Non-Financial Firms' Investments and Interest Rates' Variations:

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Abstract

In this paper, I study the effect of risk-free rate shocks on firms that are exposed to interest rate risk. To examine their influence on the firms' investment behaviours, I define an interest rate exposure, which is measured by the total floating debt, so that the impact of interest rate shocks on firms can be measured by the product of the interest rate exposure and the change in the interest rate. Using the Compustat data from 1974-2012 and the US annual fundamental financial data, I firstly find that the firms, which are exposed more to interest, have more sensitive cash flows of interest payments and retained earnings. Secondly, I find that exposed firms' investment behaviours are sensitive to the interest rate shocks as well: the higher the exposure to interest rate risk, the more the firms would react to interest rate shocks. Furthermore, I show that financially constrained or high-leverage firms are more sensitive to interest rate shocks than financially non-constrained or low-leverage ones. Interestingly, I find that the fact that firms have different reactions to the interest rate shocks of different signs also works for R&D policies. Finally, I show that the model structure changes a lot after the 2008 financial crisis.

JEL-Codes:

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1 Introduction

What determines the firm's investment level? This question has been mainly studied by using microdata and starts to be studied more and more with macro factors. According to the classical theory, at the firm level, a higher interest rate induces directly a higher unit cost of capital for debted firms, which will affect negatively the investment level of firms. Meanwhile, for the banks exposed more to interest rate variations, the higher the interest rate, the more they want to lend (Landier, Sraer, & Thesmar 2013 Table 6). With more capital resources available to firms, a higher interest rate can induce an increase in investment. These two facts lead to our interest to study more carefully the impact of the risk-free rate variations on firms' investment levels. In other words, we are studying how firms' investment decisions are affected by the interest rate shocks when they have different degrees of exposure to the interest rate. A lot of economists agree that, at least in the short run, that firm's activities are significantly influenced by the monetary policy in the course of the real economy. In 1963 Friedman and Schwartz found that the monetary policy actions are followed by movements in real output that may last for two years or more.

The direct effects of a change in the interest rate are transmitted not only through the resulting increase in the user cost of capital but also through the exacerbation of financial constraints: an increase in policy rates is reflected in larger interest payments, hence a worsening of the firm's cash flow, and in a decrease in the value of assets that could be used as collateral for new loans (Bernanke, Gertler and Gilchrist (1996)). Furthermore, the macroeconomic impact of monetary policy on sales can affect investment decisions both directly (as sales enter the neoclassical demand for capital) and indirectly through their effect on the cash flows. In this paper, I mainly study this exogenous macro cash-flow shocks on firms' investment policies. Do firms have to tighten their investments when these shocks come? Lamont(1990) and Rauh(2006) show that firms' investments are sensitive to cash flow shocks. From Fazzari, Hubbard and Petersen (1988) we could know that financially constrained firms are more sensitive to cash flow shocks.

Besides the macro factors described above, we still have to consider the micro factors of firms which can have significant effects on firm levels so as to control the sensitivity of firms' investments. These micro facts have been studied a lot by the previous researcher and we will consider them as the control variables in this paper.

When interest rate increases, the risk management manager would start to be active. The increased interest rate could possibly increase the risk of default if firms depend on bank loans. Then firms would possibly cut their long-term debt or the total debt amount which could have an indirect effect on investments. Fridson et al. (1997) exclusively focus on the correlation between real interest rate and default rate. Using Moody's quarterly default rate on high-yield bonds from 1971-1995, they find a weak positive correlation between default rate and nominal interest rates, a moderate positive correlation between default rates and real interest rate, and a strong positive correlation between default rate and lagged 2-year real interest rate. They argue that the interest rate level is the basis of the cost of capital. When the interest rate is high, the firm must generate a higher rate of return in order to survive. If the cost of capital is higher than the rate of return, the firm would run into financial insolvency or bankruptcy. This indicates that there is a positive relationship between the default rate and real interest rates. Meanwhile, Longstaff and Schwartz (1995) develop a simple approach to valuing risky corporate debt that incorporates both default and interest rate risk, and test its empirical implications. Using the changes in the 30-year Treasury bond yield and the changes in the bond yield using Moody's corporate bond database from 1977- 1992, they find a negative correlation between the two across combinations of industries and rating categories. For example, a 100 basis point increase in the 30-year Treasury yield reduces Baa-rated Utility industry credit spreads by 62.6 basis point.

Hayashi (1982) proved the Q-theory of investment that Tobin's Q, Market value/book value, is positively correlated to investment. According to maximum profits program of firms, the higher the marginal benefits (Tonbin's Q) from the investment, the more the investor want to invest. So we are expecting this factor will have a positive sign with the investment. Firms that pay no dividend demonstrate a higher sensitivity of investment to cash flows, which suggests that investment-cash flow sensitivity reflects the tighter liquidity constraints faced by these firms (Fazzari, Hubbard, & Petersen, 1988). Lang, Ofek, and Stulz (1996) argue that investment should be negatively related to leverage because high leverage reduces the current funds available for investment and affects the firm's ability to raise additional funds due to reasons discussed by Myers (1977) and Jensen and Meckling (1976). They provide evidence that for firms with unattractive growth opportunities investment is significantly negatively related to leverage. For the size of firms, Audretsch & Elston (2000) indicate that medium-sized firms appear to be more constrained by liquidity in their investment behaviour than either the smallest or largest firms.

Using all these controls, I am focusing on the impact of interest risk-free rate shocks on 9830 US firms using Compustat annual data from 1974 to 2012 in this paper. I find evidence that monetary policy affects significantly investments through the variation of the risk-free interest rate. Also, the measure of exposure to interest rate has the power of prediction on investment changes. I show that the way interest shocks affects investment differs across types of firms and across time. Financially constrained firms and the ones with a large ratio of leverage are in overall more sensitive to interest shocks than financially non-constrained firms and low leverage firms; with particularly a faster answer to monetary policy changes. Moreover, I find that when investment is financed by long-term floating debts, firms have consistent investment policies responding to interest shocks, i.e., when there is a positive shock, the growth of total investment is more aggressive; when there is a negative shock, the growth of investment decreases. Finally, I find that patterns change after the last financial crisis.

I will structure the rest of the paper in this following way. In section 2, I present the evolutions of monetary policies and investment in the US. Section 3 describes data sets, the variables and the composition of the groups I realized. Section 4 specifies the main model and shows the empirical results. Section 5 discusses possible problems and way for further studies. Section 6 concludes.

2 Monetary Policy and Investment: Stylized Facts in the US

2.1 The US Interest Rate

How is the US interest rate determined? As defined in the Federal Reserve Act, the US Congress assigned three objectives to the monetary policy: full employment, the stability of prices and not too high long-term interest rate. To attain these objectives, the Federal Reserve use different instruments in the open market operations, such as adjusting the level of treasury securities, the discount window and the reserve requirement of commercial banks. These operations aim at manipulating the short-term interest rate and the money base so as to make an influence on the rate at which commercial banks lend to their clients. The Interest rate is cyclical and also a result of a fine tuning trade-off between potentially opposite objectives (full employment and low inflation as stated by the standard relationship in the Phillips' curve). As shown in Figure 1, it was set to be high in 1978-1982 due to a need for controlling excess inflation following the second oil peak. On the contrary, it is set to be low to revitalize the economy when unemployment is high, as in the last period since 2008.

The 1979-1982 monetary policy aimed at controlling an inflation which lasted over one decade and peaked at 13% in 1981. The FED new chairman Paul Volcker increased the interest rate up to 20% in June 1981. Also, because it was politically impossible to further adjust the interest rate too sharply and fast, the FED entered in an active targeting policy on banks' reserve requirements (Meulendyke, 1998). As a result, inflation sharply dropped to 3% in 2 years, with the prices of an unemployment rate larger than 10% and an economic recession. An expansion started again after the end of 1982 and the inflation was controlled then by continuously targeting the monetary base until the end of the 1980s. Nevertheless, a long-term impact persists in the US economy and is even recognized by some scholars as a major cause of the saving and loans crisis in the 1980s and 1990s (Bodie, 2006).

The 1990s correspond to the longest expansion in the US. However, this period turned also to be difficult for the monetary policy, which had to fight the inflation following the stock price crisis of October 1987, decrease the fed funds rate in the recession of the early 1990s and stabilize it in the long boom of 1994-99. The burst of the internet bubble and the sharp decrease in investment then made the authorities obliged to decrease the interest rate again to fight against recession and maintained it as a low level even when the expansion came back (Goodfriend, 2002). Recently, the sub-prime crisis forced the FED to reduce its interest rate further, almost closed to 0, and even to use nonstandard instruments such as quantitative easing.

2.2 The US Investment

Figure 2 depicts the evolution of the US investment, which is increasing over time with some small fluctuations. The first decrease occurred during the period 1979-1982, in which the US interest rate also decreased at the same time aiming at diminishing the inflation. In the period of expansion starting from the end of 1982, the investment stopped decreasing but maintained a relatively stable level, which might be due to the inflation shock in the previous period. During this time, even a decreased interest rate could not dramatically boost the economy. Only after 1986 did the investment start to increase very slowly until 2001. It appears that the economic expansion that began in 2001 drew to a close in 2007; at the beginning of this period policy maker reduced the interest rate in the first several years and made a tax cut at the same time. From 2004, the US started to adopt a tightening policy and increased the interest rate, while the investment still went up until 2007 and then dropped down after the end of 2007. During these years, the total investment responded slowly to the monetary policies. The short-term interest became close to zero after 2008 and the investment started to increase after 2009.

Although the level of total investment is sensitive to the changes in interest rate to some extent, how the monetary policy affects a firm's investment decisions is not fully clear. Firms would like to expand their investment when they face good opportunities (good market expectations) and are able to obtain financial resources. On the one hand, from the perspective of opportunities, Tobin Q, which generally measures the investment opportunities for firms, is one of the main factors considered by firms; sale growth could be used as a major signal of market expansion; macroeconomic information could be incorporated into investors' market expectations. On the other hand, from the perspective of financial resources, cash available and debt ratio, which exert a direct effect on interest payment and an indirect effect on solvency, could also affect the firms' investment decisions. To better understand what determines the firm's level of investment, both two channels need to be thoroughly discussed.

2.3 Investment and Risk Management

From the view of a firm's investment manager, the variations of interest rate could affect its investment decisions through the two main channels. Firstly, the change of interest rate could transfer some exact macroeconomic information to the firm. Secondly, the change of interest rate could affect the firm's level of investment through making an influence on the financial resources it can obtain. For example, an increase in the interest rate could make investor have good predictions of economics while at the same increase the cost of capital.

Meanwhile, from the view of a firm's risk manager, an increase of interest rate would increase the risk of default, so the firm would like to decrease the level of debt or cut the investment to control the default risk. Moody's Analytics (2009) empirically examines the relationship between interest rates and default risks using firm-level corporate default data in the United States between 1982 and 2008. They find significant negative contemporaneous correlations between the changes in short-term interest rates and aggregate default rates, with a particularly strong relationship around financial crises. It implies that positive interest shocks could make firms become more aggressive on investment.

3 Data and Descriptive statistics

In this section, I first describe the data used and definitions of interest rate shocks in subsection 3.1, and then discuss how to measure firms' exposures to interest rate risk in subsection 3.2. Subsection 3.3 discusses the construction of our sub-samples on financially constrained or non-constrained firms and high-leverage or low-leverage firms.

3.1 Data Construction

3.1.1 Firm-level Data

I use annual fundamental data of North American firms available in Compustat from WRDS, which covers the period 1974-2012. I restrict my analysis to non-financial firms in the US to isolate the effect of monetary policy within one country. Financial firms are not taken into account since the effect of interest rate shocks on them will be different. The data of US firms is used for its advantage of being complete for the whole period of time considered. I also exclude the bottom 3% and the upper 97% of the sample in the data to avoid the outliers. From this data, I construct a set of dependent variables and controls variables. The details of the construction of these variables are presented in Appendix I and the summary statistics in Table 1.

Two classes of dependent variables are used. The first is a set of investment-related variables: an investment ratio, defined as the change of investment between t and t-1 divided by the total assets of the last period, and a dummy variable for the firms making some acquisitions. We expect that they will be negatively correlated with the shocks of the interest rate. The second is a set of three dependents variables related to the firms' cash flows and market values: the yearly change in interest payments, retained earnings and market values, all of which are scaled down by total assets. I use the second set of dependent variables to check whether the measure of impact on firms from interest rate shocks is valid or not.

As shown in the Table 1, the change of retained earnings has a negative mean, which is closed to its 25th percentile. The dummy for acquisition has 0 value at the 75th percentile, which means that I have only a few observations of acquisitions in this sample. I use two control variables that I present in Table 1. First, to limit endogeneity problems, I consider the lag on the investment ratio. Second, I consider the cash held by the firm in period t and in period t-1 and the tangibility (Property, Plant and Equipment Net). The three are normalized by total assets of the last period. Also, I take market leverage, the Tobin Q (market value over book value) at period t and t-1 and the sale growth of firms. All these control variables are conventionally used in the literature as the other determinants of firms' investment. Interestingly for the leverage, I find a mean around 0.24 while the p- 25% value is of only 0.024.

3.1.2 Interest Rate Data and the Definition of Interest Rate Shocks

There are several valid proxies for the risk-free rate in the existed studies (Tobin, & Golub, (1998) page 16). The return on domestically held short-dated government bonds is normally perceived as a good proxy for the risk-free rate. However, it is only theoretically correct if there is no perceived risk of default associated with the bond. Meanwhile, another proxy for the risk-free rate is the inter-bank lending rate: fed funds rate. [1]

In this paper, I first use the time series of both monthly and annual fed funds rate from 1974-2012 as a measure of the risk-free rate from Board of Governors of the Federal Reserve system[2] . When using annual rates, I take the rate observed in December of each year. In the end, I will also look at whether the changes of long-term 10-year interest rate would affect the firms' investment levels. I find that the monthly fed funds rate has a similar value and variations as the annual interest rate. Following Landier, Sraer&Thesmars (2013), I use the realized change in fed funds rate to estimate the natural interest shocks for firms, defined as $\Delta r_t = r_t - r_{t-1}$.

