm	FOMC statement	-5.8
QE2	September 21, 2010	2:14pm	FOMC statement	-1.8
FG	August 9, 2011	2:18pm	FOMC statement	-14.4
FG	January 25, 2012	12:28pm	FOMC statement	-6.3
QE3	September 13, 2012	12:31pm	FOMC statement	6.4
QE3	May 22, 2013	10:30am	Bernanke testimony	6.6
QE3	June 19, 2013	2:00pm	FOMC statement	7.8
QE3	July 10, 2013	4:45pm	Bernanke speech	-7.3
QE3	September 18, 2013	2:00pm	FOMC statement	-14

a. Change in the yield to maturity of the on-the-run five year Treasury note from the 5 minute window ending 2 minutes before the announcement to the 5 minute window beginning 18 minutes after the announcement. The yield to maturity is based on the mean of the indicative bid and ask prices in each window.

For equity and bond prices, I use tick-by-tick data to construct the difference in the five minute average trading price from seven to two minutes before the monetary policy announcement to eighteen to twenty-three minutes after. The narrow intraday window virtually ensures that other aggregate shocks do not contaminate the results (Nakamura and Steinsson, 2013; Kiley, 2013). Furthermore, both the TRACE bond data and the TAQ equity data contain prices from actual trades, and the constructed windows contain only securities with valid transactions both before and after the announcement. This alleviates concerns of market illiquidity biasing price changes toward zero. For CDS spreads, I use data from the market close in Tokyo (3:15am eastern), London (12:15pm eastern), and New York (5:15pm eastern) to construct quasi-intraday windows corresponding to the shortest possible window surrounding each announcement. While the CDS data have a greater concern of incorporating information other than the monetary policy surprise, the quasi-intraday refinement substantially improves on using only daily frequency.¹¹

monetary surprise shocks implies a loss of power but no bias from omitting valid policy surprises.

¹¹For example, the Markit end of day spreads for March 17, 2009 and March 18, 2009 indicate an *increase* of 51

I use Treasury prices to validate the second identification assumption. Appendix figure C.1 shows minute-by-minute yields of the on-the-run five year Treasury note on each date. The dashed lines define the period from two minutes before to 18 minutes after the announcement. Treasuries adjust almost instantaneously to the news, with the window sufficient to capture nearly all of the movement.¹² The narrow window does assume market participants interpret the effect of an announcement on individual bond or equity prices as quickly as they do the effect on Treasuries. Section 3.3 conducts robustness exercises in this regard.

3.1. Life insurer results

Life insurers' liabilities consist of roughly \$4.5 trillion in life insurance policies and annuities (American Council of Life Insurers, 2013). Life insurers divide their asset holdings between a general account backing essentially all of their life insurance policies as well as fixed rate annuities, and a separate account backing pass-through products such as variable rate annuities and pension products. State law regulates asset allocation of the general account but not the separate account.

Both annuities and life insurance contracts often have longer duration than asset holdings, causing balance sheet duration mismatch. When interest rates fall, life insurers face a compressed or even negative interest spread as they roll over assets at the lower rates. While the long-term liability structure provides insulation from the threat of runs, a compressed spread reduces operating profits. This has led some industry analysts to postulate a *negative* effect of low interest rates on life insurers, and especially so if the low interest rates persist for a long period of time (Moody's Investors Services, 2012; McKinsey Global Institute, 2013). Life insurers can try to offset the lower interest rates by reaching for yield, implying greater risk to their policy holders, shareholders, and the state guarantee funds backing their policies in the event of bankruptcy.¹³

On the other hand, life insurers hold roughly one-quarter of their general account assets in

basis points in the value-weighted mean life insurer spread. To preview a result to come, using the change between the London and New York close instead gives a *decline* of 25 basis points.

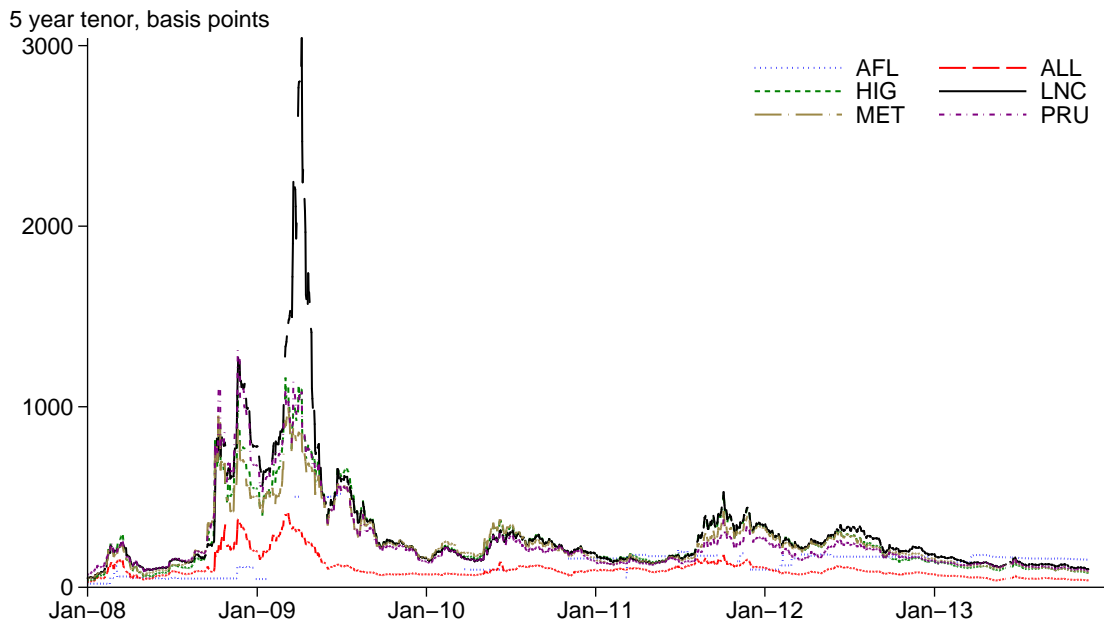
¹²The on-the-run five-year note is the mostly recently issued five-year note, and generally has the greatest liquidity. In some cases the surprise announcement came in the form of an FOMC statement, which was later followed by a Chairman's press conference. Although Treasury prices also respond to news in the press conference, I limit the window to include only effects from the statement itself.

¹³Becker and Ivashina (forthcoming) find evidence of life insurers reaching for yield before the crisis in the sense of choosing riskier fixed income securities within regulatory asset classes. However, they find the phenomenon *diminished* following the financial crisis.

mortgage-backed securities or directly held mortgages, and nearly half in corporate securities. These assets lost value during the 2008-09 crisis, rendering some life insurers nearly insolvent. Also, before the crisis many life insurers had sold variable annuities with minimum return guarantees, on which they would need to make good if the stock market did not recover sufficiently. As a result, the positive general equilibrium effects of Federal Reserve policy on asset prices may have *benefited* life insurers' equity values and *reduced* the likelihood of insolvency.

Before presenting the event study results, it helps to view the broader time series of CDS spreads, the most direct measure of riskiness. Figure 2 plots the spreads for the six insurance companies with large life insurance components and publicly-traded CDS.¹⁴ These time series cannot establish the causal effect of monetary policy, because they do not control for the many other policy and market events taking place during the period. However, they do provide context for the event studies as well as helping to assess whether the post-2009 environment *cum* unconventional monetary policy has resulted in an unusual concentration of risk.

Figure 2: Insurance company CDS



As noted, insurance companies faced significant financial challenges during the 2008-09 crisis. A contemporary account put their estimated losses from assets related to subprime at greater than

¹⁴These data come from Markit end of day quotes. The Bloomberg generic quotes used to construct the quasi-intraday windows lack data for Aflac (ticker: AFL) and Hartford Financial Services (ticker: HIG).

\$180 billion (Harrington and Frye, 2009), resulting in a series of downgrades by rating agencies. Kojien and Yogo (2013) report that many life insurers sold policies at deep discounts during the period to exploit an accounting loophole and avoid further downgrades. The spikes in the CDS spreads in early 2009 reflect this distress. The annual premium required for a payoff of \$10 million in the event of a default by Lincoln Financial (ticker: LNC) reached the equivalent of \$3 million per year, while CDS on MetLife (ticker: MET), Prudential (ticker: PRU) and Hartford Financial (ticker: HIG) all had premiums go as high as \$1 million per year.¹⁵ Spreads began to decline in March and April of 2009, roughly coincident with the stabilization of financial markets generally and the beginning of the recovery in asset prices. The timing thus appears consistent with general equilibrium effects of Federal Reserve policy during the winter of 2008-09 benefiting life insurers. As of the end of the sample, CDS spreads have returned to historically low levels.

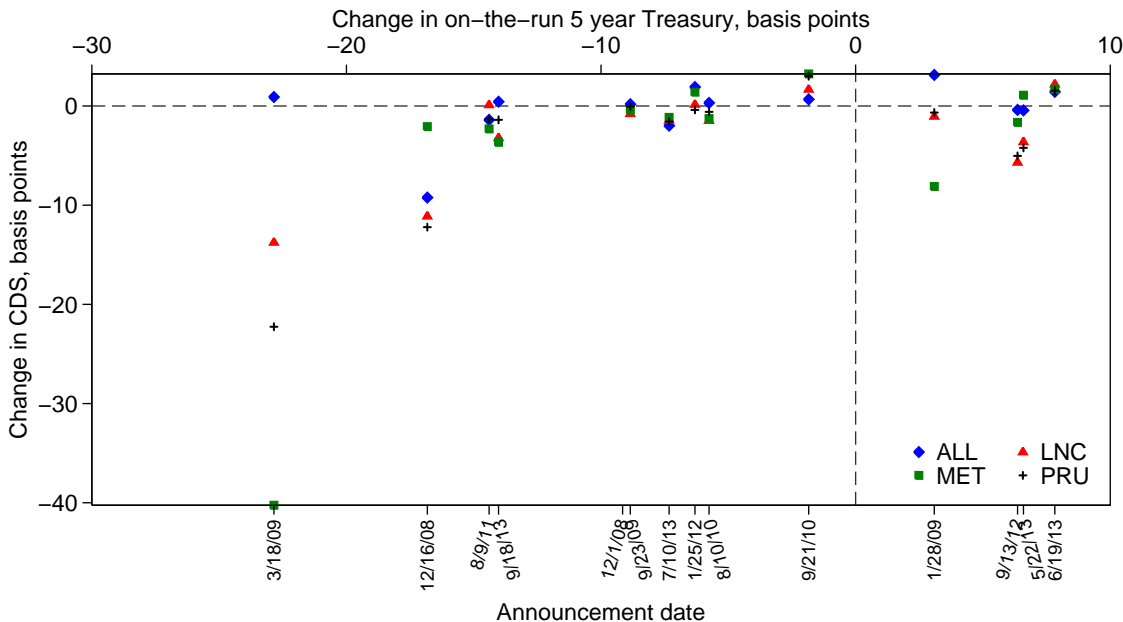
Turning to the event studies, figures 3 to 5 report the responses of CDS spreads, bond yields, and equity prices of life insurers to the monetary policy surprises. Each figure shows a scatterplot of the asset price change and the change in the five year Treasury, with the announcement date labeled on the lower horizontal axis. Table 2 reports the value-weighted mean for each announcement date. I use the sample average market capitalization as the weight for all three asset categories, and construct significance thresholds from the larger of the conventional or robust standard error in a firm-level regression of the change in the asset price on a constant on each date.¹⁶ Shaded rows in the table indicate contractionary surprises, defined as a positive response of the five-year Treasury yield during the announcement window. The table also reports the log change in the on-the-run North American IG CDX and the value-weighted mean stock price change of all companies in the S&P 500, excluding banks and life insurers.¹⁷ The comparison

¹⁵Because premium payments cease following a default event, especially distressed entities trade with an upfront payment along with fixed coupons. For example, on April 6, 2009, purchasing a five year contract for \$10 million of protection against Lincoln Financial required an upfront payment of \$4.85 million and annual coupon payments of \$500,000 thereafter. The spreads reported in figure 2 and the Bloomberg generic quotes reported below use the ISDA CDS standard model to amortize the upfront payment and report as if the only required payment were annual premiums.

¹⁶Some of the entries in table 2 have very few observations, in which case robust standard errors can have large upward bias (Angrist, Joshua and Jorn-Steffen Pischke, 2009). Unlike some previous studies, I do not use movements on non-event days in constructing the standard errors. Under the identifying assumption that no other aggregate shocks occur during the event window, the standard errors used here inform whether the monetary policy shock has a statistically significant systematic effect on the asset prices studied. The results in both tables 2 and 3 change little using an unweighted mean or median as the measure of central tendency.