Secondly, I use the one-year zero-coupon yields for the same period as risk-free rates from Federal Fund Reserve [3]. Furthermore, I will use the two-year maturity government bonds' annual returns to construct the unexpected interest shocks, defined as ε_t, in the following way: Suppose that the one-year zero-coupon rate $r_t^{(1)}$ is the risk-free rate at time t. Meanwhile, firms could also make an expectation of $r_t^{(1)}$ at time $t-1$ conditional on the information at time $t-1$, denoted as $\mathbb{E}_{t-1}(r_t^{(1)})$. Suppose that the annual return rate of a 2-year maturity zero-coupon bond at time $t-1$ is $r_{t-1}^{(2)}$. From the no-arbitrage condition:

$$(1 + r_{t-1}^{(1)})(1 + E_{t-1}(r_t^{(1)})) = (1 + r_{t-1}^{(2)})^2$$

[1] In the United States, the federal funds rate is the interest rate at which depository institutions actively trade balances held at the Federal Reserve, called federal funds, with each other, usually overnight, on an uncollateralized basis. Institutions with surplus balances in their accounts lend those balances to institutions in need of larger balances. The interest rate that the borrowing bank pays to the lending bank to borrow the funds is negotiated between the two banks, and the weighted average of this rate across all such transactions is the federal funds effective rate. The federal funds target rate is determined by a meeting of the members of the Federal Open Market Committee .

[2] From the Table Federal funds (effective). http://www.federalreserve.gov/releases/h15/data.htm

[3] From the Table The U.S. Treasury Yield Curve. http://www.federalreserve.gov/pubs/feds/2006/200628/200628abs.html

firms know that

$$E_{t-1}(r_t^{(1)}) = (1 + r_{t-1}^{(2)})^2/(1 + r_{t-1}{}^{(1)}) - 1.$$

Then the interest rate shocks for firms at period t can be obtained as $\varepsilon_t = r_t^{(1)} - E_{t-1}(r_t^{(1)})$.

In this paper, I mainly use Δr_t as the interet rate shocks and then verify the main results by using the unexpected interest shocks ε_t.

3.2 Firms' Exposures to Interest Rate Risk

In most empirical work based on panel data, the user cost of capital is not included in investment functions. Generally, it is assumed to be the same for all firms (a transformation of the interest rate) and its effect is accounted by the time dummies. While this approach makes it possible to obtain a consistent estimation of the remaining parameters, it sheds no light on the effect of monetary policy. In order to directly estimate the effect of monetary policy on firm-level investment, Ber, Blass and Yosha (2000) proxy the user cost of capital with the short-term rate and omit time dummies from the regression. However, this approach can result in biased estimations and is particularly problematic if the time dimension of the sample is limited.

From the firms' capital structure, we know that firms can borrow short-term debts and long-term debts, where short term debts' borrowing rates are directly affected by the current risk-free rate. At the same time, firms may borrow long-term floating debts whose interest payments depend on the current borrowing interest rate. Therefore, firms can be directly affected by the monetary policy through the capital structure by affecting the cash flows of interest payments. Therefore, I use the change of cash flows to represent the effect of interest rate shocks on firms through the cash channel, which has also been used by Mishkin &Eakins (2009).

According to Chava and Purnanandam (2006), the total floating debt is the sum of the short-term debt and long-term floating debt:

$$Total\, floating\, debt = DLC + DLTP$$

where DLC (in Compustat) is the total amount of short-term debts (due in one year) and DLTP represents the total amount of long-term debts, of which the interest rate fluctuates with the prime interest rate. This item includes any long-term debt tied to a fluctuating or floating rate. The interest payments on both debts depend on the current interest rate. From the definition above, I know that total floating debt measures the extent to which a firm's interest payments are sensitive to the changes of interest rate paid. If interest rate paid increases, the borrowing cost also increases for firms. The changes of interest payment could be measured by $total\, floating\, debt \times change\, of\, borrowing\, rate$. We know that the interest rate paid by the company can be modeled as the risk-free rate plus a risk premium, which itself incorporates a probable rate of default (and amount of recovery given default). Therefore, I can use total floating debt, scaled down by the total assets in the last period, to measure the extent of firms' exposures to the risk-free rate variations: $exposure_{i,t-1} = total\, floating\, debt_{i,t-1}/total\, assets_{i,t-1}$. Following Mishkin and Eakin (2009), I measure the effect of changes in short-term risk-free rate on firms by calculating: $exposure_{i,t-1} \times \Delta r_t$.

Besides, I also take into account the effect of lag one interest rate changes (Δr_{t-1}) by $exposure_{i,t-1} \times \Delta r_{t-1}$, which measures the firms' exposures to the last period's short-term interest rate variations. At the same time, in order to account for the individual effects of Δr_{t-1} and $total\, floating\, debt$ (that will disturb the effect of $exposure_{i,t-1} \times \Delta r_t$), I control in my regressions the level of Δr_t, Δr_{t-1} and $exposure_{i,t-1}$. Table 2 presents the summary statistics of debt levels and changes of risk-free rate.

3.3 Grouping on Firms' Financial Constraints and Leverage

Will interest rate shocks have the homogeneous effect on financially constrained firms and financially non-constrained firms? In the literature, several measures of financial constraints have been proposed. One approach is to use a proxy to measure it. Fazzari, Hubbard, and Peteresen (1988) propose dividend payout as a proxy for financial constraint while Gertler and Gilchrist (1994) use the size of the firm, with the idea that the bigger the firm, the less likely it can experience some cash constraints. Another approach is to construct some index. Kaplan and Zingales (1997) construct a KZ index, using the estimates from the Probit model of investment on the five factors (cash flows, cash stock, Tobin Q, leverage and dividends). Whited and Wu (2006) propose to modify their index by using factors as cash flow, positive dividends, long-term debt, the log of assets, the industry sales growth and the sale growth of the company. The first three are scaled down by the assets of the firm. In this paper, I choose to use the generic one, KZ index, and present the details on how to construct it in the appendix.

Giroud and Mueller (2012) classify a firm as financially constrained if its KZ index larger than the median of the sample. However, they also mention that empirical studies using Compustat data typically classify about 30% to 40% of firms as financially constrained, which would thus need a slightly adjustment of the cutoff value below or above the median. In this paper, to avoid a blurred adjustment on the cutoff value when differentiating financially constrained firms from non-constrained ones, I choose to only keep the firms in my sample whose KZ index is above the 75th percentile and classify them as financially constrained, and keep the firms whose KZ index is below the 25th percentile and classify them as financially non-constrained.

Table 3 presents the summary statistics of the KZ index and the factors used to construct it. The mean of KZ is a negative and its standard deviation is relatively large. According to my classification, the firm whose KZ index is smaller than -4.4 (25th percentile) is treated as financially non-constrained and the firm whose KZ index is larger than 0.89 (75th percentile) is treated as financially constrained.

I also group firms by their levels of market leverage in the analysis to take into account potential heterogeneous effects. Several literatures have investigated the relationship between firms' values or levels of investment with the leverage, but the result is inconclusive. McConnell and Servaes (1995) examine a large sample of non-financial US firms for the years 1976-1988. Through separating their sample into two groups: those with strong growth opportunities and those with weak growth opportunities, they show that the firms' value is negatively correlated with the leverage of firms with strong growth opportunities (indicated by high Tobin's Q), and positively correlated with the leverage of firms with weak growth opportunities (or low Tobin's Q). Lang et al. (1996) analyze a large sample of US industrial firms over the period 1970-1989 and find a strong negative relation between leverage and subsequent investment, but only for firms with weak growth opportunities (with Tobin's Q less than one). Again, their results are consistent with the hypothesis that leverage attenuates incentives to invest in poor projects. In this paper, I define the firms with market leverage less than 0.024 (25th pecentile) as the low-leverage group and the firms with market leverage larger than 0.41 (75th pecentile) as the high-leverage group.

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4 Empirical results

In this section, I present the empirical results of the effects of interest rate shocks on firms' investment decisions. In the first sub-section, I verify the validity of the independent variable that I constructed by studying the effect of $exposure_{i,t-1} \times \Delta r_t$ on firms' cash flows of interest payments and market values. Then, I investigate the effect of risk-free rate variations on the changes of interest payments, retained earnings and firms' market values. Since the changes of interest rate could have a direct effect on the changes of expenses which influence directly on net earnings, we could examine the effect of $exposure_{i,t-1} \times \Delta r_t$ on retained earnings to verify the validation of measure of interest rate risk exposure.

Then, I study how the change of short-term interest rate affects investment decisions made by the firms that are exposed to interest rate risk, which is the main result I am looking for in this paper. I use the changes of investment from t-1 to t, scaled down by total assets, as the dependent variables to represent the firms' reactions to the changes of short-term interest rate. The evidence that firms' investments are sensitive to cash flows has been found in a few literatures (e.g., Fazzari, Hubbard and Petersen (1988) and Kaplan & Zingales(1997)). Thus, theoretically, the change of risk-free interest rate could affect the investment through the cash flows of interest payments. Furthermore, I also investigate the reactions of R&D, a main part of investment, to the change of interest rate shocks as a robustness check.

4.1 Cash flows & firm values respond to Interest rate shocks

Firstly, I check the sensitivity of cash flows (interest payments and retained earnings) and firm values to interest rate exposure. If interest risk exposure affects cash flows or firm values, then it could serve as a valid measure of interest risk. Following Kashyyap and Stein (1995, 2000) and Landier, Sraer and Thesmar (2013), I consider a linear specification in the following way:

$$\begin{aligned}(\Delta Y_{i,t}/A_{i,t-1}) = \beta_0 &+ \beta_1 \cdot exposure_{i,t-1} \times \Delta r_t + \beta_2 \cdot exposure_{i,t-1} \times \Delta r_{t-1} \\ &+ \gamma_1 \cdot (\Delta Y_{i,t-1}/A_{i,t-1}) + \gamma_2 \cdot exposure_{i,t-1} + \gamma_3 \cdot \Delta r_t + \gamma_4 \cdot \Delta r_{t-1} \\ &+ \tilde{\gamma} \cdot \mathbf{X}_{i,t} + y_t + v_i + u_{i,t} \qquad (1)\end{aligned}$$

where for firm i at time t, $Y_{i,t}$ represents the firms' interest payments, retained earnings or market values, $\mathbf{X}_{i,t}$ represents other control variable mentioned earlier. I also control the yearly effect and the firms' fixed effect by y_t and v_i.

4.1.1 Interest payment and interest rate shocks

When the interest payments are used as dependent variable, since their level are also determined by the level of debt and the borrowing cost, I add the leverage ratio in the model (1) as another control variable. Furthermore, I also add control variables for the factors that could affect the borrowing rate of firms: return on asset (ROA), size of firm (lsize) and cash, etc.

From Table 2-A, we see that if the exposure to interest risk is higher, firms will have a higher changes in the interest payments if there is shock in the interest rate. Both coefficients on $exposure_{i,t-1} \times \Delta r_t$ and $exposure_{i,t-1} \times \Delta r_{t-1}$ are significantly positive. For each extra unit of $exposure_{i,t-1}$, an increase of Δr_t will increase the interest payment more by $0.127\Delta r_t$, while an increase of Δr_{t-1} will increase the interest payment even more by $0.380\Delta r_{t-1}$. The results show that the level of total floating-rate debts indeed affects the firms' exposure to interest rate shocks.

The second column and third column of Table 2 show the result when firms are grouped into the financially constrained or non-constrained. For each extra unit of $exposure_{i,t-1}$, a contemporary increase of Δr_t will increase the interest payment more for the financially constrained firms than the financially non-constrained (0.137 vs. 0.0872), while a increase of Δr_{t-1} in the last period will increase the current interest payment slightly less for the financially constrained firms than the financially non-constrained (0.382 vs. 0.404).

Consistent with empirical studies (Frank & Goyal, 2002), firms with higher ROA will have lower leverage ratio; and so a negative correlation between with interest payment. If in the last period firms have higher available cash, they should have a lower leverage ratio and a lower interest payment: this confirm our negative coefficient of lag-one cash. A higher leverage ratio means that if firms increase one more unit of leverage ratio, interest payment would increase 0.00899 units. This implies a higher marginal cost of borrowing for high leverage ratio firms.

Also, in Table 2-B, I propose to distinguish between negative ($\Delta r_t < 0$) and positive shocks (Δr_t >0) of interest rate so as to see if we obtain some symmetric results or not. The first three columns present the negative interest rate shocks, while in the last three columns we look at positive interest shocks. Both of these two shocks give the same positive signs of a short term impact on interest payment: higher exposure to interest rate, higher sensitivity of interest payments. In other words, when the shocks are negative, the more firms are exposed to interest risk free rate, the more the interest payments are cut; when shocks are positive, the increase of interest payment is higher for firms with higher floating debts. From the "constrained" and "non-constrained "columns, we see that whatever the sign of the shocks, constrained firms cash flows are much more sensitive to the impact of interest shocks. When there is a negative shock, an increase of 1 unit of floating interest payment ($exposure_{i,t-1} \times \Delta r_t$) lead to a two period-cumulative decrease of interest payment by 0.61 for constrained firms while only 0.341 for non-constrained firms.

Overall, we confirm that the $exposure_{i,t-1} \times \Delta r_t$ could measure the impact of interest shocks on firms' cash flows. When firms are exposed more to interest rate, firms cash flows are more sensitive to interest shocks. So exposure\times\bigtriangleup r_{t}. is a reasonable measure to capture the impact of interest shocks of interest risk exposed firms .

4.1.2 Earnings & market values and interest shocks

Now, I check the influence of interest shocks on firm values: retained earnings and market values. Using the equation (1) above, I control leverage, sale growth, tangibility, cash which are all scaled down by total assets.

Table 3 reports the results of interest rate shocks on retained earnings, which is the difference of t and t-1 scaled down by total asset. Columns (1)-(3) present the results for the whole sample, non-constrained group and constrained group. The first columns tells that when $exposure_{i,t-1} \times \Delta r_t$ increase by 1 dollar, then the retained earnings will decrease by -0.944 for next period which is significant at 1% level. While for the current period it will be cut by 0.183 with 0.30 p-values. This show us that retained earnings are negatively sensitive to the past interest rate shocks which has one strong direct intuition: when firms are highly exposed to interest rate shocks, a higher interest rate shock could lead to higher interest payment (confirmed in table 2-A); a higher the interest expense could cut down the net earning which could have a negative effect on current and next period retained earnings.

While for non-constrained firms, when the $exposure_{i,t-1} \times \Delta r_t$ increases, the retained earnings increase by 0.996 at 10% significant level. This is contrary to constrained firms which would have a negative impact on retained earnings. From this result, we could know that when policy makers increase interest rate, constrained firms are negatively shocked on retained earnings while non-constrained firms improve their increase of retained earnings. Therefore, when exposed to interest risk, constrained firms retained earnings have different sensitivity to interest shocks than non-constrained firms.

Furthermore, we could see from the different sign of interest shocks could have different impact on firms earnings. When the shock is positive, only constrained firms have a negative and significant response to the increase of interest shocks. In other words, constrained firms who are exposed more to interest rate risk are more sensitive to interest rate shocks; and the sign is consistent with different shocks. While financially non-constrained firms are less responsive to interest shocks compared to financially constrained firms, and they have a different response to interest shocks. For negative shocks, non-constrained and constrained firms earnings are negatively correlated to $exposure_{i,t-1} \times \Delta r_t$ and $exposure_{i,t-1} \times \Delta r_{t-1}$.

Similarly as retained earnings, market value which is presented in Table 4 is defined as the difference of market value from t to t-1 scaled down by total assets. We find that the coefficients of $exposure \times \Delta r$ (when without time notations means including the current and past interest rate changes' effects) are negative and significant for the whole sample. It shows that market values of firms exposed to interest rate risk are sensitive to interest shocks: when interest rate increase firm market values increase less. The higher the exposure to interest risk, the more the market value will decrease when interest rate increase. Meanwhile, we find that, when it is a positive shock, all the firms' market values are less responsiveness to the change of interest rate. In other words, when the macroeconomics goes up, market values of firm are not sensitive to the increase of interest rate shocks. While when it's a negative shock, policy maker are trying to stimulate the economy by decreasing the interest rate. Nevertheless, both constrained firms and non-financially constrained firms' market values are negatively sensitive to the shocks. In other words, the decrease of r could make the market value of firms increase less.

Moreover, the measure of exposure extent$exposure_{i,t-1}$ is positive correlated with the increase of market value; i.e., when the floating debt ratio increases; it could concentrate on the increase of market values. As explained by the pecking order theory, debt financial resources transfer more positive information's than equity finances.

In a word, this sub-section proves that floating debt is a good measure of the extent of exposure to interest rate risk for firms;$exposure \times \Delta r$ measures the impact of interest rate shocks on firms cash and firms income value level. Even though, we measure the impact of interest rate only through the cash flow channel. But at least, it could capture the sensitivity of firm's income or cash flows to interest rate risk. Also, generally speaking, financially constrained firms who are more exposed to interest rate risk are more sensitive to interest rate shocks. Finally, negative shocks have generally more important effects than positive shocks.

These results allow us to anticipate what will be the impact of an interest shock on firm's investments. When the interest rate decreases, cash flows and the firm value increase. We can expect from that an increase of investment. We can think that this increase will be larger for constrained firms than for non-constrained ones. On the opposite, a positive shock will also have some effects, but smaller ones and only on constrained firms. We verify these intuitions in section 4.2.

4.2 Investment policy respond to interest cash-flow shocks

The level of investments of firms is mainly affected by the firm's own characteristics. Therefore we should control the fixed effect of firms to avoid that endogeneity problems affect our coefficient. Furthermore, firms face different investment opportunities at different time. For example, firms invested more before 2008 and invested much less after. At each specific year, firms have various investment policies according to the macro environment and firms development plans.

I use the same model as equation (1) but with$Y_{i,t}$ standing for investment. In this model, in addition to the general factors of equation (1), I also consider the Cash and Tobin's Q and their lags which could have a direct effect on the current investment level. From Hayashi (1982) we know that we can use the average Tobin Q to represent the marginal Tobin's Q which is representing the investment opportunities for firms. Therefore, at t-1 if firms had good investment opportunities, then they would have a good prospect on the future market. They therefore are tending to increase the investment level at the current period. This idea is supported by Aivazian, Ge Qiu (2005). While for the lag of cash, the higher the cash available at t-1; the higher the ability to invest for firms. So, when firms have good projects and available cash, they will increase their investment. Therefore, we could expect a positive sign for the Tobin Q and the cash.

Here, I find in overall as expected a negative reaction of firm investment to shocks of interest rate: a variation of $exposure \times \Delta r_t$ by one unit slows down significantly the change of investment by 0,165 units (first colunm in table 5 in Appendix I). The shock is nevertheless not completely symmetric. Indeed, a decrease of the interest rate will cause an increase of investment (one unit of increase of $exposure \times \Delta r_t$ will decrease investment by 0.162). On the contrary, an increase of interest rate will also increase investment with even a larger impact (one unit of increase of $exposure \times \Delta r_t$ will increase investment by 0.585). When the interest rate increases and the cost of capital increase, this could decrease investment. But at the same time, an increase of the FED fund rate accompanied an economic upturn and this second effect is a stronger impact than the first one. I propose now to study the difference of the impact for constrained and non-constrained firms.

4.2.1 A differenct impact between financially non-constrained and constrained firms

As I describe in the section 3.3, I split the sample into a constrained group and a non-constrained group according to the KZ index. I find a negative relation between KZ and the investment level of firms (see more details in Table II-1). The negative and significant size of KZ confirms the fact that when firms have financial constraints, everything else being equal, they will decrease their investment. So will the financially constrained firm be more sensitive to the change of interest rate? If it's true then policy maker could adjust their policies according to the categories of firms to validate the fiscal policies.

From Table 5, If we look at the non-constrained firms only (column 2) , the impact is not significant suggesting that non constrained firms respond little to policy changes compared to an average firm. Indeed, if some good investment opportunities present to them, because they own cash, they can still invest. At the opposite, other firms decrease significantly their investments when the interest rate increases. This adjustment is 20% larger than for the whole sample.

If I look at negative shocks (the last three columns),it is showed that a decrease of the interest rate is coming with an increase of investment for constrained firms. Indeed, we can interpret this decrease of the interest rate as a loosening of the constraint they are facing, which allow at least for some of them to invest more. For non-constrained firms, the impact is not significant. Turning to positive shocks, for the whole sample, the impact of this increase of interest rate is not significant. This insignificant results implies that when the economics goes up the positive shocks of interest couldn't really affect the investments of firms.

4.2.2 High leveraged VS low leveraged

Since leverage is an important characteristic of firms, I look at potential differences between low leverage ones and high leverage ones. Therefore, I split the group according to the level of leverage. I take the lower 25% quantile of market leverage as the low leverage group and the upper 75% quantile of leverage as the high leverage group.

I find that firms with a high leverage ratio significantly decrease their investments when interest rate increase (the coefficient of$exposure \times \Delta r_t$ is of -0.122), while the relation is not significant for non-constrained firms (see Table 6 column 2). When focusing only on negative shocks, I find that a financially constrained firm with a high leverage seeing a decrease of the interest rate, if $exposure \times \Delta r_t$ increase 1 dollar, investment will increase by 0.774 dollar at a significant level 1% (see the last column in Table 6)

Therefore, as expected, I find some similar pattern between the groups of constrained vs non-constrained firms as for the group of firms by their levels of leverage. While the size of the effect of a negative shock is approximately the same for the firms that I defined as constrained and the I have defined as with a high leverage (-0.356 vs -0.353), the size of the impact is 50% when we deal with a positive shock for high leverage firms compared to non-constrained (0.744 vs. 0.574).

4.2.3 Before and after 2008: Are the reactions the same in the years following the financial crisis?

From figure 2 we observe that the average of total investment experienced a large decrease around 2008 when the financial crisis occurred. It is also interesting to look at the impact of the 2008 financial crisis on our relationship (Table 7).

If we are looking at the impact for the whole sample, before the crisis, we confirmed the negative relation between investment and an increase of the interest rate. After the crisis, the effect of the current interest rate is no more significant but we keep a negative impact of the variation of the interest rate from the previous year (appearing in $exposure \times \Delta r_{t-1}$). Nevertheless, the interesting point is that while non-constrained firms did not respond to interest shocks before the crisis, they now react also negatively and at the same level than constrained firms (a variation of one unit of$exposure \times \Delta r_{t-1}$ decrease the investment of 0.501 of non-constrained firms and of 0.562 of constrained firms). This finding would advocate that while in general, investment is largely impacted by the characteristics of firms, investment in a period of crisis as since 2008 is mainly impact by the state of the macroeconomic conjuncture.

4.2.4 Why firms are exposed to interest rate variations?

Table 10 and table 11, they show the interest shocks impact only through short-term debt or long-term floating debt. Firstly, these two tables confirms that constrained firms are more sensitive to interest shocks than non-financially constrained firms whatever the signs of shocks. Secondly, it shows that both longpayment and shortpayment could help to explain well when shocks are negative. Remain that $longpayment = (DLTP_{i,t}/AT_{i,t-1}) \times \Delta r_t$,$shortpayment = (DLC/AT_{i,t-1}) \times \Delta r_t$which replace the $exposure_{i,t-1} \times \Delta r_t$, the total measure of exposure to interest rate risk. Thirdly, when there are positive shocks; only short-term debt could explain well the change investment policy. In other word, the interest shocks impact the investment decisions mainly through short-term debt channel. Fourthly, we could find that non-constrained firm's investment policies have no any negative relationships with interest shocks. This confirms that policy makers couldn't effectively affect financially non-constrained firms' investment behaviors through interest adjustments. Finally, compare the two tables, we could know that when positive shocks comes, firm's with more short-term debts will be significantly affected by shocks than firms' with long-term floating debts. While financially constrained firms' with more long-term floating debts are always negatively reacting to interest shocks. So this long-term debts are the consistent part which helps to exercise the monetary policies.

4.2.5 R&D epensen and interest shocks

R&D expense is an important part of expense aiming at the developpment of companies which is not treated as an investment in accounting ; this item is very sensitive to cash flows. So we could study the sensitivity of this item to check the responses of firms' behaviors after interest shocks. As in Table 5, we present the changes of R&D scaled down by total assets as the dependent variable. From this table, we could find that constrained firms' R&D expenses are more sensitive to interest shocks; especially sensitive to the past period's shocks. We can learn that, financially constrained firms are negatively correlated to the interest shocks; the more the financially constrained firms are exposed to interest rate, the higher sensitivity of R&D to interest cash-flow shocks. Finally, it confirms us again that financially non-constrained firms are not sensitive to interest shocks.

4.3 Comparisons With the Unexpected interest shocks

For some pubic firms who have a good magane level could predict well next period's interest rate. In this case, they could adjust their investment lelve before the change of interest rate. This could have an endogeneous problems for the model. In order to identify the exo shocks from interest rate. We will use the unexpected shocks to replcae the first shocks defined in section 3. If we use the definition (2) of interest shocks in section 3.1.2, we can do the same regressions as with the rchange (Δr_t). First stage, we check the validation of interest rate risk exposure measure $exposure_{i,t-1} \times \varepsilon_t$, now, the unexpected interest shock is $\varepsilon_t{=}{r_t}^{(1)}{-}E_{t-1}({r_t}^{(1)})$. From Table II-2 & Table II-3, we could conclude that firms who have floating debts are more sensitive to interest shocks. The higher the floating debts firms have, the more cash flows will be affected by the exo cash-flow shocks of interest adjustments. And we could find that retained earnings are overall negative correlated to the impact of interest ratee, this shows a higher sensitivity of retained earnings to interest shocks than the previous one in Table 3.

The interesting one we are looking at is the changes of investments or R&D changes, as the previous shocks; firms who have higher floating long-term debts will negatively react to the past interest rate shocks, i.e., when the there was a positive interest shocks, financially constrained firms who have more floating debts would cut 0.467 units of R&D expenses. Non-constrained firms would not be sensitive to this interest changes. And for firms who own more short-term debts have no the same reactions to the changes of interest rates. But it confirms that constrained firms are more sensitive to the interest shocks than those who are not.

5 Possible problems and Further Studies

As many financial data papers, there are endogenous problems for financial firm data. The first problem is Omitted variables: I am using the cash and salegr, TobinQ to predict the increase of investment; meanwhile, the error term which could contain the unknown variables could affect the explainable variables and dependent variable at the same time. Look at figure 5 (Appendix I), we could find a strong business cycle effect of investment; which are strongly affected by the trend of macro economics. The second problem is: the measure of the exposure to interest rate is noisy; I am measuring the effect through the change of interest payment on total floating debt. While there are about 1/4 of firms who only have a low leverage ratio around 0.026 which means a lot firm haven't affected by the monetary policy through the debt interest payment channel; maybe through other channels. Third, the interest cash-flow shocks are real interest rate; it is treated as an exogenous shock for firms while the real interest-rate paid of firms is consisted by risk free rate and risk premium. So it's better to islolate the cash-flow shocks of risk-free rate by controlling risk-premium cash-flow shocks at the same time.