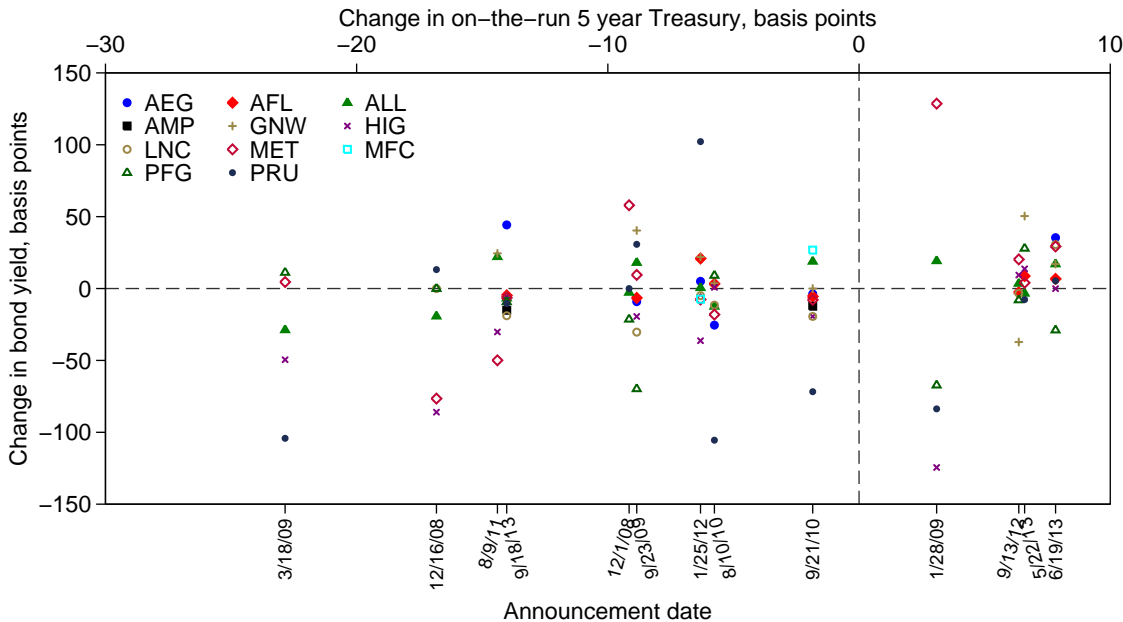
¹⁷The North American IG CDX, published by Markit, follows 125 North American single label investment grade

Figure 3: Insurance company CDS price response to unconventional monetary policy surprises



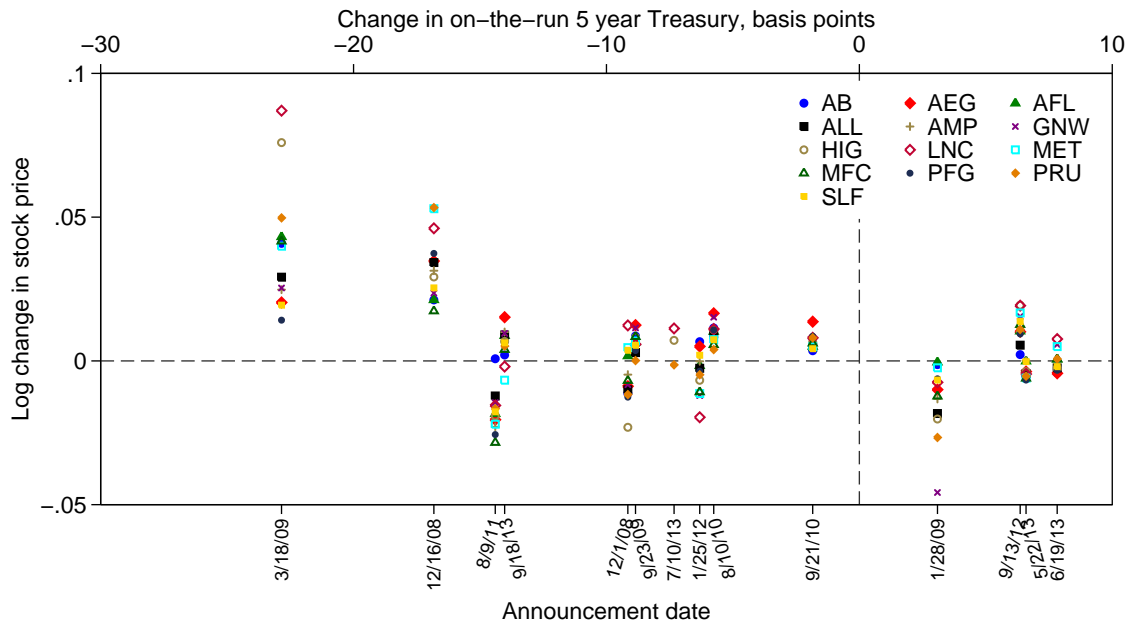
Notes: The change in CDS is the change in the 5 year spread, Tokyo close to London close (announcement before 12:15pm) or London close to New York close (announcement after 12:15pm), on the announcement date. The change in the on-the-run 5 year Treasury is the change in the yield to maturity from 2 minutes before to 18 minutes after the announcement.

Figure 4: Insurance company bond price response to unconventional monetary policy surprises



Notes: The change in bond yield is over the shortest window containing at least 2 minutes before to 18 minutes after the announcement. The change in the on-the-run 5 year Treasury is the change in the yield to maturity from 2 minutes before to 18 minutes after the announcement. To enhance readability, the figure omits: 12/1/2008 (HIG[+346]), 12/16/2008 (GNW[-232]), 1/28/2009 (GNW[-466]), 8/9/2011 (PRU[-308]), 9/13/2012 (PRU[-239]).

Figure 5: Insurance company stock price response to unconventional monetary policy surprises



Notes: The log change in stock price is from 2 minutes before to 18 minutes after the announcement. The change in the on-the-run 5 year Treasury is the change in the yield to maturity during the same window.

with nonfinancial firms helps qualitatively in distinguishing effects stemming from changes in the economy-wide price of risk from effects specific to the life insurance sector.

Consistent with strong general equilibrium effects, the introduction of near zero interest rates and quantitative easing in the winter of 2008-09 had a clear, beneficial impact on life insurers. Using the response of the five-year Treasury yield as a guide, the two most important announcements occurred on December 16, 2008, when the FOMC announced a 75 basis point reduction in the federal funds rate to a new target of 0-25 basis points, and on March 18, 2009, when it announced a balance sheet expansion of up to \$1.15 trillion. Summing over the changes in the two announcement windows gives a cumulative impact of 40 basis points on the five-year Treasury. From figure 5, every life insurer in the sample experienced an increase in its stock price during each announcement window, with a combined value-weighted change of 7.6 percent. In fact, equity prices of life insurers benefited far more from the announcements than did the average bank or the S&P 500 *ex* finance and insurance. The cost of insuring against default and bond yields

entities, chosen based on liquidity. The index “rolls” every six months, meaning on March 20 and September 20 of each year Markit launches a new index tracking CDS with a maturity date five years hence. The on-the-run CDX is the mostly recently launched index and the most liquid.

Table 2: Event study effects of unconditional monetary policy

	Treasury ^a	Life insurers			Bank holding companies			Market	
		CDS ^b	Bond ^c	Stock ^d	CDS ^b	Bond ^c	Stock ^d	CDX ^e	Stock ^f
12/1/08	-9.2		52.6	-0.4		18.1 ⁺	-0.6 ^{**}		-0.5 ^{**}
12/16/08	-16.8	-7.2	-42.9	3.6 ^{**}	-0.7	-9.1	2.2 ^{**}	-3.9	1.3 ^{**}
1/28/09	3.1	-3.1	-7.6	-1.2 ^{**}	-9.4 [*]	-0.9	-0.3	-0.4	-0.3 ^{**}
3/18/09	-22.8	-24.5 ⁺	-33.9	4.0 ^{**}	-2.6 [*]	-16.6	2.5 ^{**}	-3.7	1.5 ^{**}
9/23/09	-8.9	-0.2	3.3	0.6 ^{**}	0.2	-12.5	0.6 ^{**}	2.5	0.6 ^{**}
8/10/10	-5.8	-0.8	-25.1	0.8 ^{**}	-0.2 [*]	-1.5	0.9 ^{**}	-0.5	0.7 ^{**}
9/21/10	-1.8	2.5 [*]	-10.5	0.6 ^{**}	-0.2	-16.1	0.7 ^{**}	1.1	0.5 ^{**}
8/9/11	-14.4	-1.6 [*]	-98.8	-2.0 ^{**}	1.3	-5.5	-1.7 ^{**}	-2.8	-1.4 ^{**}
1/25/12	-6.3	0.9	15.4	-0.6 ^{**}	-1.1 [*]	-2.5	0.0	-2.3	0.3 ^{**}
9/13/12	6.4	-2.7 ⁺	-39.4	1.3 ^{**}	-4.1 ^{**}	-10.5	1.0 ^{**}	-7.0	0.5 ^{**}
5/22/13	6.6	-1.1	5.5	-0.4 ^{**}	-1.8 ^{**}	-5.5	-0.5 ^{**}	-2.8	-0.5 ^{**}
6/19/13	7.8	1.6 ^{**}	13.5 ⁺	0.1	2.9 ^{**}	-24.4	0.2 ^{**}	7.4	-0.2 ^{**}
7/10/13	-7.3	-1.5 ^{**}		0.3	0.4	-5.2		0.5	0.3 ^{**}
9/18/13	-14.0	-2.1	-8.0 ^{**}	0.4	-0.9	-33.5 ⁺	0.9 ^{**}	-5.7	1.0 ^{**}
Initial QE ^g	-39.7	-31.7 [*]	-72.8 [*]	7.6 ^{**}	-3.3 [*]	-25.0	4.5 ^{**}	-7.6	2.9 ^{**}
Taper ^h	14.4	0.5	18.6 [*]	-0.3 ^{**}	0.8	-28.7	-0.4 ^{**}	4.6	-0.6 ^{**}
Sample end ⁱ	-21.4	-3.6 [*]	-8.0 ^{**}	0.4	-0.5	-37.0 [*]	0.9 ^{**}	-5.2	1.2

Notes: +, *, ** indicate significance at the 0.1, 0.05, 0.01 levels, respectively, based on the larger of the conventional or robust standard error from a regression of the change in the asset price on a constant on the date indicated.

a. Change in the on-the-run five year Treasury note during announcement window covering two minutes before to eighteen minutes after announcement, basis points.

b. Value-weighted mean change in the CDS spread, Tokyo close to London close (announcement before 12:15pm) or London close to New York close (announcement after 12:15pm), 5 year tenor, basis points.

c. Value-weighted mean change in the bond yield during announcement window covering at least two minutes before to eighteen minutes after announcement, basis points.

d. Value-weighted mean change in the log stock price during announcement window covering two minutes before to eighteen minutes after announcement, log points.

e. Log change in the on-the-run North American IG CDX index, Tokyo close to London close (announcement before 12:15pm) or London close to New York close (announcement after 12:15pm). Significance thresholds not computed.

f. Value-weighted mean change in the log stock price of companies in the S&P 500, excluding life insurers and bank holding companies, during announcement window covering two minutes before to eighteen minutes after announcement, log points.

g. 12/16/2008 and 3/18/2009. Totals may differ due to rounding or sample composition.

h. 5/22/2013 and 6/19/2013. Totals may differ due to rounding or sample composition.

i. 7/10/2013 and 9/18/2013. Totals may differ due to rounding or sample composition.

also fell. The value-weighted 5 year CDS spread fell 32 basis points over both announcements.

The bond yield fell a total of 73 basis points, suggesting a decline in the risk premium.¹⁸

The general equilibrium effects on life insurers' legacy assets appear to have unfolded in line

¹⁸The maturity of bonds in the sample may differ from the five-year maturity of Treasuries. On a value-weighted basis, the median remaining time to maturity of life insurer bonds in the sample is 5.8 years.

with the market's expectation. For example, MetLife's 2010 annual report begins its discussion of financial condition and result of operations: "As the U.S. and global financial markets continue to recover, we have experienced a significant improvement in net investment income and favorable changes in net investment and net derivative gains (MetLife, Inc., 2010, p. 6)." The report goes on to attribute the investment gain to a "decrease in impairments and a decrease in the provision for credit losses on mortgage loans." The improvement in legacy assets accounted for fully half of the increase in pre-tax operating income MetLife experienced in 2010.

Subsequent announcements concerning unconventional policy had a more muted effect. To help quantify the difference, table 3 reports regressions of the value-weighted mean asset price response on the change in the 5 year Treasury, allowing for separate slope coefficients during winter 2008-09 and thereafter. The coefficients are signed such that a contractionary surprise corresponds to a positive realization of the right hand side variable. As foreshadowed by the previous discussion, during winter 2008-09 a 10 basis point expansionary surprise results in an 8 basis point decline in both the CDS and the bond yield, and a stock price decline of 1.7 log points, with both the CDS change and the stock price change highly statistically significant. In contrast, the CDS and stock price coefficients for announcements after winter 2008-09 fall to essentially zero, and none of the asset prices exhibits a response statistically distinguishable from zero. To be sure, these regressions have only a handful of observations, and it is possible market participants had greater difficulty interpreting later announcements during the narrow windows.¹⁹ Indeed, table 2 shows many later individual announcements still had significant, if small, effects.

The announcement surprises in 2013 merit special mention. If market participants underwent a learning process of the effects of unconventional policy on financial institutions, these dates should reflect the maturation of that process and hence contain more precise signals of the actual effect of the policies. As well, during the spring of 2013 financial markets shifted their beliefs toward an earlier taper of the Federal Reserve's most recent round of asset purchases. The

¹⁹The post period includes two dates where the immediate response of the S&P 500 differed from that of the five-year Treasury yield. The first occurred on August 9, 2011, when the FOMC introduced calendar-based forward guidance. While Treasury yields fell immediately, the S&P 500 initially fell as well before reversing and ending the day higher. The opposite occurred on September 13, 2012, with the introduction of a new round of QE. While the S&P 500 rose immediately, Treasury yields also rose during the announcement window only to reverse the increase by the end of the day.

Table 3: Value-weighted mean price response regressions

	Life insurers			Bank holding companies		
	Dependent variable: change in					
	CDS	Bond	Stock	CDS	Bond	Stock
	(1)	(2)	(3)	(4)	(5)	(6)
Right hand side variable:						
10 b.p. Δ Treasury X winter 2008-09	7.90** (1.36)	7.65 (13.87)	-1.68** (0.38)	-0.21 (1.21)	-0.34 (4.85)	-0.91* (0.35)
10 b.p. Δ Treasury X post winter 2008-09	0.26 (1.43)	17.93 (14.98)	0.28 (0.41)	-1.04 (1.26)	1.75 (5.18)	0.11 (0.38)
P value of coefficient equality	0.00	0.60	0.00	0.62	0.75	0.06
R^2	0.77	0.14	0.66	0.06	0.01	0.42
Observations	13	13	14	13	14	13

Notes: The dependent variable is the value-weighted mean change in the log stock price during announcement window covering two minutes before to eighteen minutes after announcement, in log points, the value-weighted mean change in the CDS spread, Tokyo close to London close (announcement before 12:15pm) or London close to New York close (announcement after 12:15pm), 5 year tenor, in basis points, or the value-weighted mean change in the log bond price during announcement window covering at least two minutes before to eighteen minutes after announcement, in log points, as indicated by the table header. The variable 10 b.p. Δ Treasury is the change in the yield to maturity of the on-the-run 5 year Treasury from 2 minutes before to 18 minutes after the announcement, in 10 basis point increments. Winter 2008-09 includes all announcements in December 2008-March 2009. Standard errors in parentheses. +, *, ** indicate significance at the 0.1, 0.05, 0.01 levels respectively.

response to the contractionary policy surprises contained in Chairman Bernanke's congressional testimony in May and in the FOMC statement in June of 2013 thus provide information on the symmetry of the market's response.

Beginning with the taper surprises, the Treasury yield rose a combined 14.4 basis points during the two announcement windows.²⁰ CDS spreads rose a statistically insignificant 0.5 basis point over the two dates, while bond yields rose a statistically significant 19 basis points and stock prices fell 0.3 log point.

I identify two expansionary policy surprises from the summer of 2013, a speech by Chairman Bernanke at the NBER and the September FOMC statement. Summing over the two events gives a decline in the five-year Treasury of 21 basis points. The value-weighted mean CDS spread of life insurers declined on both dates. Of the ten life insurers with bond transactions surrounding

²⁰The 5 year Treasury constant maturity yield rose by 95 basis points between May 1 and July 5, 2013. However, much of the movement came in response to stronger than expected economic data releases rather than to policy announcements. For example, the yield rose 21 basis points on July 5 following the release of the June employment report by the Bureau of Labor Statistics on that date.

the September FOMC statement, nine experienced a decline in their yield, with a value-weighted mean decline of 8 basis points.²¹ The mean stock price rose on both dates. Expansionary policy continued to benefit life insurers in 2013.

To summarize, the event studies appear consistent with general equilibrium effects strong enough to generate a positive effect of unconventional monetary policy on life insurers. Many life insurers faced solvency concerns in early 2009, and the expansionary policy in the winter of 2008-09 appears to have had a substantial beneficial effect. This conclusion bears resemblance to previous work finding that lower grade corporate bond prices reacted positively to the initial round of QE due to a decline in default risk (Krishnamurthy and Vissing-Jorgensen, 2011), and that unconventional policy lowered downside tail risk in a broad class of asset prices (Hattori et al., 2013; Roache and Rousset, 2013). Subsequent policy announcements had smaller or neutral effects. Even in late 2013, however, market participants continued to view expansionary monetary policy as beneficial to life insurers.

3.2. Bank holding company results

The regulated banking sector remains at the core of the financial system in the United States. It also contains nearly all of the U.S. institutions that have received the systemically important financial institution designation. Bank holding companies stood to benefit from the general equilibrium effects of unconventional monetary policy on loan repayment and recovery rates, as well as on the price of legacy securities on their balance sheets. Discussed already, a decline in the safe interest rate may also lead to higher leverage.

Figure 6 plots CDS spreads for the eight bank holding companies. Spreads rose sharply during the crisis, and again in late 2011 amid concerns over the U.S. debt ceiling and sovereign defaults in Europe. Like life insurers, at the end of 2013 spreads had returned to pre-crisis levels.

Figures 7 to 9 present scatterplots of the event study results for bank holding companies. Bank holding companies also benefited from the introduction of unconventional monetary policy. Summing over the December 16, 2008 and March 18, 2009 announcements, seven of the eight

²¹I do not have bond yield observations for the NBER speech because the speech took place after normal trading hours.

Figure 6: Bank CDS

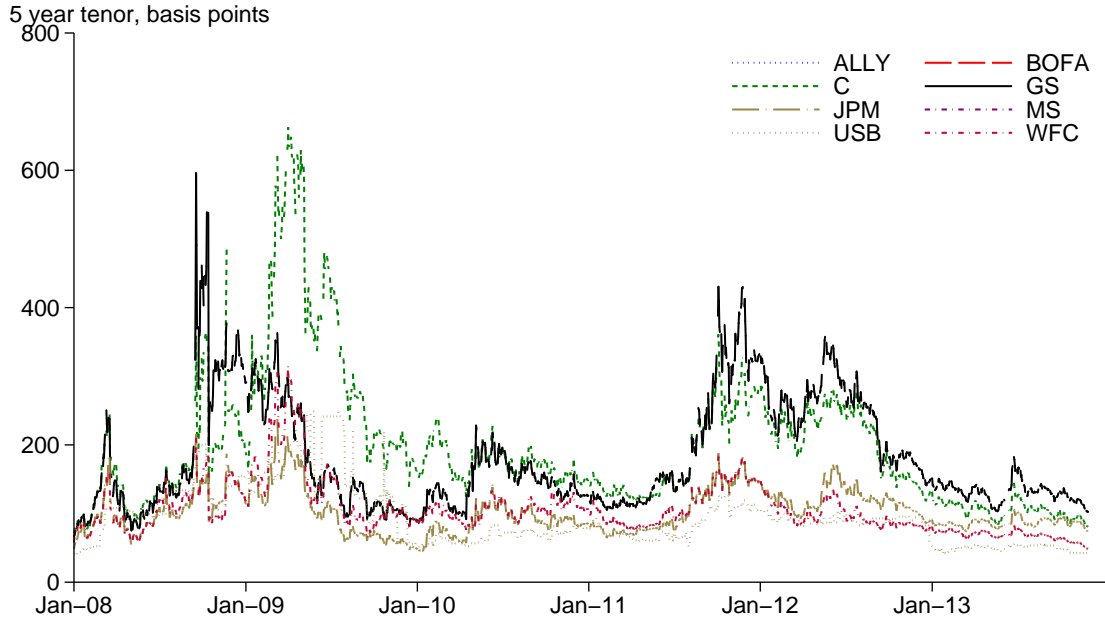
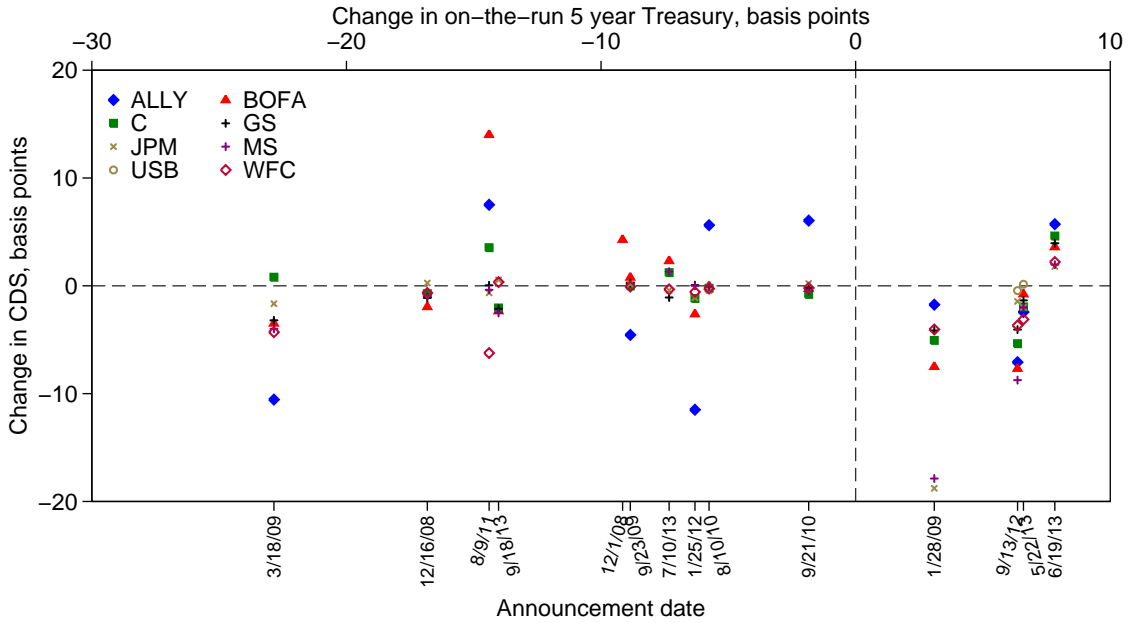
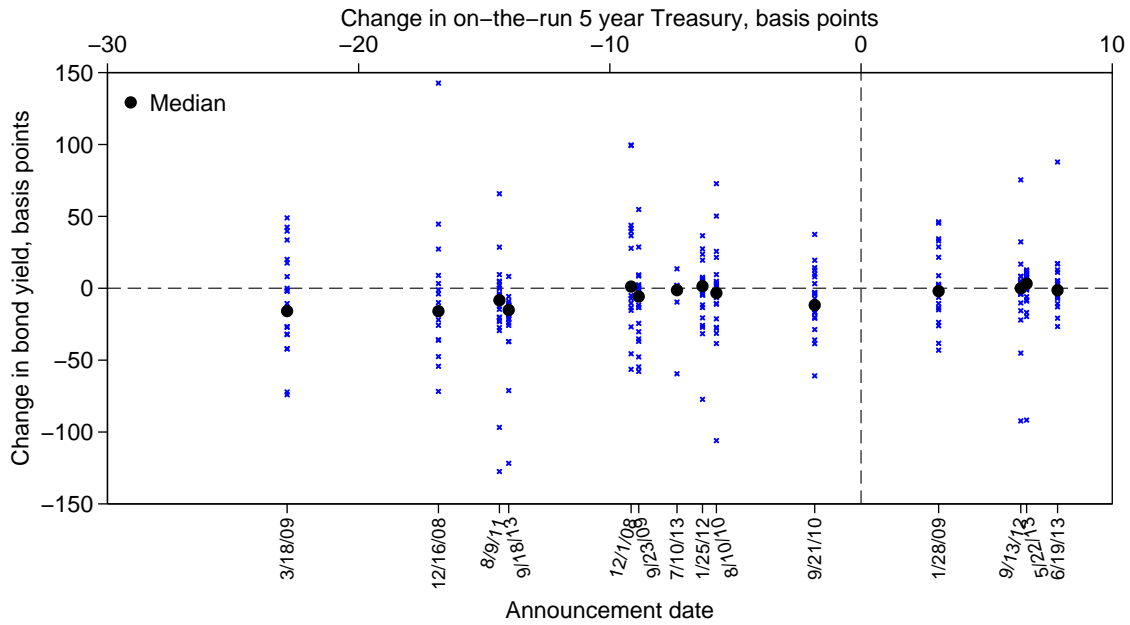


Figure 7: Bank CDS price response to unconventional monetary policy surprises



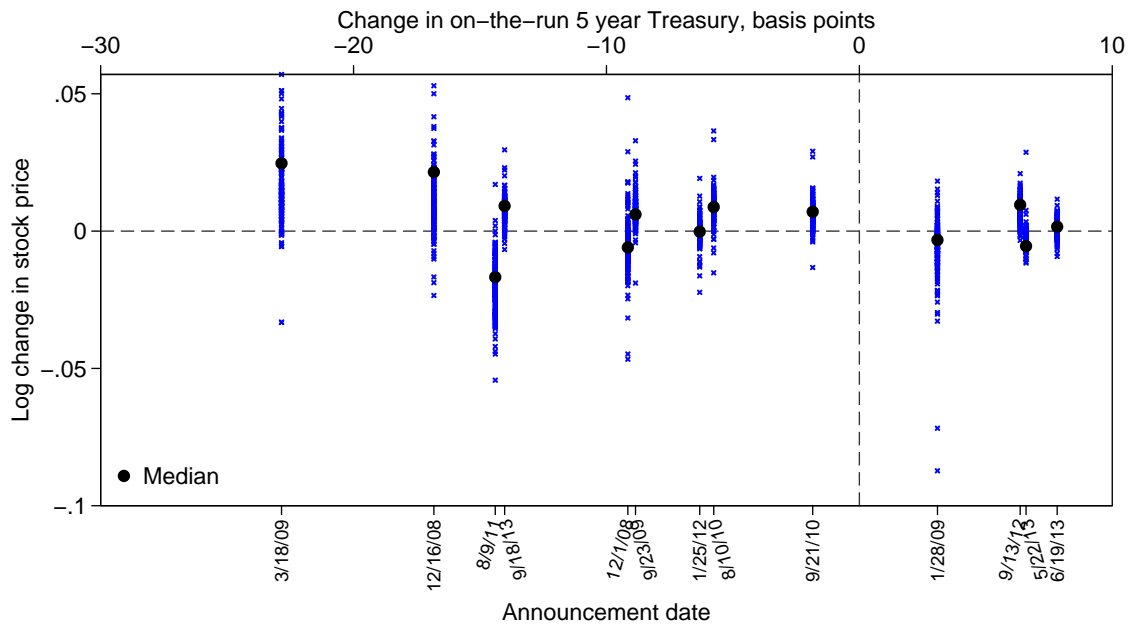
Notes: The change in CDS is the change in the 5 year spread, Tokyo close to London close (announcement before 12:15pm) or London close to New York close (announcement after 12:15pm), on the announcement date. The change in the on-the-run 5 year Treasury is the change in the yield to maturity from 2 minutes before to 18 minutes after the announcement.