In this paper, we are trying to use year effects and the instrument variables of interest rate changes to explain part of the macro variables which are changing across time. However, these couldn't all explain the cycle macro effects on the investment. Even though it is difficult to eliminate this problem; we could still find some solutions to lighten this problem. One possible way is to use less periods but larger sample size of panel data, this kind of sample construction could lessen the time variance macro variable effects. Another possible way is to consider more represented macro variables, such as the overall US Stock index which could predict well the whole economic trends.

We could continue to study whether firms who are buying the interest rate derivatives to against the interest rate risk would response less to the interest rate changes. Because the hedge of interest rate risk could make firms less affected by the monetary policies; therefore we could expect a small coefficient absolute value and less significant values from those firms. It could be interesting point to examine. If it's the case, then the transmission of monetary policy can be obstructed. The third way is to search for possible better instrument: we could further analysis the main determinants of change of floating debt and the change of interest rate, and then we could specify the effect of interest rate on the debt changes. Like that, we could find a much exacter and less noisy measure of exposure to interest rate changes.

6 Conclusion

When using the annual financial data of non-financial firms in US from 1974-2012, I fond evidence that monetary policy affects significantly investment through the interest cash-flow shocks and that often the measure of exposure to interest rate has power of prediction on investment changes. I measured the exposure to interest variations of firms by total floating debts which is sensitive to interest rate changes. I used $exposure_{i,t} \times \triangle r_t$ $(floatingdebt \times interest\,rate\,changes)$, the cash-flow shocks, to capture the effect of interest rate shocks on firms. From the overall of this paper, it is showed that firms' investment policies respond significantly to the interest cash-flow shocks.

Also, I found that the way interest risk-free rate shocks affect investment differs across types of firms and across time. In general, treated firms (highly exposed to interest rate risk), answer to an increase in interest rate by slowing down their investments increases. However, treated financially constrained firms are in overall more sensitive to the interest cash-flow changes than financially non-constrained firms; with particularly a faster answer to interest changes. In other words, an negative interest cash-flow shock could decrease the firms' investments' increment in next year. I also found a similar pattern when looking at firms which differ in terms of their level of leverage ratio. Indeed, high leverage ratio firms are found to be more sensitive to interest rate changes than low leverage ratio firms.

Moreover, I found that when investment is financed more by short term debts rather than long term debts, the investment adjustment to an increase of the interest rate is quite different and not robust. Firms who own more long-term floating debts will invest more when negative interest shocks bring positive cash-flows to firms ; while this is not true for firms with more short-term debts. Therefore, the change of interest rate could affect the firm's investment behaviors through the long term floating debts or short-term debts. Nevertheless, for firms who own more short-term debts when the macro economies boost firms, they are still expecting the good market for near future; then they will respond less to the interest free-rate shocks in normal situations or respond in an undesired direction.

Also, firms have different reactions to the different signs of shocks. When realized interest rate is higher than firms' expectations, firms don't adjust their investments policies, suggesting that an increase of the interest rate couldn't lead to investment are cut for firms. In other words, firms' investment are less affected by negative cash-flow shocks. Indeed, an increase of the FED funds rate can be seen by investors as a positive signal regarding the expected dynamism of the economy, which give them an incentive to invest more. When there is a negative shock, firms are more aggressive to investments and the impacts are significant. When focusing on the post 2008 financial crisis, we found that even financially non-constrained firms are sensitive to interest cash-flow shocks. More generally after the crisis, the level of the correlation between the overall investment and interest rate was increased to around 0.5 for these two groups. These findings advocate a structural change of the model in a period of crisis, where investment reacts much more to monetary policies movements.

Then, the sensitivity of R&D to interest rate shocks confirms us again the impact of interest risk-free rate on firms' investment policies. The unexpected interest rate shocks have the similar effects on firms.

Finally, we can conclude that firms' investments are sensitive to external financial resources and sensitive to cash-flow shocks which is contrary to the MM theorem. As previous studies, it is also showed that more financial constrained firms are more sensitive to cash-flow shocks than non-constrained firms.

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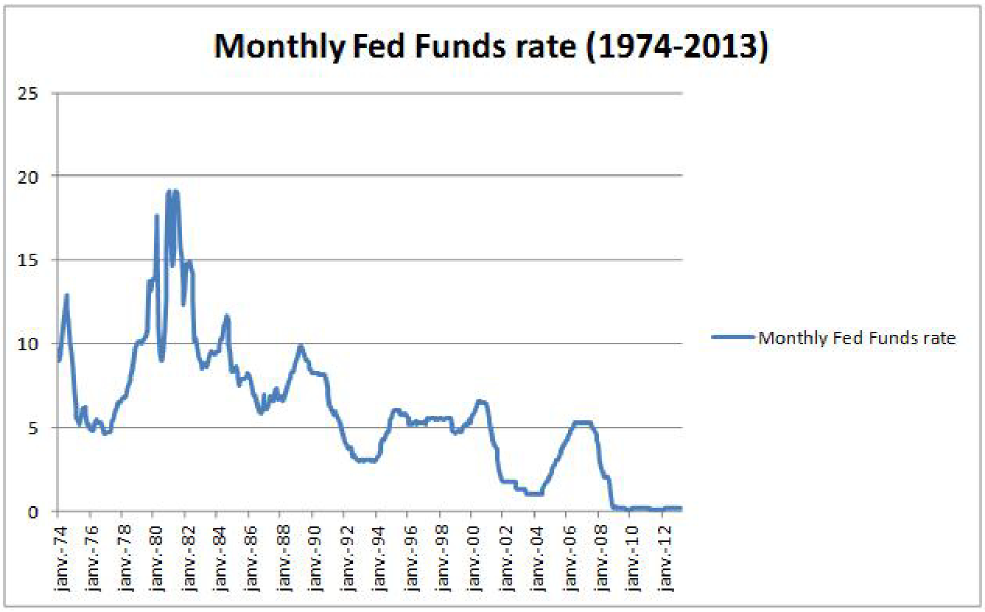
Figure 1: The Evolution of Monthly Interest Rate in the US during 1974-2012



The y-axis denotes the US monthly interest rate (in percentage) and the x-axis is time index.

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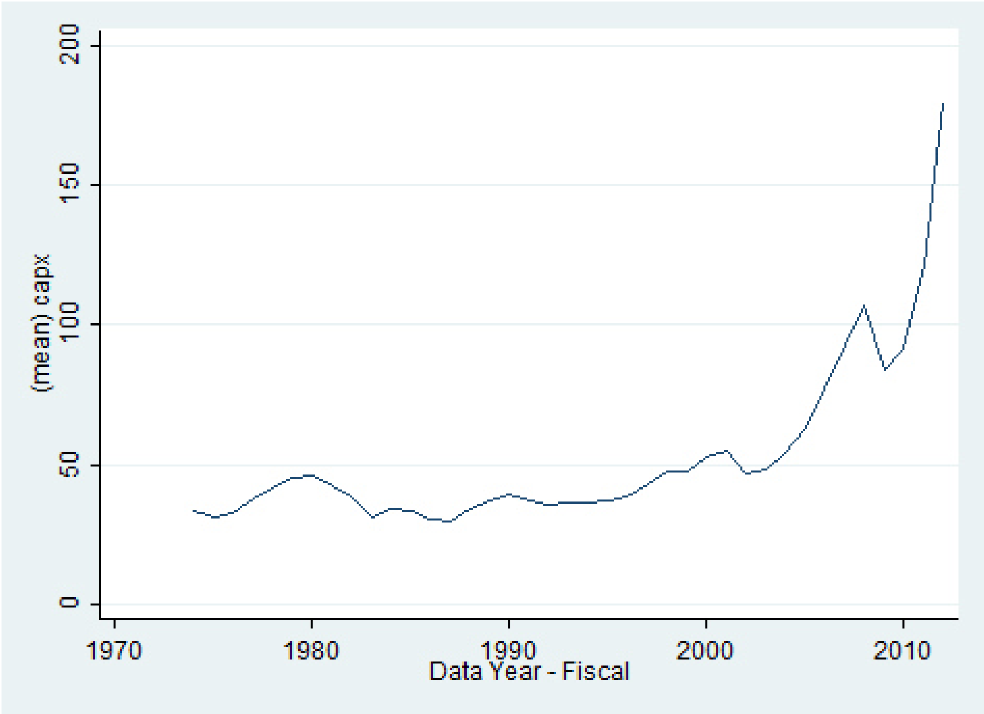
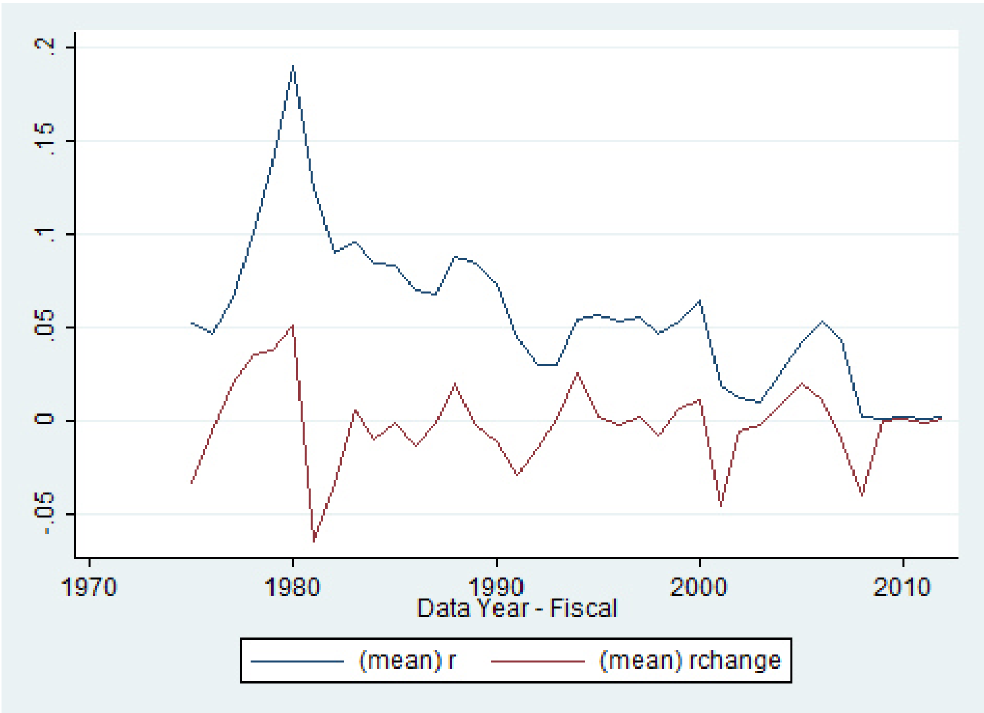
Figure 2: The Evolution of Investment and Interest Rate in the US during 1974-2012



The y-axis denotes the average of total investment of non-financial firms in each fiscal year and the x-axis is time index.



The y-axis denotes the US monthly interest rate (in percentage) and rchange is the change of interest rate from t-1 to t: Δr_t.

Table 1: Summary Statistics: Dependent Variables and Control Variables

	mean	sd	p25	p75	obs
investment/assets	.081264	.1082389	.0213416	.0995495	162494
Δinvestment/assets	.1869883	19.35171	-.0123375	.0251182	164901
earnings/assets	.0415203	.0415203	.0415203	.1961736	162789
Δretained earnings/assets	-.0636026	.3113865	-.0754273	.0651147	150383
market values/assets	1.799907	2.11331	.7459897	1.916933	173499
Δmarket value	0.148755	1.000064	-.1728309	.3330742	.3330742
acquisition	0.1525369	0.3595416	0	0	173499
Δinterest payment	-.0008447	.0095432	-.0041075	.0023418	97939
sale growth	0.1603756	0.3937623	-.021287	.2485227	155675
log of size	4.518642	2.209834	2.911005	6.054954	170068
tangibility/assets	.3340485	0.274697	.1151969	0.4865062	163910
cash/assets	0.1345651	0.256111	.0155443	0.1501027	152489
leverage	0.2435599	0.2372045	.024187	0.4103273	168399

Summary statistics are based on the annual Consolidated Financial Statements US companies from 1974-2012. All the variables are annual. Mean is the mean of all the observations. Sd is the standard deviation of the variable. p25 (p75) is the critical value at the 25th (75th) percentile. Obs is the number of observations.

Table 2: Summary Statistics: Main Considered Explainable Variables and its components

	mean	sd	p25	p75	obs
$exposure_{i,t-1} \times \Delta r_t$	-.0003586	.0042583	-.0004646	.0001354	131501
$exposure_{i,t-1}$	.1218708	.148663	0.0014034	0.1990906	89824
short-term debt/debt	.3517129	.3607004	.0448834	0.6173995	145145
floating long-term debt/debt	0.2435079	0.342971	0.003	9.21325	106846
short-term debt	12.25736	37.48395	.056	6.5	167753
floating long-term debt	12.25212	48.88848	0.013	3	111135
monthly risk-free rate	.0513289	.0350133	.0216	.0691	468
monthly Δr_t	-.0017254	.019216	-.0082	.0108	468
annual risk-free rate	.058238	.034136	.03145	.0737	39
annual Δr_t	-.002205	.019243	-.0176	.0127	39
long-run r_t	.0701	.0290353	.0463	.0849	39
long-run Δr_t	-.0012949	.0104682	-.0085	.0046	39

Summary statistics are based on the annual Consolidated Financial Statements US companies from 1974-2012. All the variables are annual. Mean is the mean of all the observations. Sd is the standard deviation of the variable. p25 (p75) is the critical value at the 25th (75th) percentile. Obs is the number of observations.