Figure 8: Bank bond price response to unconventional monetary policy surprises



Notes: The change in bond yield is over the shortest window containing at least 2 minutes before to 18 minutes after the announcement. The change in the on-the-run 5 year Treasury is the change in the yield to maturity from 2 minutes before to 18 minutes after the announcement. To enhance readability, the figure omits: 12/1/2008 (CIT[+168]), 12/16/2008 (CIT[-370], BOP[+688]), 1/28/2009 (CIT[-279], COF[-210]), 3/18/2009 (CIT[-576], COF[-300]), 9/21/2010 (BK[-326]), 5/22/2013 (ASBC[+307]), 6/19/2013 (BAC[-203], TRV[+171]).

Figure 9: Bank stock price response to unconventional monetary policy surprises



Notes: The log change in stock price is from 2 minutes before to 18 minutes after the announcement. The change in the on-the-run 5 year Treasury is the change in the yield to maturity during the same window.

banks in the CDS sample (all except Citigroup [ticker: C]) experienced a decline in their CDS spread.²² The value-weighted stock price increase of 4.5 log points exceeded that of the average nonfinancial firm in the S&P 500. The average bond yield fell 25 basis points.

Once again, subsequent announcements had smaller effects on banks. Like life insurers, the sign of the response remains unchanged even in 2013. Unconventional monetary policy does not appear to raise concerns about the health or riskiness of regulated banks.

3.3. Window length robustness

The main analysis uses 30 minute windows to measure the response of equity and bond prices to unconventional monetary policy announcements. As stated above, the short window helps to ensure other aggregate shocks do not contaminate the analysis. However, it also assumes markets can rapidly process the effects of the monetary policy announcements on diverse institutions.

Table 4 tests whether the positive responses of life insurers and banks to expansionary surprises, and the relatively large response of life insurers to QE1, survive a longer window length. The table reports loadings of the stock prices of life insurers and banks on an index of nonfinancial firms following announcements. Why examine the loading on nonfinancial firms? From appendix figure C.1, Treasury prices incorporate the monetary policy surprises extremely rapidly. The concern of a short window thus applies to whether stock prices react as quickly as Treasury prices, and in particular whether it takes additional time to differentiate effects on certain sectors such as life insurers or banks. Of course, a longer window amplifies the concern of other news shocks contaminating the results. Conditioning on the stock prices of nonfinancial firms provides one way of controlling for other aggregate shocks as the window length increases. It also gives a direct metric of whether equities of life insurers and banks react in the same direction as the broader market, and whether the response of life insurers exceeds that of the broader market.

To construct the loadings, I generate minute-by-minute equity indexes of the value-weighted life insurance, banking, and nonfinancial sectors. The samples mirror those used previously; in

²²This result contrasts somewhat with the small effects on banks' CDS found in Gilchrist and Zakrajsek (2013). The quasi-intraday windows may explain the difference. Using the quasi-intraday spread, table 2 shows a statistically significant decline of 3.3 basis points in response to the announcements on December 16, 2008 and March 18, 2009. Using the end of day spreads reported by Markit instead gives a statistically significant *increase* of 5.3 basis points on the two announcement days.

particular, the nonfinancial sector contains all firms in the S&P 500 less those in insurance or banking. I then compute the log change in each index over non-overlapping five minute periods, beginning with the five minute period ending at the time of the announcement. The sample continues on each date for the shorter of two hours or until the end of the trading day at 4pm eastern.²³ Finally, I report regressions of the log change in the life insurer or bank index on the log change in the nonfinancial index, allowing the coefficients to vary by monetary policy round (QE1, QE2, QE3, or forward guidance). The estimated coefficients have the interpretation of CAPM β s, with the important caveat that I have removed any mechanical correlation by restricting the market index to exclude banks and insurers.

Columns 1 and 3 report the loadings. I cluster standard errors using 30 minute interval bins. Similar to the analysis above, even at five minute intervals stock prices of both life insurers and banks closely track nonfinancial firms following monetary policy announcements. The estimated β for life insurers during QE1 reaches nearly 2, confirming a stronger reaction of life insurers' stock prices during that period relative to the market. The life insurer β falls to 1.19 during QE3, but again indicates stock prices of life insurers reacted in the same direction as the broader market even in 2013. Not shown, these β s roughly track the pattern of life insurer β s on non-announcement dates as well.

Columns 2 and 4 add separate coefficients for intervals beyond the initial 30 minute window (> 30 min.) following the announcement. If markets required additional time on each date to realize monetary policy should have an opposite effect on life insurers from the broader market, then the coefficients on the market change interacted with > 30 min. should enter with a negative sign. More generally, these coefficients test whether the comovement between life insurers or banks and the broader market during the initial 30 minute window persisted thereafter, or whether instead investors began to differentiate these sectors as they had additional time to process the information content of the announcement.

I find no evidence of differential effects as the window lengthens. None of the > 30 min. coefficients achieves statistical significance, all are small in magnitude relative to the main coefficients,

²³The sample excludes the July 10, 2013 announcement, which occurred after 4pm. For 9 of the 13 other announcements, the 4pm deadline binds.

Table 4: Loadings on nonfinancial firms following monetary policy announcements

	Dependent var.: log change in stock price index of			
	Life insurers		Banks	
	(1)	(2)	(3)	(4)
Explanatory variables:				
$\Delta \log(\text{nonfinancial firms}) \times \text{QE1}$	1.96** (0.27)	1.86** (0.20)	1.07** (0.066)	1.02** (0.097)
$\Delta \log(\text{nonfinancial firms}) \times \text{QE2}$	1.29** (0.068)	1.31** (0.067)	1.08** (0.075)	1.04** (0.091)
$\Delta \log(\text{nonfinancial firms}) \times \text{QE3}$	1.19** (0.10)	1.15** (0.12)	0.76** (0.047)	0.78** (0.055)
$\Delta \log(\text{nonfinancial firms}) \times \text{FG}$	1.39** (0.091)	1.38** (0.079)	1.36** (0.21)	1.27** (0.17)
$\Delta \log(\text{nonfin. firms}) \times \text{QE1} \times > 30 \text{ min.}$		0.31 (0.37)		0.13 (0.19)
$\Delta \log(\text{nonfin. firms}) \times \text{QE2} \times > 30 \text{ min.}$		-0.094 (0.14)		0.19 (0.15)
$\Delta \log(\text{nonfin. firms}) \times \text{QE3} \times > 30 \text{ min.}$		0.20 (0.15)		-0.087 (0.089)
$\Delta \log(\text{nonfin. firms}) \times \text{FG} \times > 30 \text{ min.}$		0.065 (0.19)		0.39 (0.40)
R^2	0.763	0.766	0.705	0.711
Half hour clusters	65	65	65	65
Observations	325	325	325	325

Notes: The dependent variable is the 5 minute log change in the value-weighted stock price index of the sector indicated in the table heading. The right hand side variables are the 5 minute log change of a value-weighted index of all companies in the S&P 500, excluding those in banking or insurance, interacted with QE or forward guidance round, and possibly with whether the 5 minute window occurs more than 30 minutes after the policy announcement, as indicated. The sample begins on each date at the time of the announcement and continues in non-overlapping 5 minute intervals for the shorter of two hours or until the end of the trading day at 4pm ET. Standard errors in parentheses and clustered by half hour interval. +, *, ** indicate significance at the 0.1, 0.05, 0.01 levels, respectively.

and including them has minor effect on the main coefficients. The time profile of the reaction of life insurers and banks appears similar to that of the broader stock market.²⁴ Robustness to longer window length should not surprise in light of the CDS spread results reported in the

²⁴Repeating the analysis of equity prices in table 2 using a two hour window also gives qualitatively similar results (not shown). The winter 2008-09 announcements continue to have large positive effects. The most important difference comes in response to the September 18, 2013 announcement. Stock prices of a few of the largest insurers, including Prudential, MetLife, and Lincoln National, rose immediately following the FOMC statement, but began to fall about thirty minutes later. Also around that time, news leaked to the press of a regulatory vote the following day on designating Prudential a systemically important institution, a development with potential implications for the other large life insurers as well. This again serves to highlight the usefulness of short windows.

previous sections. In most cases the quasi-intraday window for the CDS spread already went to the market close, so any reversal in perception would have resulted in changes in CDS spreads inconsistent with the equity changes using the shorter window.

4. Money market funds

Money market funds provide liquidity services to institutional and retail clients. The interaction of three features of money market funds in the United States makes them a potential concern for financial stability at low nominal interest rates. First, money market funds maintain a stable net asset value of one dollar per share. They do so by valuing assets at amortized cost and providing daily dividends as securities progress toward their maturity date.²⁵ Investors can redeem shares at the par net asset value even if the shadow market value has fallen below. This feature makes funds subject to runs.²⁶ Second, SEC rule 2a-7 imposes duration, risk, and concentration limits on a fund’s asset holdings. Funds choose investments subject to these limitations. Third, money market funds charge fees, also called expense ratios, typically on a pro rata basis. The expense ratios do not affect the net asset value calculation, which depends solely on the amortized value of the fund’s security holdings. However, they do affect a fund’s total net return.

In normal conditions, the spread between the return on funds’ assets and the interest rate on checking accounts easily accommodates the expense ratios. When nominal interest rates approach zero, however, the gross yield on funds’ assets may fall short of their normal charged

²⁵An example, adapted from Investment Company Institute (2011), helps to clarify. Treasury bills sell as discount securities, meaning a 91 day Tbill with a face value of \$100 and an interest rate of 1.2% will pay no coupons and sell at auction for $\$99.70 = \$100(1 - 0.012)^{\frac{1}{4}}$. A money market fund that acquired the security on the auction date would book the security at \$99.70. Under straight line amortization, on each day until maturity the booked value of the security would rise by $\frac{\$100 - \$99.70}{91} = \$0.0033$. The fund would balance the increase in the value of its assets by increasing its daily dividend by the same \$0.0033, thereby maintaining the stable net asset value of \$1 dollar per share.

²⁶The so-called “penny rounding rule” requires a fund’s board of directors to consider repricing the fund’s shares (“break the buck”) if the shadow market value falls 0.5% below the par net asset value. Funds must calculate their shadow market value on a periodic basis, with the interval determined by the board of directors. Thus the shadow price can fall well below 0.995 before the fund suspends redemptions at the par value. Furthermore, many of the assets held by funds, especially prime funds, do not have liquid secondary markets. If the fund must sell assets to satisfy redemptions, the market value may fall further as fire sale prices generate additional capital losses. See Securities and Exchange Commission (2013, pp. 14-19) for further discussion of the mechanics of a run on a money market fund.

expenses. An after-fee return below zero would prompt investors to move into hard currency or bank deposit accounts that do not charge fees. A fund’s sponsor can suspend the fees, implying an operational loss to the sponsor of keeping the fund open. Alternatively, funds may seek higher yield investments within the allowed asset classes – reach for yield – to avoid having to waive fees. If the additional risk causes some of a fund’s securities to lose even a small amount of value, the fund may have to “break the buck,” causing a broad run on money market funds similar to what ensued following the Reserve Primary Fund’s breaking the buck in September 2008.²⁷ Importantly, a single fund will not internalize the social costs of a broad run in the event its additional risk exposure causes its assets to lose value.