Table 3: Summary Statistics: KZ Index

	mean	sd	p25	p75	obs
KZ	-5.324468	25.2977	-4.41558	.8904605	161707
Cash Flow/Capital Stock	.1062014	5.582171	.2887584	1.433184	163184
Dividends/Capital Stock	.0424449	.1400165	0	.0362727	167149
TobinQ	2.215805	1.699674	1.305222	2.410963	162144
Coverage Ratio	.134987	.3587155	0	.2433819	153764
Positive shock: $\Delta r_t > 0$	.0151647	.0149028	.0018	.02245	17
Negative shock: $\Delta r_t < 0$	-.0161682	.0176046	-.029925	-.002975	22

Summary statistics are based on the annual Consolidated Financial Statements US companies from 1974-2012. All the variables are annual. Mean is the mean of all the observations. Sd is the standard deviation of the variable. p25 (p75) is the critical value at the 25th (75th) percentile. Obs is the number of observations. KZ is defined in Appendix. Coverage is the total interest payment /income.

Table 4: Interest payment changes and Interest shocks (Δr_t) from 1974-2012 in the US

	Δ Interest payment		
VARIABLES	All	Nonconstrained	Constrained
$exposure_{i,t-1} \times \Delta r_t$	**0.127*** **	**0.0872** **	**0.137*** **
	(0.01360)	**(0.03410)**	**(0.03380)**
$exposure_{i,t-1} \times \Delta r_{t-1}$	**0.380*** **	**0.404*** **	**0.382*** **
	(0.01370)	**(0.03510)**	**(0.03450)**
$exposure_{i,t-1}$	0.0221***	0.0181***	0.0188***
	(0.00039)	(0.00091)	(0.00094)
interestdifflag1	-0.0936***	-0.101***	-0.159***
	(0.00492)	(0.01020)	(0.01190)
leverage	0.00899***	0.0133***	0.00968***
	-0.000347	-0.000844	-0.00104
roa	-0.00228***	0.000282	0.000685
	(0.00051)	(0.00080)	(0.00169)
roalag1	-0.0118***	-0.00888***	-0.0189***
	(0.00062)	(0.00087)	(0.00211)
cashlag1	-0.00358***	-0.00227***	-0.00950***
	(0.00042)	(0.00050)	(0.00170)
Constant	0.00243***	4.31E-05	0.00254*
	(0.00037)	(0.00069)	(0.00154)
Observations	42,838	10,793	9,859
R-squared	0.169	0.123	0.182
Number of id	7,694	2,994	3,647

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

In this table, dependent variable : I use the interest payment changes as the cash flow changes which is scaled down by last period's total assets : $(XINT_{it,} - XINT_{i,t-1})/AT_{i,t-1}$. the column "all", represents the whole sample; "non-constrained" represents the financial non-constrained firms defined as the lower 25% quantile of KZ firms; while "constrained " means the financial constrained firms which lies on the upper 75% quantile of KZ. We recall that KZ is the (Kaplan-Zingales index) the constrained measures of firms in our analysis. Independent variable:stexposure$_{i,t}$, is the floating debt (FD$_{i,t}$ =short term debt+long term floating debt) of firm i at time t multiplying the change of interest rate at t (Δr_t) scaled down by A$_{i,t-1}$: $exposure_{i,t-1} \times \Delta r_t = (floatingdebt/assets) \times interest\, rate\, change = (DLTP_{i,t} + DLC_{i,t})/AT_{i,t-1} \times \Delta r_t$. Where $\Delta r_t = r_t - r_{t-1}$is the change of short term interest rate in US(r$_t$represents the monthly fed funds rate.) ; where i stands for firm and t is time index. . $exposure_{i,t-1} \times \Delta r_{t-1}$ is the floating debt at t of firm i multiplying the Δr_{t-1}. $exposure_{i,t-1}$ is the floating debt amount over last period total asset. Mlev is the market leverage ratio which is the total debt (DLC+DLTT) over the market asset (total debt+number of share×price per share). inrerestdifflag1 represents the lag one of the dependent variable: the change of interest payment of last period. Cash is the cash$_{i,t}$/A$_{i,t-1}$and cashlag1 is its lag-one. Roa is the return on asset, which is the current total earnings over current total assets, and its lag one is presented as roalag1. We still control the year effect , r change level and lag one of r change which are not presented in the table.

Table 5: Cash flow changes with positive and negative Interest shocks (Δr_t) from 1974-2012 in US

	ΔINTEREST PAYMENT					
	Positive			Negative		
VARIABLES	All	Nonconstrained	Constrained	All	Nonconstrained	Constrained
$exposure_{i,t-1} \times \Delta r_t$	**0.219*** **	**0.156**	**0.229** **	**0.174*** **	**0.0641**	**0.232*** **
	(0.04560)	**(0.11200)**	**(0.09680)**	**(0.02350)**	**(0.06060)**	**(0.05980)**
$exposure_{i,t-1} \times \Delta r_{t-1}$	**0.536*** **	**0.504*** **	**0.512*** **	**0.360*** **	**0.341*** **	**0.378*** **
	(0.03240)	**(0.08580)**	**(0.06730)**	**(0.01740)**	**(0.04550)**	**(0.04400)**
$exposure_{i,t-1}$	0.0165***	0.0117***	0.0140***	0.0267***	0.0170***	0.0259***
	(0.00077)	(0.00184)	(0.00155)	(0.00069)	(0.00167)	(0.00181)
interestdifflag1	-0.0796***	-0.0646***	-0.129***	-0.0947***	-0.104***	-0.172***
	(0.00798)	(0.01680)	(0.01580)	(0.00711)	(0.01570)	(0.01740)
leverage	0.00902***	0.00923***	0.0106***	0.00832***	0.0132***	0.00872***
	(0.000569)	(0.00147)	(0.00193)	(0.000491)	(0.00120)	(0.00151)
roa	-0.00169*	0.00122	-0.00343	-0.00324***	0.00227*	-0.000812
	(0.00087)	(0.00135)	(0.00243)	(0.00075)	(0.00128)	(0.00251)
roalag1	-0.0124***	-0.00774***	-0.0221***	-0.0107***	-0.00800***	-0.0149***
	(0.00102)	(0.00145)	(0.00287)	(0.00089)	(0.00129)	(0.00307)
cashlag1	-0.00340***	-0.00254***	-0.00932***	-0.00392***	-0.00368***	-0.00897***
	(0.00063)	(0.00077)	(0.00227)	(0.00065)	(0.00082)	(0.00275)
Constant	-0.000765*	-0.000973	-0.00263*	0.000171	-0.000383	0.00171*
	(0.00041)	(0.00078)	(0.00135)	(0.00037)	(0.00071)	(0.00097)
Observations	22,570	5,509	5,408	20,268	5284	5548
R-squared	0.179	0.129	0.23	0.163	0.097	0.173
Number of id	6,528	2,271	2,771	6,496	2,334	2,327

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

At the left panel, present the cash flow changes results with negative interest shocks (Δr_t<0) while the right hand side presents the results with positive shock of intrest rate.The column "all", represents the whole sample; "non-constrained" represents the financial non-constrained firms defined as the lower 25% quantile of KZ firms; while "constrained " means the financial constrained firms which lies on the upper 75% quantile of KZ. In this table,dependent variable : I use the interest payment changes as the cash flow changes which is scaled down by last period's total assets : $(XINT_{it,} - XINT_{i,t-1})/AT_{i,t-1}$.We recall that KZ is the (Kaplan-Zingales index) the constrained measures of firms in our analysis. Independent variable:stexposure$_{i,t}$, is the floating debt (FD$_{i,t}$ =short term debt+long term floating debt) of firm i at time t multiplying the change of interest rate at t (Δr_t) scaled down by A$_{i,t-1}$: $exposure_{i,t-1} \times \Delta r_t$=(floating debt/assets)×interest_change=$(DLTP_{i,t} + DLC_{i,t})/AT_{i,t-1} \times \Delta r_t$. Where Δr_t=r$_t$-r$_{t-1}$is the change of short term interest rate in US. ; where i stands for firm and t is time index. $exposure_{i,t-1} \times \Delta r_{t-1}$ is the floating debt at t of firm i multiplying the Δr_{t-1}. $exposure_{i,t-1}$ is the floating debt amount over last period total asset. Mlev is the market leverage ratio which is the total debt (DLC+DLTT) over the market asset (total debt+number of share×price per share). inrerestdifflag1 represents the lag one of the dependent variable: the change of investment. Cash is the cash$_{i,t}$/A$_{i,t-1}$and cashlag1 is its lag. Roa is the return on asset, which is the current total earnings over last periond's total assets, and its lag one is presented as roalag1. We also contol rchange ($\Delta r_{t)}$ and rchanglag1 (Δr_{t-1}) which are ommitted because of the dummy year effects.We still control the year effect , r change level and lag one of r change which are not presented in the table.

Table 6: Earnings and Interest rate shocks(Δr_t)

	ΔRetained earnings							
	All shocks			Positive shocks			Negativ	
VARIABLES	All	Nonconstraint	Constraint	All	Nonconstraint	VARIABLES	All	Constr
$exposure_{i,t-1} \times \Delta r_t$	**-0.183**	**0.996***	**-0.202**	**3.266**	**0.746**	**0.488**	**-0.739**	**-0.54**
	(0.17400)	**(0.57300)**	**(0.28600)**	**(2.06100)**	**(0.91700)**	**(0.55300)**	**(0.52100)**	**(0.298**
$exposure_{i,t-1} \times \Delta r_{t-1}$	**-0.944*** **	**-0.929**	**-0.993*** **	**-1.726**	**-1.322** **	**-0.473**	**-0.999*** **	**-1.204**
	(0.17400)	**(0.60000)**	**(0.28700)**	**(1.58000)**	**(0.65300)**	**(0.40100)**	**(0.38400)**	**(0.223**
$exposure_{i,t-1}$	-0.0299***	-0.0382**	-0.0199**	-0.0573*	0.000795	-0.0322***	-0.0423***	-0.0397
	(0.00533)	(0.01670)	(0.00822)	(0.03480)	(0.01600)	(0.01020)	(0.01530)	(0.008
leverage	-0.152***	-0.104***	-0.141***	-0.112***	-0.142***	-0.137***	-0.130***	-0.156
	(0.00426)	(0.01500)	(0.00741)	(0.02810)	(0.01250)	(0.00700)	(0.01080)	(0.005
cash	0.105***	0.0406***	0.00166	0.012	-0.0572**	0.0760***	0.0617**	0.159
	(0.00528)	(0.00858)	(0.01600)	(0.01380)	(0.02480)	(0.00772)	(0.02690)	(0.008
tangibility	0.0961***	0.0309	0.192***	-0.0484	0.131***	0.0667***	0.206***	0.115
	(0.00548)	(0.02350)	(0.00964)	(0.03760)	(0.01530)	(0.00848)	(0.01460)	(0.007
salegr	0.0909***	0.0949***	0.0672***	0.0820***	0.0547***	0.0772***	0.0797***	0.105
	(0.00227)	(0.00472)	(0.00427)	(0.00780)	(0.00690)	(0.00349)	(0.00694)	(0.003
rearninglag1	0.189***	0.180***	0.103***	0.188***	0.112***	0.210***	0.147***	0.195
	(0.00388)	(0.00740)	(0.00790)	(0.01280)	(0.01330)	(0.00628)	(0.01260)	(0.005
cashlag1	-0.0315***	-0.0223***	-0.0127	-0.0599***	0.00993	-0.0455***	-0.0264	-0.0448
	(0.00490)	(0.00821)	(0.01190)	(0.01340)	(0.02010)	(0.00745)	(0.01920)	(0.007
Constant	-0.0311***	0.0212*	-0.0812***	0.0511***	-0.0656***	0.0142**	-0.0816***	-0.0422
	(0.00461)	(0.01240)	(0.00858)	(0.01350)	(0.01100)	(0.00608)	(0.01370)	(0.005
Observations	54,535	13,655	17,922	6,597	8,082	25,575	9,840	28,9
R-squared	0.176	0.137	0.154	0.116	0.126	0.148	0.18	0.2
Number of id	9,064	3,562	5,698	2,763	4,011	7,649	4,509	7,92

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

We present the results of all shocks in the first three columns ; the middle three columns with negative interest shocks; the last colunms with positive interest shocks. Dependent variable is the change of retained earnings over total assent $AT_{i,t-1}$: $(RE_{i,t} - RE_{i,t-1})/A_{i,t-1}$. The column "all", represents the whole sample; "non-constrained" represents the non-constrained firms defined as the lower 25% quantile of KZ firms; while "constrained " means the constrained firms which lies on the upper 75% quantile of KZ.We recall that KZ is the (Kaplan-Zingales index) the constrained measures of firms in our analysis. Independent variable:stexposure$_{i,t}$, is the floating debt (FD$_{i,t}$ =short term debt+long term floating debt) of firm i at time t multiplying the change of interest rate at t (Δr_t) scaled down by A$_{i,t-1}$:$exposure_{i,t-1} \times \Delta r_t$=(floating debt/assets)×interest_change=$(DLTP_{i,t} + DLC_{i,t})/AT_{i,t-1} \times \Delta r_t$. Where Δr_t=r$_t$-r$_{t-1}$is the change of short term interest rate in US. ; where i stands for firm and t is time index. .$exposure_{i,t-1} \times \Delta r_{t-1}$ is the floating debt at t of firm i multiplying the Δr_{t-1}. $exposure_{i,t-1}$ is the floating debt amount over last period total asset. Mlev is the market leverage ratio which is the total debt (DLC+DLTT) over the market asset (total debt+number of share×price per share).rearninglag1 represents the lag one of the dependent variable: the change of investment. Cash is the cash$_{i,t}$/A$_{i,t-1}$and cashlag1 is its lag. Roa is the return on asset, which is the current total earnings over last periond's total assets, and its lag one is presented as roalag1. Tangibility is PPENT/A$_{i,t-1}$. Salegr is the sale growth of firm i between t and t-1.We still control the year effect , r change level and lag one of r change which are not presented in the table.

Table 7: Market Value and Interest rate shocks (Δr_t)

	Δ Market values							
	All shocks			Positive shocks			Negative sh	
VARIABLES	All	Nonconstrained	Constrained	All	Nonconstrained	Constrained	All	Nonconstra
$exposure_{i,t-1} \times \Delta r_t$	**-9.532*** **	**-15.12*** **	**-6.553*** **	4.196	6.82	-4.521	**-12.91*** **	-12.31
	(1.33000)	(5.16400)	(1.88500)	(4.93600)	(19.18000)	(7.91100)	(2.01100)	(9.19200
$exposure_{i,t-1} \times \Delta r_{t-1}$	-3.512***	-6.633	0.723	4.625	9.05	6.761	-6.688***	-13.82*
	(1.32300)	(5.21200)	(1.88000)	(3.52200)	(14.24000)	(5.56000)	(1.49100)	(7.15600
$exposure_{i,t-1}$	0.770***	0.967***	0.693***	0.790***	1.017***	0.830***	0.553***	0.860**
	(0.04010)	(0.14800)	(0.05380)	(0.08820)	(0.32400)	(0.13400)	(0.06030)	(0.28300
leverage	-0.988***	-1.366***	-1.271***	-1.378***	-2.114***	-1.663***	-0.738***	-1.105**
	(0.03170)	(0.13200)	(0.04810)	(0.05900)	(0.25800)	(0.10200)	(0.03860)	(0.19300
deltamarketlag1	-0.235***	-0.235***	-0.248***	-0.303***	-0.291***	-0.306***	-0.196***	-0.202**
	(0.00406)	(0.00845)	(0.00761)	(0.00699)	(0.01400)	(0.01530)	(0.00561)	(0.01350
cash	1.754***	1.558***	2.317***	2.093***	1.524***	3.569***	1.356***	1.289**
	(0.03840)	(0.07470)	(0.10200)	(0.06450)	(0.12300)	(0.19300)	(0.05140)	(0.11800
tangibility	0.622***	0.861***	0.719***	0.727***	0.951***	0.762***	0.533***	0.720**
	(0.04100)	(0.20400)	(0.06270)	(0.07160)	(0.32800)	(0.12400)	(0.05160)	(0.32600
salegr	0.776***	1.045***	0.422***	0.898***	1.135***	0.465***	0.691***	0.889**
	(0.01730)	(0.04340)	(0.02780)	(0.03000)	(0.07330)	(0.05720)	(0.02340)	(0.07150
Constant	-0.00997	-0.111	-0.0129	0.144***	0.273**	-0.0542	-0.126***	-0.0117
	(0.03880)	(0.12100)	(0.05440)	(0.04920)	(0.13200)	(0.08790)	(0.03590)	(0.13500
Observations	54,198	14,024	14,325	25,280	6,782	7,730	28,918	6,201
R-squared	0.246	0.268	0.259	0.232	0.218	0.265	0.287	0.344
Number of id	8,791	3,514	3,448	7,389	2,754	3,859	7,737	2,479

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

We present the results of all shocks in the first three columns ; the middle three columns with positive interest shocks; the last colunms with negative interest shocks. Dependent variable is the change of retained earnings over total assent $AT_{i,t-1}$:$(Marketvalue_{i,t} - Marketvalue_{i,t-1})/AT_{i,t-1}$, market value=total debt+number of shares×*price*per share. The column "all", represents the whole sample; "non-constrained" represents the non-constrained firms defined as the lower 25% quantile of KZ firms; while "constrained " means the constrained firms which lies on the upper 75% quantile of KZ. We recall that KZ is the (Kaplan-Zingales index) the constrained measures of firms in our analysis. Independent variable:st$exposure_{i,t}$, is the floating debt ($FD_{i,t}$ =short term debt+long term floating debt) of firm i at time t multiplying the change of interest rate at t (Δr_t) scaled down by $A_{i,t-1}$: $exposure_{i,t-1} \times \Delta r_t = (floatingdebt/assets) \times interest\ change = (DLTP_{i,t} + DLC_{i,t})/AT_{i,t-1} \times \Delta r_t$.. Where $\Delta r_t = r_t - r_{t-1}$is the change of short term interest rate in US. ; where i stands for firm and t is time index. . $exposure_{i,t-1} \times \Delta r_{t-1}$ is the floating debt at t of firm i multiplying the Δr_{t-1}. $exposure_{i,t-1}$ is the floating debt amount over last period total asset. Mlev is the market leverage ratio which is the total debt (DLC+DLTT) over the market asset (total debt+number of share×price per share). deltamarketlag1 represents the lag one of the dependent variable: the change of market value of last period. Cash is the $cash_{i,t}/A_{i,t-1}$. Tangibility is $PPENT/A_{i,t-1}$. Salegr is the sale growth of firm i between t and t-1.We also contol rchange ($\Delta r_{t)}$ and rchanglag1 (Δr_{t-1}) which are ommitted because of the dummy year effects. We still control the year effect , r change level and lag one of r change which are not presented in the table.

Table 8: Investment and interest rate shocks (Δr_t)

VARIABLES	ΔINVESTMENT							
	All shocks			Positive shocks			Negati	
	All	Nonconstraint	Constraint	All	Nonconstraint	Constraint	All	Nonc
$exposure_{i,t-1} \times \Delta r_t$	**-0.165*** **	**-0.0468**	**-0.190** **	**0.185**	**0.132**	**0.574** **	**-0.162***	**-0**
	(0.05290)	**(0.12800)**	**(0.08540)**	**(0.17200)**	**(0.46000)**	**(0.28900)**	**(0.09160)**	**(0.2**
$exposure_{i,t-1} \times \Delta r_{t-1}$	**0.0851**	**-0.0748**	**0.11**	**0.112**	**-0.0301**	**0.0329**	**0.098**	**-0.**
	(0.05270)	**(0.12600)**	**(0.08490)**	**(0.12300)**	**(0.32700)**	**(0.20600)**	**(0.06850)**	**(0.1**
$exposure_{i,t-1}$	0.00777***	-0.00398	0.00784***	0.00315	-0.00162	0.00268	0.0106***	-0.
	(0.00152)	(0.00334)	(0.00240)	(0.00299)	(0.00696)	(0.00500)	(0.00264)	(0.0
invstratiolag1	-0.212***	-0.281***	-0.222***	-0.185***	-0.248***	-0.182***	-0.216***	-0.3
	(0.00438)	(0.00895)	(0.00713)	(0.00725)	(0.01550)	(0.01280)	(0.00626)	(0.0
leverage	-0.00744***	0.0047	-0.0102***	-0.0241***	0.000611	-0.0360***	-0.0206***	0.0
	(0.00172)	(0.00389)	(0.00282)	(0.00229)	(0.00608)	(0.00428)	(0.00196)	(0.0
cashlag1	0.0277***	0.0174***	0.0377***	0.0278***	0.0136***	0.0381***	0.0301***	0.01
	(0.00151)	(0.00176)	(0.00353)	(0.00226)	(0.00275)	(0.00593)	(0.00241)	(0.0
tangibility	0.0806***	0.0888***	0.0886***	0.0914***	0.108***	0.0924***	0.0704***	0.06
	(0.00189)	(0.00535)	(0.00319)	(0.00293)	(0.00835)	(0.00523)	(0.00276)	(0.0
TobinQ	0.00146***	0.000580**	0.00266***	0.000760***	0.000788*	0.000515	0.000973***	0.0
	(0.00021)	(0.00027)	(0.00044)	(0.00029)	(0.00041)	(0.00070)	(0.00035)	(0.0
TobinQlag1	0.00193***	0.00196***	0.00229***	0.00238***	0.00170***	0.00388***	0.00268***	0.00
	(0.00020)	(0.00025)	(0.00044)	(0.00029)	(0.00039)	(0.00073)	(0.00033)	(0.0
salegr	0.0220***	0.0163***	0.0212***	0.0212***	0.0139***	0.0195***	0.0235***	0.01
	(0.00071)	(0.00103)	(0.00130)	(0.00109)	(0.00169)	(0.00221)	(0.00112)	(0.0
Constant	-0.0243***	-0.0201***	-0.00217	-0.0259***	-0.0115***	-0.0208***	-0.0241***	-0.0
	(0.00148)	(0.00272)	(0.00336)	(0.00176)	(0.00363)	(0.00348)	(0.00174)	(0.0
Observations	53,591	13,414	13,149	25,054	6,556	6,436	28,537	6
R-squared	0.169	0.185	0.192	0.146	0.147	0.156	0.163	0
Number of id	9,039	2,601	2,613	7,554	2,783	2,818	7,855	2

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

We present the results of all shocks in the first three columns ; the middle three columns with positive interest shocks; the last colunms with negative interest shocks. The dependent variable is the change of investment of firm i from t-1 to t scaled down by the last year's total asset $A_{i,t-1}$:$(Investment_{i,t} - Investment_{i,t-1})/AT_{i,t-1}$. The column "all", represents the whole sample; "non-constrained" represents the financial non-constrained firms defined as the lower 25% quantile of KZ firms; while "constrained " means the financial constrained firms which lies on the upper 75% quantile of KZ.We recall that KZ is the (Kaplan-Zingales index) the constrained measures of firms in our analysis. Independent variable:st$exposure_{i,t}$, is the floating debt ($FD_{i,t}$ =short term debt+long term floating debt) of firm i at time t multiplying the change of interest rate at t (Δr_t) scaled down by $A_{i,t-1}$: $exposure_{i,t-1} \times \Delta r_t = (floatingdebt/assets) \times interes\,change = (DLTP_{i,t} + DLC_{i,t})/AT_{i,t-1} \times \Delta r_t$. Where $\Delta r_t = r_t - r_{t-1}$is the change of short term interest rate in US. ; where i stands for firm and t is time index. $exposure_{i,t-1} \times \Delta r_{t-1}$ is the floating debt at t of firm i multiplying the Δr_{t-1}. $exposure_{i,t-1}$ is the floating debt amount over last period total asset. Mlev is the market leverage ratio which is the total debt (DLC+DLTT) over the market asset (total debt+number of share×price per share). **invstratiolag1** represents the lag one of the dependent variable: the change of investment. Cash is the $cash_{i,t}/A_{i,t-1}$.. Tangibility is $PPENT/A_{i,t-1}$. Salegr is the sale growth of firm i between t and t-1.TobinQ is the market

Table 9: Investment and Interest shocks (Δr_t) with different leverage levels

	ΔINVESTMENT							
	All shocks			Positive shocks			Negative sho	
VARIABLES	All	Low	High	All	Low	High	All	Low
$exposure_{i,t-1} \times \Delta r_t$	**-0.165*** **	**-0.105**	**-0.122***	**0.185**	**-1.084**	**0.744****	**-0.162***	**-4.043**
	(0.05290)	**(0.15400)**	**(0.07010)**	**(0.17200)**	**(1.25100)**	**(0.35500)**	**(0.09160)**	**(2.46100**
$exposure_{i,t-1} \times \Delta r_{t-1}$	**0.0851**	**0.242**	**0.0608**	**0.112**	**0.619**	**-0.203**	**0.098**	**-0.89**
	(0.05270)	**(0.14700)**	**(0.06970)**	**(0.12300)**	**(1.28200)**	**(0.26000)**	**(0.06850)**	**(1.98300**
$exposure_{i,t-1}$	0.00777***	0.0107***	0.00484**	0.00315	0.124***	-0.00187	0.0106***	0.0555
	(0.00152)	(0.00380)	(0.00197)	(0.00299)	(0.02770)	(0.00626)	(0.00264)	(0.07200
invstratiolag1	-0.212***	-0.231***	-0.225***	-0.185***	-0.259***	-0.222***	-0.216***	-0.238**
	(0.00438)	(0.00628)	(0.00651)	(0.00725)	(0.00939)	(0.01730)	(0.00626)	(0.01480
leverage	-0.00744***	-0.0101	-0.00999***	-0.0241***	-0.329***	-0.0341***	-0.0206***	-0.179
	(0.00172)	(0.00732)	(0.00253)	(0.00229)	(0.07530)	(0.00633)	(0.00196)	(0.11600
cash	-0.00450***	-0.00525***	0.000434	-0.00345	-0.00950***	0.0029	-0.00736***	-0.0143**
	(0.00169)	(0.00191)	(0.00427)	(0.00246)	(0.00265)	(0.01300)	(0.00276)	(0.00418
cashlag1	0.0277***	0.0291***	0.0301***	0.0278***	0.0379***	0.0531***	0.0301***	0.0310**
	(0.00151)	(0.00172)	(0.00368)	(0.00226)	(0.00304)	(0.01260)	(0.00241)	(0.00378
tangibility	0.0806***	0.102***	0.0762***	0.0914***	0.113***	0.0862***	0.0704***	0.0975**
	(0.00189)	(0.00316)	(0.00273)	(0.00293)	(0.00535)	(0.00645)	(0.00276)	(0.00880
TobinQ	0.00146***	0.00120***	0.00358***	0.000760***	0.000789***	0.00489	0.000973***	0.00148*
	(0.00021)	(0.00023)	(0.00088)	(0.00029)	(0.00030)	(0.00338)	(0.00035)	(0.00085
TobinQlag1	0.00193***	0.00193***	0.00154**	0.00238***	0.00253***	0.00912***	0.00268***	0.00216**
	(0.00020)	(0.00022)	(0.00069)	(0.00029)	(0.00029)	(0.00231)	(0.00033)	(0.00056
salegr	0.0220***	0.0213***	0.0206***	0.0212***	0.0203***	0.0150***	0.0235***	0.0205**
	(0.00071)	(0.00095)	(0.00116)	(0.00109)	(0.00136)	(0.00283)	(0.00112)	(0.00235
Constant	-0.0243***	-0.00658**	-0.0257***	-0.0259***	0.0108	-0.0425***	-0.0241***	-0.0203**
	(0.00148)	(0.00318)	(0.00257)	(0.00176)	(0.00786)	(0.00639)	(0.00174)	(0.00484
Observations	53,591	12,724	12,867	25,054	6,233	6,249	28,537	6,333
R-squared	0.169	0.174	0.176	0.146	0.187	0.168	0.163	0.178
Number of id	9,039	5,956	6,187	7,554	2,621	3,097	7,855	2,621