I begin by describing how money market funds have adjusted their fees. Data on asset holdings, yields, and administrative costs come from iMoneyNet. As shown in figure C.2, the coverage of these data matches that of the Financial Accounts of the United States. I follow Kacperczyk and Schnabl (2013) and aggregate asset holdings, yields, and expenses up to the fund level using share class asset shares as weights. Table 5 displays summary statistics for 2006 and 2013.

Figure 10 shows a scatterplot of incurred expenses (horizontal axis) and charged expenses (vertical axis). Incurred expenses are meant to reflect the cost of running the fund, including management fees and advertising, while charged expenses are the fees actually paid by investors. Data points below the 45 degree line indicate funds that have waived part of their fees. The red dots show the relationship in 2006. Most lie on the 45 degree line or slightly below. The data also indicate substantial dispersion in fees charged, with a mean of 0.54 and a standard deviation of 0.27 (table 5 top panel).²⁸ The blue triangles show the relationship in 2013, and almost all lie well below the 45 degree line. They also show a substantial decline and compression in fees charged in 2013, with the mean falling to 0.14 and standard deviation to 0.06. The bottom panel of table 5, labeled “7 day net compound yield”, sheds further light. The panel reports summary

²⁷McCabe (2010) and Kacperczyk and Schnabl (2013) study the behavior of prime money market funds between the onset of the subprime crisis and the Lehman Brothers bankruptcy. The subprime crisis sparked a revaluation of risk and an opening of yield differentials among eligible AAA securities. Some funds responded by investing in higher yield securities within the AAA class, prompting institutional investors to reallocate their investments to higher yield funds and further increasing the incentive for a fund to reach for yield. Beginning in August 2007, the Reserve Primary Fund offered a yield of roughly 20 basis points higher than competitor funds, in part by purchasing large quantities of Lehman Brothers commercial paper, generating large inflows into the fund until the Lehman bankruptcy forced it to break the buck (Kacperczyk and Schnabl, 2013, figure III).

²⁸See Christoffersen and Musto (2002) for discussion of the reasons for the dispersion in fees charged.

Table 5: Money market fund summary statistics

	Statistic					Obs.
	Mean	Std. dev.	P10	P50	P90	
Charged expense ratio, annual average						
2006	0.54	0.27	0.20	0.53	0.93	685
2013	0.14	0.06	0.07	0.13	0.22	469
Incurred expense ratio, annual average						
2006	0.65	0.33	0.27	0.62	1.03	685
2013	0.57	0.35	0.23	0.52	0.98	469
7 day gross simple yield, annual average						
2006	4.40	0.82	3.39	4.92	5.06	685
2013	0.16	0.06	0.09	0.14	0.25	469
7 day gross simple yield, standard deviation						
2006	0.33	0.12	0.23	0.35	0.39	685
2013	0.03	0.01	0.02	0.03	0.04	469
7 day net compound yield, annual average						
2006	3.94	0.90	2.73	4.30	4.90	685
2013	0.02	0.02	0.00	0.01	0.04	469

Notes: The table reports cross-sectional statistics, by year, of time-series properties at the fund level.

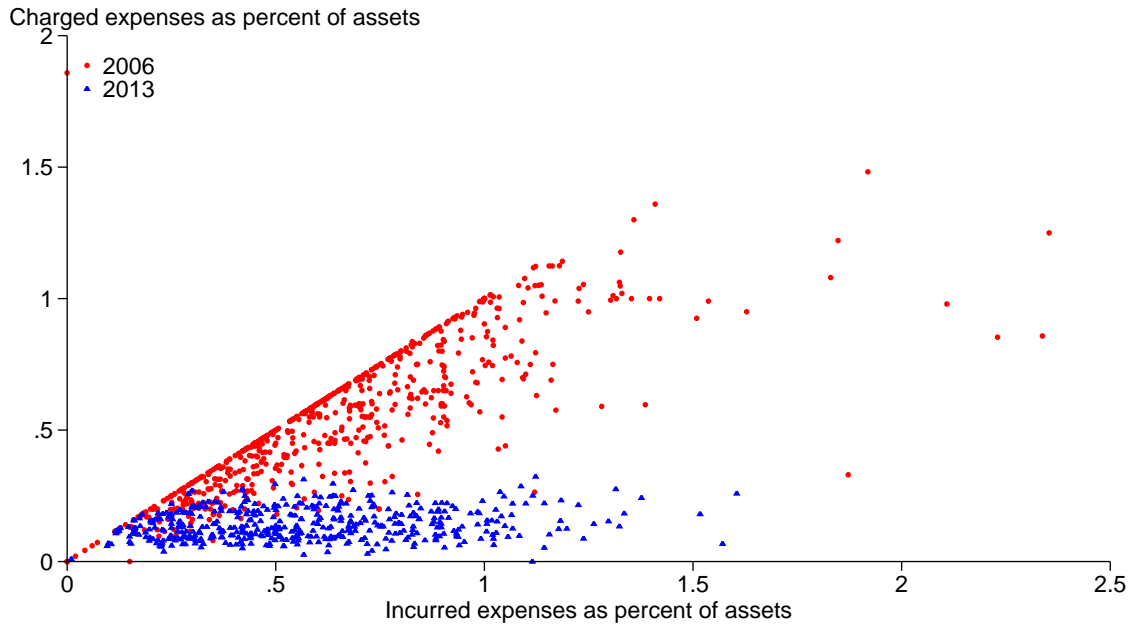
statistics for the average net (after-fee) yield, annualized, an investor would earn if she reinvested the dividends received each week. In 2013, the average yield was two basis points, with a median of 1 and a 90th percentile of 4 basis points.

The compression of net yields and ubiquity of fee waivers suggest funds responded to the low interest rate environment by waiving exactly enough of their fees to ensure their investors received a non-negative nominal return. I confirm this interpretation by estimating the following regression by fund share class and at a weekly frequency:

$$\text{Charged expenses}_{i,t} = \alpha_t + \beta_t [\text{Gross yield}_{i,t}] + \gamma_t [\text{Incurred expenses}_{i,t}] + e_{i,t}. \quad (5)$$

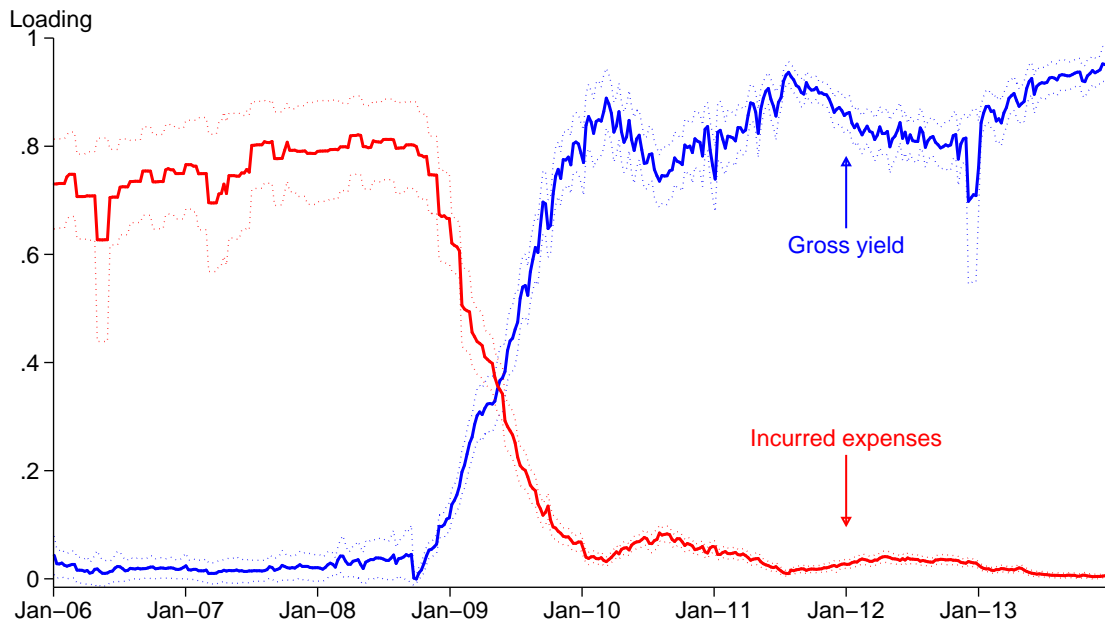
Equation (5) allows non-parametrically for time-varying loadings of charged expenses on the gross (before fee) yield (the $\{\beta_t\}$) and on the costs of running the fund (the $\{\gamma_t\}$). Inclusion of week

Figure 10: Money market fund expense ratios, 2006 and 2013



Notes: To enhance readability, the figure omits one 2013 fund with \$6 million under management, incurred expenses of 4.6 percent, and charged expenses of 0.04 percent.

Figure 11: Determinants of money market fund charged expenses



Notes: The solid lines plot the weekly coefficients from an OLS regression of charged expenses on week fixed effects, gross yield, and incurred expenses. Equation (5) provides the estimating equation. The dotted lines plot 95% confidence interval bands based on standard errors clustered by fund sponsor. The regression winsorizes observations with the smallest and largest 0.01 percent of incurred expenses.

fixed effects limits identification to coming from variation across funds in a given week.

Figure 11 reports the estimated $\{\beta_t\}$ in blue and $\{\gamma_t\}$ in red. Prior to late 2008, the marginal basis point of gross yield has essentially no effect on the charged fee. In contrast, a 10 basis point increase in incurred expenses corresponds to an increase of roughly 8 basis points in fees charged. The relationship reverses completely after gross yields fall to close to zero. Throughout 2010 to 2013, an additional 10 basis points in gross yield corresponds to 9 additional basis points in charged fees, while the marginal basis point of incurred expenses has no effect on charged fees.²⁹

The almost complete pass-through of higher gross returns to higher charged fees suggests funds' operators had cognizance of the cost of waiving fees and the potential to avoid such costs by generating higher gross returns – reaching for yield. I therefore test in the cross section of funds whether funds with higher structural administrative costs reached for yield.

I examine four measures of reaching for yield: the gross yield, the ex-post realized standard deviation of monthly excess returns, the share of holdings in foreign bank obligations net of repurchase agreements (repo), and the average asset maturity. The gross yield captures directly whether a fund has successfully reached for yield. The ex-post standard deviation measures risk. Figure 13 below shows foreign bank obligations to be the highest yield asset class during most of the unconventional monetary policy period, and repo the lowest. The average asset maturity provides a measure of reaching for yield through reaching for maturity.³⁰

I assume a data generating process for each measure of the form

$$y_{i,t} = \alpha_i + \delta_t + \beta_t [\text{Administrative costs}]_{i,t} + \gamma_t' x_i + e_{i,t}. \quad (6)$$

The identifying assumption is that funds with high and low management costs do not differ along other features that would make them respond differently to low nominal interest rates. The fund fixed effect α_i absorbs time-invariant unobserved fund characteristics such as managerial skill. The

²⁹I have also estimated a specification replacing the weekly fixed effects with fundXyear fixed effects, such that identification comes from variation within a single fund over the course of the year. I obtain coefficients of 0.86, 0.84, and 0.90 for the loadings on gross yield in 2011, 2012, and 2013, respectively, up from 0.00 in 2007. These loadings mirror almost exactly those shown in figure 11. Absence of within fund variation in incurred expenses, however, renders the loadings on incurred expenses very imprecisely estimated with the fund fixed effects.

³⁰Kacperczyk and Schnabl (2013) also use the gross yield and average maturity measures. I adapt their measure of risky asset holdings based on the asset class loadings during my sample period.

time effect δ_t controls for variation in the macroeconomic environment such as short term interest rates. For the two ex post measures of gross yield and standard deviation of returns, the vector x_i includes the observed fund characteristics of fund category (tax-free, prime, or U.S. government and agency securities and backed repo), whether the fund has any institutional shares, and 2005 portfolio allocation by asset class category. Because credit spreads vary during the sample period, a fund could obtain higher yield or more variable returns in certain periods without having changed its asset composition. The time-varying loadings in γ_t absorb fluctuations due to time invariant asset allocation into the control set, limiting reaching for yield to fluctuations resulting from an active decision on the part of the fund manager. Finally, because incurred expenses may proxy imperfectly for administrative costs and because funds may endogenously adjust incurred expenses in the low interest rate environment, I instrument for a fund's incurred expenses using the fund's 2005 incurred expenses.

Table 6 reports results using annual average data for a balanced panel of funds over 2006-2013. I cluster standard errors at the fund sponsor level, thus allowing for both arbitrary serial correlation and arbitrary correlation across funds with the same sponsor. The table reports the first stage F statistics for 2013 expenses, showing 2005 incurred expenses to be a strong instrument. Identification of the unobserved characteristics $\{\alpha_i\}$ requires imposing $\beta_t = 0$ for at least one year, and I set $\beta_{2006} = 0$. The near zero coefficients across specifications for β_t in the normal interest rate year of 2007 both justify this restriction and serve as a useful placebo check.

Table 6 provides evidence of money market funds reaching for yield in 2009-2011. However, the effects appear economically quite small. For example, the 2010 coefficient for the gross yield measure achieves statistical significance at the 1 percent level, but has the interpretation of a one percentage point (or roughly three standard deviation) increase in administrative costs resulting in an additional six basis points of annualized gross yield. Likewise, 2011 incurred expenses have a statistically strong effect on the standard deviation of returns, but a one percentage point increase in expenses still results in an increase of the standard deviation of just 1.8 basis points. Both the gross yield and standard deviation measures indicate a precise zero effect of incurred expenses on reaching for yield in 2013, the most recent data available. The asset allocation and maturity measures indicate no differences in allocations among funds with high and low costs.

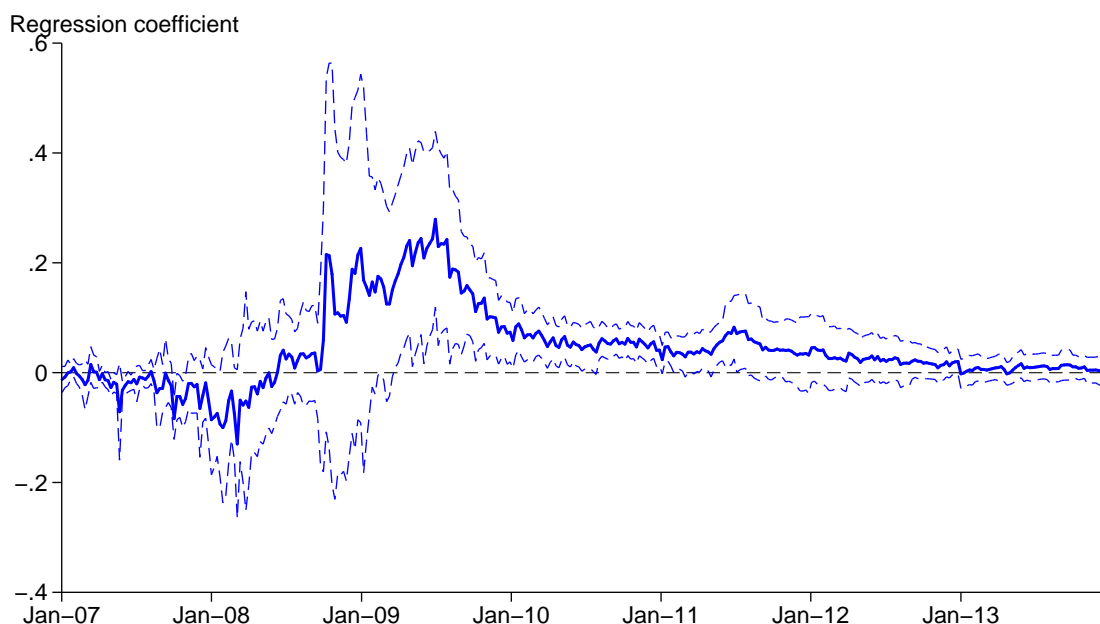
Table 6: Money market fund reaching for yield regressions

	Dependent variable:			
	Gross yield (1)	Std. dev. return (2)	Risky asset allocation (3)	Average maturity (4)
Right hand side variables:				
2007 incurred expenses (IV: 2005 value)	0.000 (0.011)	0.006 (0.011)	1.482 (2.302)	0.496 (1.471)
2008 incurred expenses (IV: 2005 value)	0.125 ⁺ (0.076)	0.060 (0.045)	0.630 (4.007)	-1.833 (2.067)
2009 incurred expenses (IV: 2005 value)	0.184* (0.078)	0.058 (0.041)	-0.725 (4.808)	-2.996 (2.535)
2010 incurred expenses (IV: 2005 value)	0.064** (0.016)	0.010 (0.007)	-0.744 (5.333)	-2.091 (2.106)
2011 incurred expenses (IV: 2005 value)	0.049* (0.024)	0.018** (0.005)	2.571 (7.387)	-1.549 (3.289)
2012 incurred expenses (IV: 2005 value)	0.029 (0.019)	0.011 (0.008)	5.952 (7.299)	-5.504 (4.024)
2013 incurred expenses (IV: 2005 value)	0.013 (0.012)	0.002 (0.005)	1.362 (7.504)	-4.455 (3.749)
Sample period	2006-13	2006-13	2006-13	2006-13
Fund FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Time-varying controls	Yes	Yes	No	No
2013 first stage F statistic	149.6	149.6	382.0	352.3
Unique funds	379	379	135	379
Fund sponsor clusters	76	76	65	76
Observations	3,032	3,032	1,080	3,032

Notes: The gross yield is the annual average of the weekly gross simple yield. The standard deviation is the annual standard deviation of the monthly excess return, defined as the gross return less the 1 month TBill. The risky asset allocation equals the asset share in foreign bank obligations less the share in repo, and for this regression the sample excludes non-Prime funds. The average maturity refers to the average of the maturity of a fund's securities, in days. The time-varying controls are categorical variables, interacted with year, for fund category (tax free, prime, or U.S. government and agency securities and backed repo), 2005 portfolio share by asset class, and for whether the fund has any institutional shares. Standard errors in parentheses and clustered by fund sponsor. +,*,** indicate significance at the 0.1, 0.05, 0.01 levels respectively.

Figure 12 further explores the timing of reaching for yield behavior. The figure plots the second stage coefficient on incurred expenses from a weekly regression with gross yield the dependent variable, the weekly incurred expenses instrumented using the 2005 values, a fund fixed effect identified from including observations from 2006, and the full set of time-varying controls described previously. Thus the specification corresponds to column 1 of table 6, but allowing the effect of

Figure 12: Loading of gross yield on incurred expenses, by week



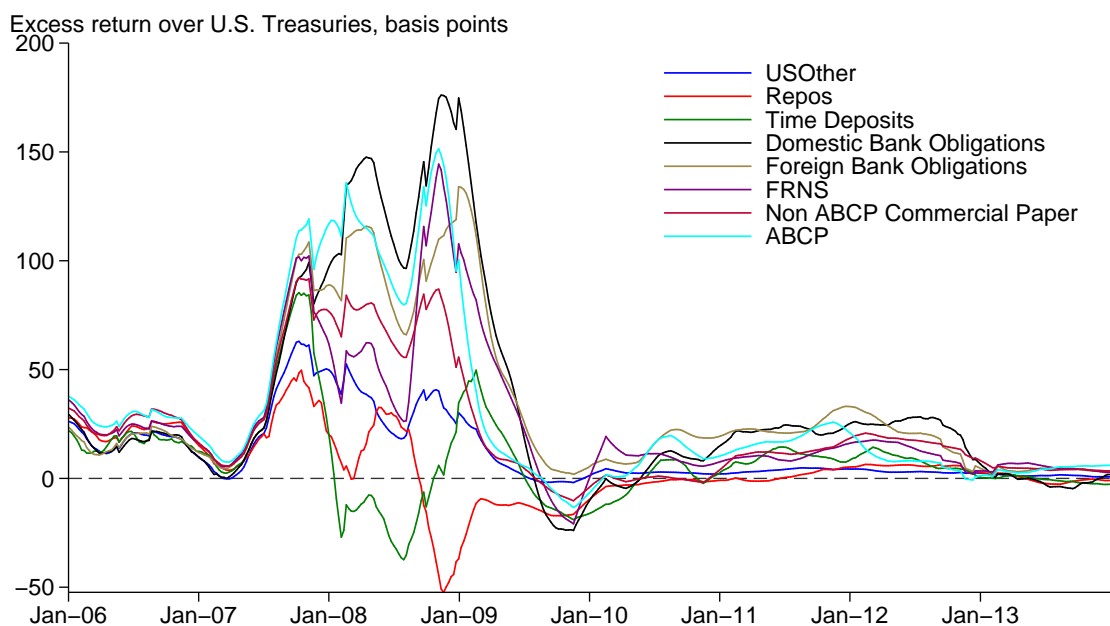
Notes: The solid line plots the coefficients from a weekly regression of gross yield on incurred expenses, with incurred expenses instrumented using their 2005 average value. The regression also contains fund fixed effects identified by including observations from 2006, and fund type and asset class holdings in 2005 interacted with week. Sample excludes fund-weeks with a gross yield of zero. The dotted lines plot 95% confidence interval bands based on standard errors clustered by fund sponsor.

administrative costs to vary at a weekly frequency. Consistent with the annual regressions, costs have a zero or even negative effect on gross yield until late 2008. The spike in the estimated coefficient occurs in the beginning of October 2008, the month in which the average yield on a one-month TBill first fell below 50 basis points. The reaching behavior remains statistically significant through the middle of 2011, and falls to a precise zero throughout 2013.

What explains the relative absence of reaching for yield compared to during the subprime crisis, and the apparent complete dissipation in 2013? Figure 13 displays 3-month centered moving averages of coefficients from a weekly regression of gross yield on the allocation to each asset class. As stressed by Kacperczyk and Schnabl (2013), the subprime crisis created large return differentials from investing in different asset classes. Many prime funds responded by concentrating holdings in higher yield classes. These differentials compressed substantially beginning in mid 2009, and by 2013 had reached historically low levels. Such small differentials provide little opportunity for prime funds to reach for yield through asset class allocation.³¹

³¹Of course, reaching for yield could return if spreads open up again, for example due to renewed sovereign risk

Figure 13: Money market fund yields by category



Notes: The figure plots the 3-month centered moving average of coefficients from a weekly regression of gross yield on the asset allocation in the categories shown. U.S. Treasuries are the omitted category, and the sample includes all taxable money market funds. The regression also includes a fund fixed effect allowed to vary by calendar year.

A second explanation of the 2012 and 2013 results stems from a set of reforms implemented by the SEC in mid-2010. These included reducing the allowable fraction of assets in illiquid securities, the weighted-average maturity of assets, the fraction of assets in second tier securities, and the concentration limit for securities issued by any single issuer. In distinguishing these explanations, the timing of the reaching for yield decline evident in figure 12, and in particular the absence of a series break in mid-2010 when the reforms came into effect, gives some reason to favor the spread compression explanation.

If the link between charged fees and gross yields has not produced much reaching for yield by money market funds, it does still have a potentially important implication for constraints on Federal Reserve policy. Even with the introduction of the extraordinary policy measures described above, the FOMC since 2009 has maintained a target federal funds rate of between 0 and 25 basis points and paid interest on excess reserves of 25 basis points. One justification for not reducing both of these rates to zero has centered on the risk of disruptive outflows from money market concerns in Europe. Even so, the first-best policy response should involve further reform of the money market sector to remove the threat of runs, rather than changing monetary policy.

funds forced into a negative after-fee return. Yet, funds already subsidize investors by waiving fees. Figure 11 suggests funds might respond to a further decline in gross yields by simply waiving fees completely, leaving investors with the same net yield of zero they currently receive.

Reductions of the federal funds rate and the interest on reserves to zero could prompt further consolidation of the money market industry. The fee waivers to date have already induced substantial exit, as seen both in the decline in the number of funds by year in table 5 and by the trillion dollar decline in total assets under management since early 2009 shown in figure C.2. Many of the remaining funds receive cross-subsidization from other lines of business of their sponsors, and some of these could exit if the required subsidization rises further. Nonetheless, further consolidation need not adversely affect financial stability or the transmission of monetary policy, as long as it continues to occur in an orderly fashion as it has done since 2009.

5. Pension funds

Private defined benefit pension funds manage roughly \$3 trillion in retirement assets. I start from two previously documented dimensions of heterogeneity in fund risk taking in normal conditions. First, funds reduce risk exposure as liability duration decreases (Lucas and Zeldes, 2006; Rauh, 2009). Second, funds with a higher fraction of unfunded liabilities engage in less risk taking, in opposition to a risk shifting hypothesis where underfunded plans “reach for solvency” because of limited liability in the event a pension shortfall pushes the plan into bankruptcy (Rauh, 2009).

I investigate whether fund behavior along these dimensions changes in the low interest rate environment. For example, having a short duration of liabilities in a period of low interest rates following a market downturn may lead to increased risk taking as these funds have less time to make up any funding shortfall. Similarly, low interest rates exacerbate a funding shortfall by making it harder to close the gap through higher returns, possibly leading to greater risk taking.

I collect data on private pension funds from the form 5500 reports funds file with the IRS. Plans with 100 or more participants must file a schedule H, containing a detailed asset and income statement, and a schedule B (or SB or MB after 2009) showing their funding status. Appendix A

Table 7: Defined benefit pension fund summary statistics

Year	S&P 500	Fund return		Expenses/Assets		Benefits NPV/Assets		Obs.
	return	Mean	St. dev.	Mean	St. dev.	Mean	St. dev.	
2006	13.6	11.2	2.6	0.06	0.03	1.13	0.22	4225
2007	3.5	7.2	2.5	0.06	0.03	1.1	0.22	4225
2008	-38.5	-22.1	7.3	0.06	0.03			4225
2009	23.5	18.3	6.1	0.08	0.04	1.16	0.18	4225
2010	12.8	11.6	2.8	0.07	0.03	1.19	0.16	4225
2011	0.0	1.7	3.9	0.06	0.03	1.24	0.17	4225
2012	13.4	11.3	2.9	0.07	0.04	1.09	0.16	4225

Notes: The table reports cross-sectional statistics, by year. Data for funding status in 2008 are not available from the Department of Labor.

contains further details of the sample construction and filters.