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

We present the results of all shocks in the first three columns ; the middle three columns with positive interest shocks; the last colunms with negative interest shocks. The dependent variable is the change of investment of firm i from t-1 to t scaled down by the last year's total asset $A_{i,t-1}$:$(Investment_{i,t} - Investment_{i,t-1})/AT_{i,t-1}$. The column "all", represents the whole sample; "LOW" represents the low leveraged firms defined as the lower 50% quantile of leverage firms; while "High " means the high lerveage ratio firms which lies on the upper quantile of Mlev. Mlev is the market leverage ratio which is the total debt (DLC+DLTT) over the market asset (total debt+number of share×price per share). Other Independent variables :stexposure$_{i,t}$, is the floating debt ($FD_{i,t}$ =short term debt+long term floating debt) of firm i at time t multiplying the change of interest rate at t (Δr_t) scaled down by $A_{i,t-1}$: $exposure_{i,t-1} \times \Delta r_t = (floatingdebt/assets) \times interest\ change = (DLTP_{i,t} + DLC_{i,t})/AT_{i,t-1} \times \Delta r_t$. Where $\Delta r_t = r_t - r_{t-1}$is the change of short term interest rate in US. ; where i stands for firm and t is time index. . stexposure$_{i,t-1}$ is lag one of stexposure$_{i,t}$: the floating debt at t of firm i multiplying the Δr_{t-1}. Fdebt1 is the floating debt amount over last period total asset. **invstratiolag1** represents the lag one of the dependent variable: the change of investment of last period. Cash is the $cash_{i,t}/A_{i,t-1}$.. Tangibility is

Table 10: Investment and interest rate(Δr_t): before and after 2008

	ΔINVESTMENT					
	Before 2008			After 2008		
VARIABLES	All	Nonconstrained	Constrained	All	Nonconstraint	constraint
$exposure_{i,t-1} \times \Delta r_t$	**-0.214*** **	**-0.169**	**-0.270*** **	**0.0102**	**0.0453**	**-0.271**
	(0.060)	**(0.163)**	**(0.096)**	**(0.129)**	**(0.233)**	**(0.337)**
$exposure_{i,t-1} \times \Delta r_{t-1}$	**0.0968**	**0.0737**	**0.109**	**-0.233* **	**-0.501* **	**-0.562* **
	(0.059)	**(0.158)**	**(0.094)**	**(0.141)**	**(0.268)**	**(0.331)**
$exposure_{i,t-1}$	0.00849***	-0.00308	0.00853***	-0.00711*	-0.00966	-0.00644
	(0.00174)	(0.00432)	(0.00270)	(0.00431)	(0.00688)	(0.01060)
invstratiolag1	-0.225***	-0.301***	-0.234***	-0.247***	-0.335***	-0.197***
	-0.00476	-0.0103	-0.00763	(0.01300)	(0.02110)	(0.03630)
leverage	-0.00830***	0.00665	-0.0102***	-0.00393	-0.00347	-0.0208*
	(0.00198)	(0.00497)	(0.00319)	(0.00423)	(0.00744)	(0.01110)
mlevlag1	-0.0273***	-0.0144***	-0.0346***			
	(0.00178)	(0.00398)	(0.00289)			
cash	-0.00350*	-0.00355	-0.0131***	-0.00443	-0.00701*	0.002
	(0.00188)	(0.00232)	(0.00502)	(0.00349)	(0.00378)	(0.01300)
cashlag1	0.0302***	0.0200***	0.0424***	0.0205***	0.00904***	0.0269**
	(0.00174)	(0.00214)	(0.00409)	(0.00317)	(0.00328)	(0.01200)
tangibility	0.0890***	0.108***	0.0968***	0.0837***	0.0645***	0.0898***
	(0.00217)	(0.00669)	(0.00359)	(0.00743)	(0.01340)	(0.01920)
TobinQ	0.00170***	0.000990***	0.00300***	0.00142*	0.00119	-0.00111
	(0.00024)	(0.00033)	(0.00051)	(0.00079)	(0.00086)	(0.00321)
TobinQlag1	0.00195***	0.00186***	0.00256***	0.00328***	0.00297***	0.00257
	(0.00023)	(0.00030)	(0.00051)	(0.00053)	(0.00059)	(0.00228)
salegr	0.0219***	0.0165***	0.0211***	0.0168***	0.0103***	0.0174***
	(0.00080)	(0.00124)	(0.00144)	(0.00161)	(0.00196)	(0.00483)
Constant	-0.0268***	-0.0235***	-0.0213***	-0.0241***	-0.00867***	-0.0165
	(0.00160)	(0.00302)	(0.00345)	(0.00244)	(0.00255)	(0.01010)
Observations	45,691	10,493	10,377	7,059	2,052	1,455
R-squared	0.171	0.197	0.194	0.262	0.26	0.295
Number of id	8,492	3,198	3,111	2,528	1,183	782

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

We present the results before 2008 in the first three columns ;the last colunms contains the results with shocks after 2008. The dependent variable is the change of investment of firm i from t-1 to t scaled down by the last year's total asset $A_{i,t-1}$:$(Investment_{i,t} - Investment_{i,t-1})/AT_{i,t-1}$. The column "all", represents the whole sample; "non-constrained" represents the financial non-constrained firms defined as the lower 25% quantile of KZ firms; while "constrained " means the financial constrained firms which lies on the upper 75% quantile of KZ.We recall that KZ is the (Kaplan-Zingales index) the constrained measures of firms in our analysis. Independent variable:stexposure$_{i,t}$, is the floating debt ($FD_{i,t}$ =short term debt+long term floating debt) of firm i at time t multiplying the change of interest rate at t (Δr_t) scaled down by $A_{i,t-1}$: $exposure_{i,t-1} \times \Delta r_t$=(floating debt/assets)×interest_change=$(DLTP_{i,t} + DLC_{i,t})/AT_{i,t-1} \times \Delta r_t$. Where Δr_t=r_t-$r_{t-1}$is the change of short term interest rate in US. ; where i stands for firm and t is time index.$exposure_{i,t-1} \times \Delta r_{t-1}$ is the floating debt at t of firm i multiplying the Δr_{t-1}. $exposure_{i,t-1}$ is the floating debt amount over last period total asset. Mlev is the market leverage

Table 11: Acquisition Probit Model with interest rate shocks (Δr_t)

		Aquisition		
EQUATION	VARIABLES	All	Conconstrained	Constrained
acquisition	$exposure_{i,t-1} \times \Delta r_t$	**4.571***	**-9.875**	**7.680****
		(2.508)	**(7.089)**	**(3.780)**
	$exposure_{i,t-1} \times \Delta r_{t-1}$	**6.677****	**15.12****	**5.937**
		(2.600)	**(7.220)**	**(4.025)**
	rchange	71.11***	39.77	109.5**
		(25.090)	(40.160)	(49.600)
	rchangelag1	5.451	9.982	0.0567
		(4.463)	(8.053)	(8.794)
	$exposure_{i,t-1}$	1.870***	1.763***	1.572***
		(0.06560)	(0.17200)	(0.09140)
	invstratiolag1	0.16	0.176	0.0448
		(0.20600)	(0.59600)	(0.30400)
	leverage	0.269***	0.590***	-0.151*
		(0.05060)	(0.14300)	(0.08060)
	cashlag1	0.0712	0.00865	0.286**
		(0.05340)	(0.08470)	(0.11300)
	tangibility	-0.153***	-0.572***	-0.0401
		(0.03650)	(0.14500)	(0.05400)
	TobinQ	-0.0918***	-0.0819***	-0.152***
		(0.01290)	(0.02180)	(0.02540)
	TobinQlag1	0.0455***	0.0539***	0.0182
		(0.00843)	(0.01360)	(0.01610)
	salegr	1.062***	0.926***	1.027***
		(0.02960)	(0.05610)	(0.04840)
	Constant	-0.974***	-1.016***	-0.713***
		(0.03690)	(0.06190)	(0.07630)
	Observations	46,423	12,765	13,362

In this table, we present the probit model with acquisition which is the dependent variable is defined as follows: acquisition=1 if firm have acuisitions at year t; otherwise acquisition=0. The column "all", represents the whole sample; "non-constrained" represents the financial non-constrained firms defined as the lower 25% quantile of KZ firms; while "constrained " means the financial constrained firms which lies on the upper 75% quantile of KZ.We recall that KZ is the (Kaplan-Zingales index) the constrained measures of firms in our analysis. Independent variable:stexposure$_{i,t}$, is the floating debt (FD$_{i,t}$ =short term debt+long term floating debt) of firm i at time t multiplying the change of interest rate at t (Δr_t) scaled down by A$_{i,t-1}$: $exposure_{i,t-1} \times \Delta r_t$=(floating debt/assets)×interest_change=$(DLTP_{i,t} + DLC_{i,t})/AT_{i,t-1} \times \Delta r_t$.. Where Δr_t=r$_t$-r$_{t-1}$is the change of short term interest rate in US. ; where i stands for firm and t is time index.$exposure_{i,t-1} \times \Delta r_{t-1}$ is the floating debt at t of firm i multiplying the Δr_{t-1}. $exposure_{i,t-1}$ is the floating debt amount over last period total asset. Mlev is the market leverage ratio which is the total debt (DLC+DLTT) over the market asset (total debt+number of share×price per share). **invstratiolag1** represents the lag one of the dependent variable: the change of investment. Cash is the cash$_{i,t}$/A$_{i,t-1}$.. Tangibility is PPENT/A$_{i,t-1}$. Salegr is the sale growth of firm i between t and t-1.TobinQ is the market value of firm i over the book value of firm i at time t; Tobinlag1 is the lag one of TobinQ.We also contol rchange ($\Delta r_{t)}$ and rchanglag1 (Δr_{t-1}) .

Table 12: Acquisitions with different shocks(Δr_t)

	Aquisition					
	Positive			Negative		
VARIABLES	All	Nonconstrained	Constrained	All	Nonconstrained	Constrained
$exposure_{i,t-1} \times \Delta r_t$	**-4.329*** **	**-1.691**	**-4.564***	**1.579** **	**-5.553***	**2.335***
	(1.62100)	**(6.39900)**	**(2.65300)**	**(0.78700)**	**(2.92600)**	**(1.22100)**
$exposure_{i,t-1} \times \Delta r_{t-1}$	**0.681**	**-1.5**	**-0.192**	**1.727*** **	**3.541**	**1.873** **
	(1.16300)	**(4.61100)**	**(1.89100)**	**(0.58300)**	**(2.20500)**	**(0.88500)**
$exposure_{i,t-1}$	0.481***	0.602***	0.406***	0.395***	0.441***	0.359***
	(0.02820)	(0.09830)	(0.04480)	(0.02270)	(0.07960)	(0.03500)
leverage	0.194***	0.15	0.104**	0.173***	0.292***	0.0195
	(0.02770)	(0.09910)	(0.04730)	(0.02060)	(0.07590)	(0.03340)
mlevlag1	-0.427***	-0.381***	-0.423***	-0.369***	-0.436***	-0.301***
	(0.02430)	(0.08080)	(0.04110)	(0.01880)	(0.06400)	(0.03050)
cashlag1	0.204***	0.200***	0.236***	0.209***	0.141***	0.226***
	(0.02060)	(0.03780)	(0.05080)	(0.01890)	(0.03660)	(0.04180)
tangibility	0.317***	0.378***	0.404***	0.292***	0.305***	0.373***
	(0.02510)	(0.10800)	(0.04440)	(0.02130)	(0.10100)	(0.03520)
TobinQ	-0.0123***	-0.0266***	0.000596	-0.00636**	-0.0133**	-0.00606
	(0.00279)	(0.00565)	(0.00630)	(0.00299)	(0.00612)	(0.00613)
TobinQlag1	0.0031	0.00932*	-0.00166	-0.00423	6.29E-05	-0.0116*
	(0.00268)	(0.00510)	(0.00601)	(0.00284)	(0.00568)	(0.00594)
salegr	0.197***	0.162***	0.198***	0.192***	0.188***	0.162***
	(0.00992)	(0.02310)	(0.01900)	(0.00931)	(0.02310)	(0.01600)
Constant	-0.0192	0.0307	0.0463	-0.0393***	-0.0409	0.0474*
	(0.01680)	(0.04480)	(0.03570)	(0.01490)	(0.04150)	(0.02780)
Observations	29,992	7,231	7,388	34,637	7,719	8,073
R-squared	0.088	0.061	0.122	0.082	0.058	0.103
Number of id	8,486	3,027	4,990	8,933	3,084	4,638