The first metric of risk taking uses the fund’s reported investment earnings to construct an annual return on assets, defined as total earnings on investments (including unrealized capital gains) divided by the sum of beginning of period assets plus one-half of net contributions. A second metric divides the sample into two periods, 2004-08 and 2009-12, and constructs the standard deviation of the fund’s return in each period. Table 7 reports summary statistics for a balanced panel of pension plans. Of note, the mean return tracks the return on the S&P 500 reasonably closely.³²

Equation (7) describes a difference-in-difference specification for estimating the effect of a pension plan measure on the ex post annual return:

$$r_{i,t} = \delta_t + \pi_t' Z_i + \gamma [r_{m,t}^e] [\text{Plan measure}]_{i,t} + \mathbb{I}\{t > 2006\} \gamma_t [r_{m,t}^e] [\text{Plan measure}]_{i,t} + e_{i,t}, \quad (7)$$

where $r_{i,t}$ denotes fund i ’s return in period t ; $r_{m,t}^e$ is the Fama-French excess return of the stock market over the risk free rate; and the vector of controls Z_i includes fund size and age. Equation (7) defines reaching for yield as a fund’s increasing its loading on the market excess return.³³

³²Rauh (2009) instead studies asset allocation using a subset of smaller plans which do not invest in Direct Filing Entities and for which asset allocation is available from the 5500 reports. The ex post return and standard deviation of return have the advantage of applying to all defined benefit plans.

³³From the Federal Reserve’s Financial Accounts of the United States (table L.117.b), in aggregate private defined benefit pension funds held between 50 and 70 percent of their assets in equities between 2005 and 2013. These plans held an additional 15 percent of their assets in the “safe asset” categories of deposits, money-market funds, repo, open market paper, treasury securities, and agency securities.

The coefficient γ gives the estimated loading per unit of the measure of plan status in 2006, and γ_t the additional loading in subsequent years.

Equation (8) describes a difference-in-difference specification of the ex post standard deviation of fund returns, over 2004-08 and 2009-12, and for funds with varying status as of the first year of the period (i.e. 2004 or 2009):

$$\sigma(r_{i,t}) = \delta_t^{sd} + \pi_t^{sd'} Z_i + \gamma^{sd} \sigma(r_{m,t}) [\text{Plan measure}]_{i,t} + \gamma_{09-12}^{sd} \sigma(r_{m,t}) [\text{Plan measure}]_{i,09} + \epsilon_{i,t}^{sd}. \quad (8)$$

The first plan measure is the ratio of a fund's benefit expenses in a given year to its total assets. This measure captures liability maturity horizon. In equation (7), $\gamma < 0$ if plans with a shorter duration of liabilities allocate to safer assets. $\gamma_{2007} - \gamma_{2012}$ then ask whether these plans allocated relatively less to safer assets in the low interest rate environment. The coefficient γ_{09}^{sd} in equation (8) gives the additional standard deviation of returns, scaled by the standard deviation of the market excess return, of funds with a shorter horizon in 2009.

The first two columns of table 8 report the results. The coefficients γ and γ^{sd} are both negative and highly statistically significant, consistent with the negative relationship between near-term liabilities and risk taking in Lucas and Zeldes (2006) and Rauh (2009). The coefficients γ_{2007} and γ_{2008} cannot reject a constant effect of liability duration before the low interest rate environment.

The regressions provide some evidence of reaching for yield beginning in 2009. The effect of liability duration on return falls by one-half to two-thirds in 2009 and 2010, and the differences relative to 2006 are statistically significant at the 1 and 5 percent levels, respectively. Similarly, the decline in the loading on the standard deviation of the market excess return falls by about two-thirds for 2009-12 relative to 2004-08. While statistically significant, these differences do not translate into particularly large economic effects. For example, the difference in the loading on the market excess return in 2005 and 2009 for a fund one standard deviation (0.04) above the mean of expenses/assets is $0.52 * 0.04 = 0.02$. This difference corresponds to an additional return of about 50 basis points on the 2009 excess return of 28 percent. The effect on return loading loses statistical significance in 2011 and 2012. The large standard error in 2011 reflects the near zero Fama-French excess return (0.44) in that year.

Table 8: Defined benefit pension fund reaching for yield regressions

	Plan measure:				
	Benefits / Assets		Benefits NPV / Assets		
	Dependent variable (p.p.):				
	$r_{i,t}$	$\sigma(r_{i,t})$	$r_{i,t}$	$\sigma(r_{i,t})$	$r_{i,t}$
	(1)	(2)	(3)	(4)	(5)
Right hand side variables:					
r_m^e X (Plan measure)	-0.67**		-0.13**		
	(0.12)		(0.03)		
2006 X r_m^e X (Plan measure)					-0.07*
					(0.03)
2007 X r_m^e X (Plan measure)	-0.32		-0.45 ⁺		0.63
	(1.14)		(0.27)		(0.55)
2008 X r_m^e X (Plan measure)	0.10				
	(0.14)				
2009 X r_m^e X (Plan measure)	0.52**		0.33**		0.14**
	(0.13)		(0.03)		(0.02)
2010 X r_m^e X (Plan measure)	0.32*		0.13**		0.04
	(0.14)		(0.03)		(0.03)
2011 X r_m^e X (Plan measure)	0.41		-6.38**		-5.32**
	(3.47)		(1.01)		(1.32)
2012 X r_m^e X (Plan measure)	0.08		0.07 ⁺		0.05 ⁺
	(0.17)		(0.04)		(0.03)
$\sigma(r_m^e)$ X (Plan measure)		-0.36**		0.01	
		(0.11)		(0.02)	
2009 X $\sigma(r_m^e)$ X (Plan measure)		0.24*		0.18**	
		(0.11)		(0.03)	
Year FE	Yes	Yes	Yes	Yes	Yes
Size, age controls	Yes	Yes	Yes	Yes	No
Fund FE	No	No	No	No	Yes
Fund-specific r_m^e loading	No	No	No	No	Yes
Unique funds	4,225	3,580	3,665	3,177	3,665
Fund sponsor clusters	3,719	3,186	3,177	2,806	3,177
Observations	29,575	7,160	21,990	6,353	21,990

Notes: The pension return $r_{i,t}$ is the annual earnings on investments divided by the sum of beginning of year assets plus one half net transfers and contributions. $\sigma(r_{i,t})$ is the standard deviation of the pension return over 2004-08 or 2009-12. r_m^e is the Fama-French stock market excess return. Benefits NPV/assets are not available for 2008, and in all years specifications including this variable remove multiemployer (MB) plans. If included, size (log assets) and age controls interacted with year. Observations with a distance to the median larger than five times the interquartile range are winsorized. Standard errors in parentheses and clustered by fund sponsor. +, *, ** indicate significance at the 0.1, 0.05, 0.01 levels respectively.

I next investigate the effects of plan solvency. Loosely, the Pension Protection Act of 2006 (PPA) requires pension plans to value their assets at market prices, but their liabilities using a combination of actuarial assumptions to predict future payments and market interest rates to discount those cash outflows back into current dollars.³⁴ Low interest rates contribute directly to underfunded status by lowering the discount rate used to discount future liabilities. The PPA also mandated that pension plans with funding shortfalls increase contributions sufficiently to amortize their unfunded liability over a seven year period. However, if a plan can realize a higher return on its assets than the rate used to discount liabilities, it can close the funding shortfall without requiring higher contributions. This creates a temptation to reach for yield. I measure funding shortfall as the ratio of the net present value of benefits to total assets.

Columns 3 and 4 of table 8 report results corresponding to equations (7) and (8) but for the plan solvency measure.³⁵ The difference-in-difference specification for the return standard deviation in column 4 indicates no effect of funding shortfall on return standard deviation during 2004-08, but a strong positive relationship in 2009-12, consistent with reaching for yield. Results for equation (7) are more mixed. I find a negative relationship between fund shortfall and reaching for yield in the pre-low interest rate year of 2006, as in Rauh (2009). Funding shortfall has a small positive effect on return in 2009, 2010, and 2012, but a large negative effect in 2011.

The specifications so far rely on a parallel trends assumption, namely that plans with differing liability horizons or solvency did not differ along other dimensions that would have caused their relative risk taking to change beginning in 2009. Column 5 of table 8 relaxes this assumption by exploiting the panel structure of the data. I assume the data generating process

³⁴Specifically, single employer plans must discount future liabilities using the two year average of the yield on investment grade corporate bonds, with separate maturities of bonds used for liabilities due in 0 to 5 years, 5 to 15 years, and longer than 15 years. A 2012 law temporarily changed the horizon for averaging yields to 25 years, resulting mechanically in improved funding status. Plans can smooth asset values over a two year period as long as the difference between the smoothed actuarial valuation and fair market value does not exceed ten percent of the plan's assets. Also of relevance, the PPA applies the penalty premium for contributions to the Pension Benefit Guaranty Corporation to any underfunded plan, and it created the category of "at risk" plans, containing plans in particularly poor funding status and subjecting them to additional required contributions. Together, these changes make level comparisons of funded status reported on the 5500 forms across years inappropriate. Inclusion of time fixed effects helps to solve this problem by absorbing statutory changes into the time effects.

³⁵Data for funding status in 2008 are not available. Data are missing in select other years for a few plans. Results remain essentially unchanged when restricting to a balanced panel of funds not missing data in any non-2008 year.

$$r_{i,t} = \alpha_i + \delta_t + \beta_i r_{m,t}^e + \gamma_t r_{m,t}^e [\text{Plan measure}]_{i,t-1} + \epsilon_{i,t}. \quad (9)$$

Under the null hypothesis $\gamma_t = 0 \forall t$, and if $\delta_t = r_t^{\text{risk free}}$, the process (9) collapses to a single factor pricing model, with the market excess return the single factor. The factor pricing model allows funds to have different permanent risk profiles through the fund-specific loading β_i , and fund-specific managerial skill through the fixed effect α_i . The time effect δ_t controls for macroeconomic conditions such as the risk free rate, as well as changes in the definition of funding status that occurred throughout the sample period. Identification of γ_t requires zero serial correlation of the residuals $\epsilon_{i,t}$.³⁶

The fund fixed effect and fund specific loading render equation (9) incompatible with return standard deviation the dependent variable and standard deviations computed over only two periods. Likewise, the correlation between liability horizon and risk taking even absent low interest rates, and the deterministic nature of liability horizon, violate the assumption of constant β_i and could make $\epsilon_{i,t}$ correlated with liability horizon. Hence I estimate equation (9) only for the plan solvency measure and for the ex post return as the outcome variable.

The coefficients in column 5 appear reassuringly close to the total effects (main plus interaction) in column 3. Funds with larger shortfalls engage in less risk taking in the pre-low interest rate year of 2006. Funding shortfall has a small positive effect on return in 2009, 2010, and 2012, but again a large negative effect in 2011.

To review, the strongest evidence of pension funds' reaching for yield comes in 2009, and occurs robustly for both measures of fund status and for both the level and standard deviation of returns. The effect on the loading on the market excess return declines thereafter or loses statistical significance. Gains in the stock market and the overall economy provide one explanation for the time path, as improvement in the solvency position of defined benefit pension funds and their sponsors would counteract any deleterious effect of low interest rates on reaching for yield.

³⁶Intuitively, if there is positive serial correlation in the error term, then a fund that does poorly one year resulting in poor funding status will also do poorly the next, biasing down γ_t , and vice versa if the serial correlation is negative. Inclusion of the fund fixed effect α_i may exacerbate the identification problem for the same reason panel data models cannot include both a fixed effect and lagged dependent variable. However, results remain qualitatively unchanged with the fixed effect removed.

An important clarification is that nothing in the regression evidence distinguishes the effects of low interest rates from other aspects of the post-2009 environment. For example, bankruptcy risk rises during recessions. Because of limited liability, higher bankruptcy risk may also lead plans to engage in higher risk taking.

6. Conclusion

The paper has investigated the effects of unconventional monetary policy on financial institutions. Using high frequency event studies, I find the introduction of unconventional policy in the winter of 2008-09 had a strong, stabilizing impact on banks and especially on life insurance companies, consistent with the positive effects on legacy asset prices and future business dominating any impulse for additional risk taking. The positive effects on life insurers in particular suggest a recapitalizing channel of monetary policy. The interaction of low nominal interest rates and administrative costs led money market funds to waive fees, producing an incentive to reach for higher returns to reduce waivers. I find evidence of money market funds reaching for yield in 2009-11, but not thereafter. Private defined benefit pension funds with worse funding status or shorter liability duration also seem to have reached for higher returns beginning in 2009, but again such behavior mostly dissipated by 2012. In sum, unconventional monetary policy helped to stabilize some sectors and provoked modest additional risk taking in others. I do not find evidence that the financial institutions studied formented a tradeoff between expansionary policy and financial stability at the end of 2013.

I conclude with some caveats and directions for further research. First, if unconventional policy has benefited life insurers and banks, then withdrawing monetary stimulus may have a detrimental impact. The 2013 taper event dates provide some reassurance here. Tightening adversely affected life insurers and banks, but the magnitudes do not appear especially large or asymmetric. A second concern relates to monetary policy fostering financial instability or a mispricing of risk outside of the institutions studied. Feroli et al. (2014) discuss how a small tightening of monetary policy could generate a coordinated withdrawal by asset fund managers from riskier

assets, resulting in an increase in risk premia. This mechanism resembles the metaphor in Stein (2013b) of the Federal Reserve having a looser grip on the steering wheel than it would prefer. Public pension funds, hedge funds, and households also merit scrutiny for possibly engaging in reaching for yield behavior. In the international realm, some emerging market economies appear vulnerable to the effects of tightening, and history teaches that instability from emerging markets can have global effects. Finally, money market fund reaching for yield could again become a vulnerability if credit spreads widen.

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Appendix

A. Pension fund data description

The Department of Labor collects the form 5500 series annual filings by private pension plans and provides them in machine readable format.³⁷ The main form reports the filing date and the plan filing id. The filing id allows within year linking of schedule H (financial information), schedule B (actuarial information, pre-2008) and schedule SB (actuarial information, single employer plans post-2008). Schedule SB is not provided for 2008.

The sample in the paper starts from the universe of all observations for defined benefit plans with a plan year between 2004 and 2012, and with a non-missing filing id. I drop observations where:

- the reported total asset value differs by more than 1% from the sum of individual asset categories,
- reported total income is not the sum of income categories,
- reported total assets at the end of the filing period differ by more than 1% from the sum of reported total assets at the beginning of the period plus total flows,
- the reporting period covers fewer than 300 days or more than 400 days and doesn't start January 1st,
- plan year expenses or income exceed one third of initial assets.

In general, the filing id also longitudinally matches plans across years. Plans that change filing id report their previous filing id. A complication emerges when multiple plans consolidate into one. In that event, I drop observations where total assets at the beginning of the year differ by more than 5% or \$1000 from the sum of end of year assets across filings in the previous year.

Finally, before 2009 the raw data may contain multiple submissions (amended or restated filings) by the same plan. To remove duplicates, I sequentially

³⁷<http://www.dol.gov/ebsa/foia/foia-5500.html>.

- drop duplicate filing id-year observations with a filing date before the most recent filing,
- drop duplicates with incorrect signature or filing status,
- drop duplicates reported as non amended filings,
- keep the filing id-year with beginning of year assets closest to the end of year assets in the previous year,
- drop duplicates with missing funding measures,
- drop duplicates with missing signature or entity code.

If duplicate filing id-years remain I randomly select one for inclusion.

B. Derivations for the model in section 2.1

I make parametric assumptions that yield a closed-form solution to the consumer's problem. The return on a risky project with mean μ and variance σ^2 , denoted $R(\mu, \sigma)$, is normally distributed and independent of the return on other projects. The space of possible projects has a maximum return μ_H . Utility takes the exponential (CARA) form, $u(C) = -\exp(-\gamma C)$, and I do not require $C > 0$. Finally, I assume initial real money balances Y_0 large enough that the household makes strictly positive riskless deposits, $A^f > 0$.

The portfolio of risky projects A^p satisfies

$$A^p = \int_{R^f}^{\mu_H} \int_0^{\infty} K(\mu, \sigma) A(\mu, \sigma) d\sigma d\mu. \quad (\text{B.1})$$

With independent normally distributed returns, the risky portfolio return R^p has distribution $R^p \sim N(\mu^p, \sigma^p)$, where

$$\mu^p = \frac{1}{A^p} \int_{R^f}^{\mu_H} \int_0^{\infty} \mu K(\mu, \sigma) A(\mu, \sigma) d\sigma d\mu, \quad (\text{B.2})$$

$$(\sigma^p)^2 = \frac{1}{(A^p)^2} \int_{R^f}^{\mu_H} \int_0^{\infty} \sigma^2 K(\mu, \sigma) A(\mu, \sigma) d\sigma d\mu. \quad (\text{B.3})$$

The assumption $A^f > 0$ means that R^f prices the consumption Euler equation,

$$\gamma \exp(-\gamma C_0) = \beta R^f \gamma E_0 [\exp(-\gamma C_1)]. \quad (\text{B.4})$$

Substituting into the Euler equation (B.4) using the budget constraints in equations (3) and (4), taking logs, and solving for A^f as a function of $A^p, \mu^p, (\sigma^p)^2$, and parameters, gives

$$A^f = [1 + R^f]^{-1} \left[\frac{1}{\gamma} (\ln \beta + \ln R^f) + Y_0 - A^p (1 + \mu^p) + \frac{\gamma}{2} (A^p \sigma^p)^2 \right]. \quad (\text{B.5})$$

Substituting equations (B.5), (3) and (4) into the maximization problem (2), making use of the parametric assumptions of exponential utility and normally-distributed returns, and ignoring constants, the problem becomes

$$\max \left\{ (\mu^p - R^f) A^p - \frac{\gamma}{2} (A^p \sigma^p)^2 \right\}. \quad (\text{B.6})$$

Substituting equations (B.2) and (B.3) into the maximization (B.6) then gives

$$\max_{\{A(\mu, \sigma)\}} \left\{ \int_{R^f}^{\mu_H} \int_0^\infty \left[\left(\mu - R^f - \frac{\gamma}{2} \sigma^2 \right) K(\mu, \sigma) A(\mu, \sigma) \right] d\sigma d\mu \right\}. \quad (\text{B.7})$$

Projects receive funding if their expected excess return $\mu - R^f$ exceeds a multiple $\gamma/2$ of their variance.

C. Appendix figures

Figure C.1: Five year note yield to maturity, percent

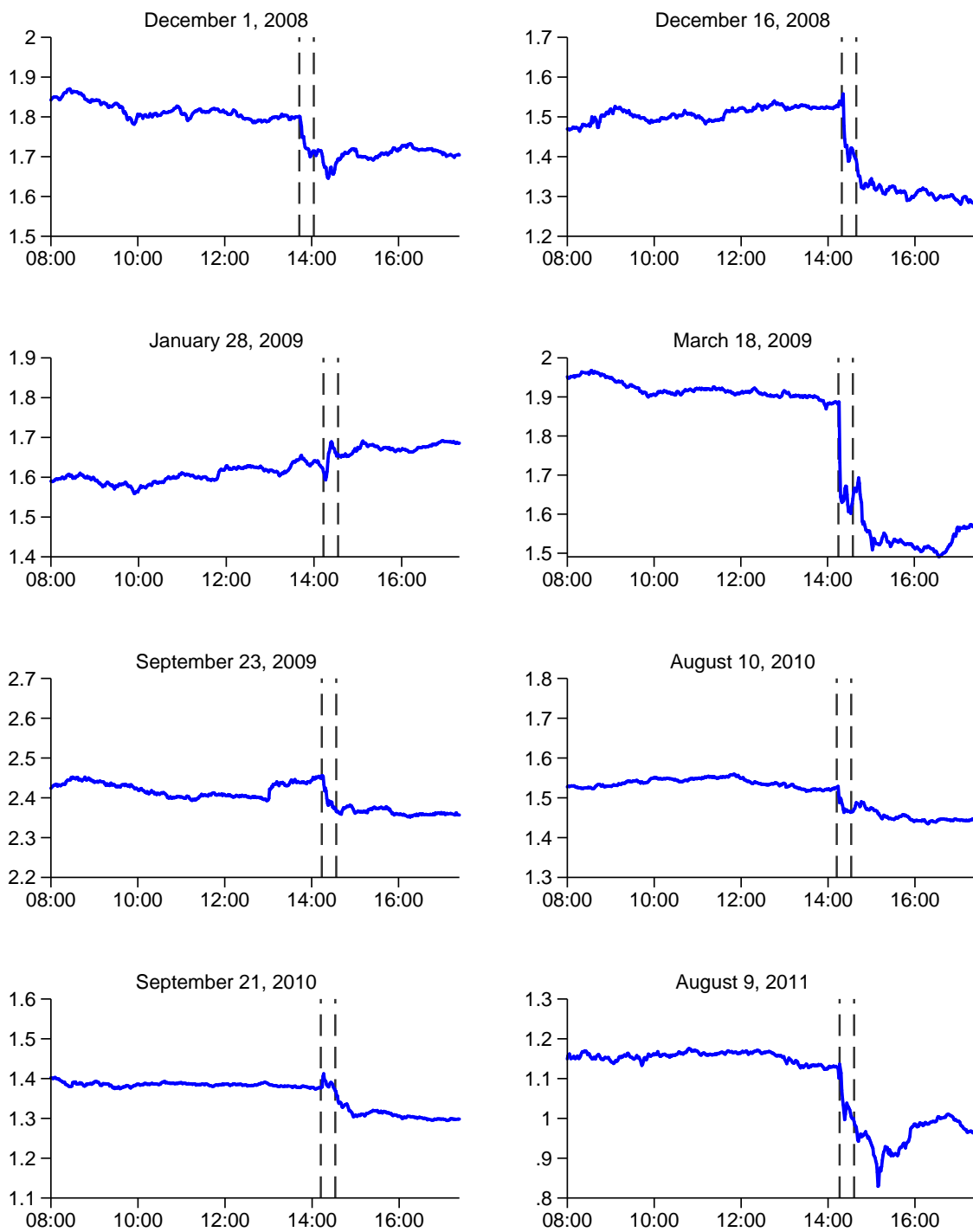


Figure C.1: Five year note yield to maturity, percent (continued)

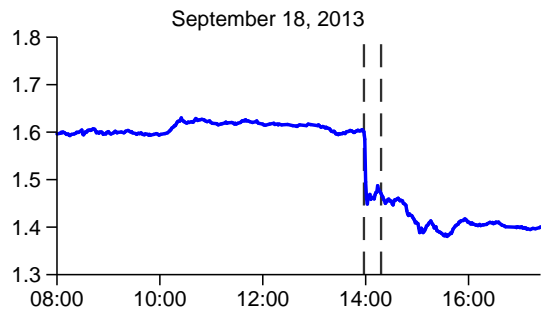
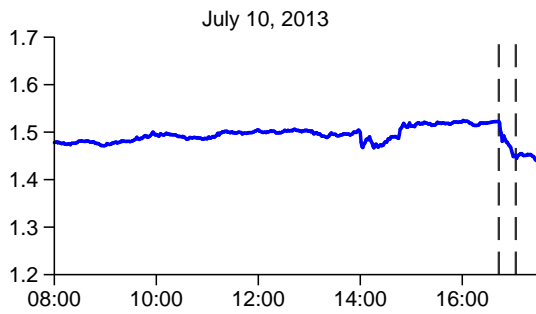
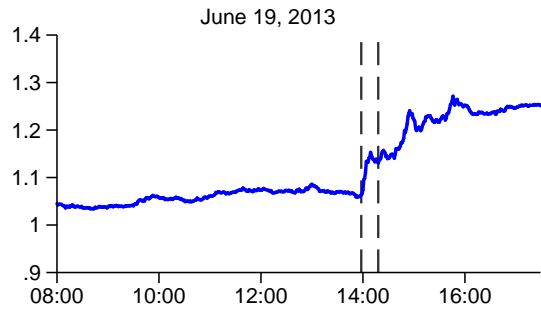
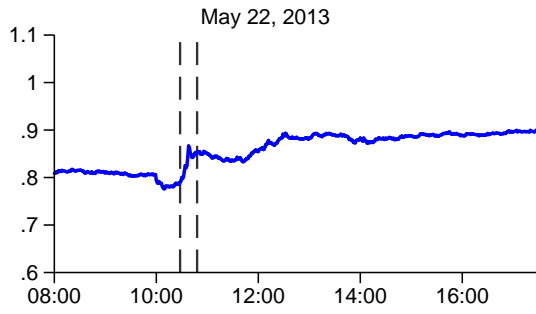
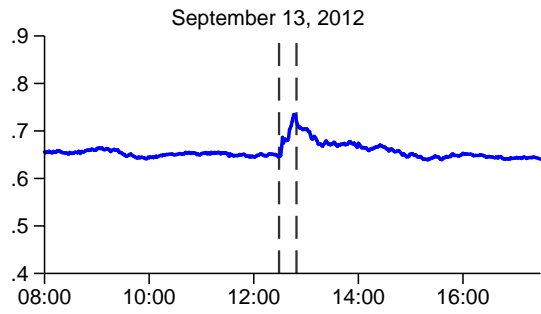
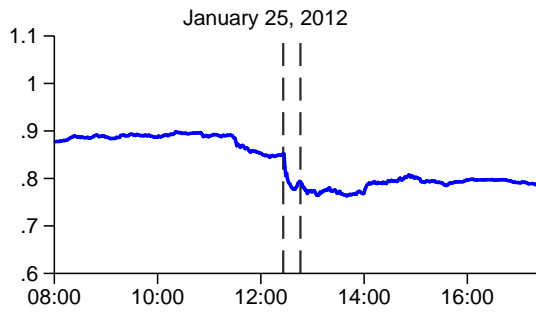


Figure C.2: Money market fund total financial assets