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

In this table, we present the within estimator model with acquisition which is the dependent variable is defined as follows: acquisition=1 if firm have acuisitions at year t; otherwise acquisition=0. The first three columns represnt the negative shocks while the last columns presents the positive shocks. The column "all", represents the whole sample; "non-constrained" represents the financial non-constrained firms defined as the lower 25% quantile of KZ firms; while "constrained " means the financial constrained firms which lies on the upper 75% quantile of KZ.We recall that KZ is the (Kaplan-Zingales index) the constrained measures of firms in our analysis. Independent variable:stexposure$_{i,t}$, is the floating debt (FD$_{i,t}$ =short term debt+long term floating debt) of firm i at time t multiplying the change of interest rate at t (Δr_t) scaled down by A$_{i,t-1}$: $exposure_{i,t-1} \times \Delta r_t = (floatingdebt/assets) \times interest\,change = (DLTP_{i,t} + DLC_{i,t})/AT_{i,t-1} \times \Delta r_t$. Where Δr_t=r$_t$-r$_{t-1}$is the change of short term interest rate in US. ; where i stands for firm and t is time index. $exposure_{i,t-1} \times \Delta r_{t-1}$ is the floating debt at t of firm i multiplying the Δr_{t-1}. $exposure_{i,t-1}$ is the floating debt amount over last period total asset. Mlev is the market leverage ratio which is the total debt (DLC+DLTT) over the market asset (total debt+number of share×price per share). **invstratiolag1** represents the lag one of the dependent variable: the change of investment. Cash is the cash$_{i,t}$/A$_{i,t-1}$.. Tangibility is PPENT/A$_{i,t-1}$. Salegr is the sale growth of firm i between t and t-1.TobinQ is the market value of firm i over the book value of firm i at time t; Tobinlag1 is

Table 13: Short-term debts and interest shocks (Δr_t)

	INVESTMENT							
	All			Positive			N	
VARIABLES	All	Nonconstrained	Constrained	All	Nonconstrained	Constrained	All	Nonc
$short\,debt \times \triangle r_t$	**-0.132****	**0.203****	**-0.17**	**0.854*****	**-0.0588**	**1.662*****	**-0.421*****	**0**
	(0.06060)	**(0.09570)**	**(0.11000)**	**(0.17100)**	**(0.37400)**	**(0.35100)**	**(0.09260)**	**(0.**
$short\,debt \times \triangle r_{t-1}$	**-0.182*****	**0.0271**	**-0.255*****	**-0.483*****	**0.0851**	**-0.851*****	**-0.263*****	**0**
	(0.05400)	**(0.08350)**	**(0.09180)**	**(0.14500)**	**(0.36900)**	**(0.25000)**	**(0.07010)**	**(0.**
shortdebt	-0.000789	0.000201	0.0011	-0.00327***	0.000714	-0.00493*	-0.000809	-1.
	(0.00059)	(0.00082)	(0.00153)	(0.00100)	(0.00139)	(0.00299)	(0.00092)	(0
invstratiolag1	-0.200***	-0.283***	-0.200***	-0.180***	-0.289***	-0.156***	-0.203***	-0.
	(0.00376)	(0.00918)	(0.00667)	(0.00620)	(0.01580)	(0.01170)	(0.00531)	(0
leverage	-0.00615***	-7.68E-05	-0.0130***	-0.0254***	-0.00545	-0.0331***	-0.0215***	-0
	(0.00135)	(0.00289)	(0.00261)	(0.00180)	(0.00460)	(0.00401)	(0.00154)	(0
cash	-0.000574	0.00243	-0.000438	-0.000193	0.00672**	0.00515	-0.00389	-0
	(0.00169)	(0.00203)	(0.00514)	(0.00249)	(0.00312)	(0.00790)	(0.00274)	(0
cashlag1	0.0293***	0.0177***	0.0437***	0.0300***	0.0144***	0.0483***	0.0321***	0.0
	(0.00154)	(0.00191)	(0.00391)	(0.00234)	(0.00304)	(0.00629)	(0.00244)	(0
tangibility	0.0745***	0.0804***	0.0796***	0.0822***	0.0765***	0.0809***	0.0683***	0.0
	(0.00153)	(0.00487)	(0.00284)	(0.00230)	(0.00739)	(0.00442)	(0.00223)	(0
TobinQ	0.00160***	-1.74E-05	0.00239***	0.000794***	-0.000188	0.000925	0.000247	-0
	(0.00021)	(0.00028)	(0.00050)	(0.00030)	(0.00041)	(0.00076)	(0.00037)	(0
TobinQlag1	0.00198***	0.00212***	0.00181***	0.00293***	0.00202***	0.00327***	0.00317***	0.0
	(0.00021)	(0.00027)	(0.00051)	(0.00030)	(0.00040)	(0.00074)	(0.00034)	(0
salegr	0.0241***	0.0165***	0.0211***	0.0237***	0.0180***	0.0206***	0.0259***	0.0
	(0.00064)	(0.00106)	(0.00123)	(0.00098)	(0.00165)	(0.00201)	(0.00100)	(0
Constant	-0.0174***	-0.0163***	-0.0202***	-0.0166***	-0.00694**	-0.0107**	-0.0201***	-0.0
	(0.00130)	(0.00240)	(0.00331)	(0.00141)	(0.00277)	(0.00435)	(0.00158)	(0
Observations	70,397	12,927	15,455	32,518	6,175	8,505	37,879	
R-squared	0.167	0.18	0.185	0.154	0.174	0.153	0.157	
Number of id	9,830	3,631	6,630	8,366	2,707	4,895	8,662	

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

In this table, we present the long term floating debt and short term floating debt The column "all", represents the whole sample; "non-constraint"represents the non-constraint firms which is the lower 25% quantile of KZ firms; while "constraint " means the constraint firms which lies on the upper 75% quantile of KZ. KZ is the (Kaplan-Zingales index) the constraint measure of firms. Dependent variable is the change of investment of firm i from t-1 to t scaled down by last year's total asset $A_{i,t-1}$; where i stands for firm and t is time index.stexposure$_{i,t-1}$ is lag one of stexposure$_{i,t}$: the floating debt at t of firm i multiplying the Δr_{t-1}. Shortdebt$_{i,t}$,× $\Delta r_t$is the short term debt of firm i at time t multiplied by the change of interest rate at t (Δr_t) scaled down by $A_{i,t-1}$. Where $r_t$represents the monthly fed funds rate. Short debt1 is : the short term debt at t of firm i multiplying the Δr_{t-1}. Cash is the cash$_{i,t}/A_{i,t-1}$and cashlag1 is its lag. Tangibility is PPENT/$A_{i,t-1}$. Mlev is the market leverage ratio of firms: $total\,debt\,/\,the\,market\,value\,of\,firms$. TobinQ is the market value of firm i over the book value of firm i at time t; Tobinlag1 is the lag one of TobinQ. Salegr is the sale growth of firm i between t and t-1.

Table 14: Long-term floating debts and Interest shocks (Δr_t)

	INVESTMENT							
	All shocks			Positive			Negative	
VARIABLES	All	Nonconstrained	Constrained	All	Nonconstrained	Constrained	All	Nonconstrained
$f\,long\,debt \times \triangle r_t$	**-0.189*** **	**-0.109**	**-0.145**	**-0.11**	**-0.411**	**0.19**	**-0.368*** **	**-0.028**
	(0.05600)	**(0.13400)**	**(0.09330)**	**(0.17300)**	**(0.47500)**	**(0.31300)**	**(0.09400)**	**(0.21500)**
$f\,long\,debt \times \triangle r_{t-1}$	**0.0992***	**-0.0713**	**0.173***	**0.182**	**0.254**	**0.118**	**0.0762**	**-0.0369**
	(0.05460)	(0.09150)	(0.10300)	(0.12700)	(0.36600)	(0.23100)	(0.07020)	(0.14000)
flongdebt	0.0017	-0.00293	-0.0024	0.00413	0.00364	0.00414	-0.000284	-0.00262
	(0.00138)	(0.00291)	(0.00245)	(0.00270)	(0.00617)	(0.00528)	(0.00238)	(0.00554)
invstratiolag1	-0.211***	-0.280***	-0.209***	-0.188***	-0.243***	-0.154***	-0.214***	-0.307***
	(0.00432)	(0.00826)	(0.00847)	(0.00718)	(0.01450)	(0.01580)	(0.00617)	(0.01190)
leverage	-0.00529***	0.00139	-0.00895***	-0.0219***	-0.00176	-0.0346***	-0.0177***	-2.20E-05
	(0.00161)	(0.00322)	(0.00330)	(0.00213)	(0.00519)	(0.00531)	(0.00180)	(0.00398)
cash	-0.00442***	-0.00268	-0.00593	-0.00283	0.00134	0.00256	-0.00736***	-0.00203
	(0.00159)	(0.00169)	(0.00578)	(0.00234)	(0.00264)	(0.00935)	(0.00258)	(0.00279)
cashlag1	0.0265***	0.0174***	0.0326***	0.0266***	0.0133***	0.0363***	0.0292***	0.0173***
	(0.00147)	(0.00158)	(0.00441)	(0.00221)	(0.00250)	(0.00753)	(0.00235)	(0.00258)
tangibility	0.0792***	0.0953***	0.0847***	0.0912***	0.113***	0.0899***	0.0692***	0.0730***
	(0.00185)	(0.00477)	(0.00380)	(0.00286)	(0.00757)	(0.00624)	(0.00270)	(0.00729)
TobinQ	0.00153***	0.000296	0.00286***	0.000927***	0.000356	0.00095	0.000863**	0.000394
	(0.00020)	(0.00024)	(0.00055)	(0.00029)	(0.00037)	(0.00087)	(0.00034)	(0.00041)
TobinQlag1	0.00195***	0.00172***	0.00192***	0.00231***	0.00125***	0.00264***	0.00271***	0.00184***
	(0.00020)	(0.00022)	(0.00056)	(0.00028)	(0.00034)	(0.00091)	(0.00033)	(0.00038)
salegr	0.0220***	0.0155***	0.0190***	0.0213***	0.0143***	0.0181***	0.0232***	0.0165***
	(0.00069)	(0.00093)	(0.00151)	(0.00107)	(0.00154)	(0.00258)	(0.00109)	(0.00154)
Constant	-0.0236***	-0.00899***	-0.0184***	-0.0251***	-0.0187***	-0.0190***	-0.0172***	-0.0183***
	(0.00147)	(0.00265)	(0.00437)	(0.00172)	(0.00272)	(0.00462)	(0.00177)	(0.00269)
Observations	54,805	15,333	16,877	25,626	7,357	7,597	29,179	7,976
R-squared	0.168	0.181	0.189	0.147	0.144	0.149	0.16	0.195
Number of id	9,147	3,851	5,454	7,673	3,009	3,825	7,950	3,042

In this table, only the short-term debt int Table 10 is replaced by the long-term floating debt.f_long_debt is the long term floating debt of firm i at time t multiplied by the change of interest rate at t (Δr_t) scaled down by $A_{i,t-1}$: $DLTP_{i,t} \times \Delta r_t / AT_{i,t-1}$. F_long_debt$\times \triangle r_{t-1}$ is equal to $DLTP_{i,t} \times \Delta r_{t-1}$ scaled down by $A_{i,t-1}$. flonglong debt is $DLTP_{i,t}/AT_{i,t-1}$. And all the other variables are the same in Table10.

Table 15: R&D and Interest rate shocks (Δr_t)

	INVESTMENT							
	All shocks			Positive			N	
VARIABLES	All	Nonconstrained	Constrained	All	Nonconstrained	Constrained	All	Non
$exposure_{i,t-1} \times \Delta r_t$	0.122*	0.337	0.196**	0.0553	-0.265	0.193	0.0457	
	(0.06550)	(0.24600)	(0.08130)	(0.22600)	(0.79900)	(0.38300)	(0.10300)	(
$exposure_{i,t-1} \times \Delta r_{t-1}$	-0.170***	0.205	-0.178**	-0.299*	-0.0352	-0.425	-0.140*	
	(0.06590)	(0.21900)	(0.08270)	(0.15900)	(0.56800)	(0.26800)	(0.07830)	(
exposure	0.00549***	-0.00927	0.00732***	0.0133***	0.00666	0.0104*	9.67E-05	
	(0.00185)	(0.00591)	(0.00225)	(0.00367)	(0.01180)	(0.00592)	(0.00298)	(
RDlag1	-0.0631***	-0.0931***	-0.0535***	-0.0527***	-0.0605***	-0.188***	-0.0392***	-0
	(0.00536)	(0.01030)	(0.00921)	(0.00856)	(0.01580)	(0.02220)	(0.00773)	(
leverage	0.00414*	0.00436	0.00424	0.00656*	0.000252	0.00151	0.00151	0
	(0.00218)	(0.00750)	(0.00279)	(0.00379)	(0.01310)	(0.00559)	(0.00278)	(
cash	0.00741***	0.00604*	0.0106**	0.0118***	0.00269	0.0243***	-0.00642**	-
	(0.00197)	(0.00358)	(0.00454)	(0.00288)	(0.00518)	(0.00939)	(0.00292)	(
cashlag1	0.0220***	0.0246***	0.0312***	0.00700**	0.0127**	0.0276***	0.0359***	0
	(0.00182)	(0.00334)	(0.00338)	(0.00276)	(0.00492)	(0.00766)	(0.00263)	(
tangibility	0.0166***	0.0392***	0.0109***	0.0181***	0.0404**	0.0221***	0.0151***	0
	(0.00236)	(0.01110)	(0.00307)	(0.00364)	(0.01610)	(0.00630)	(0.00320)	(
TobinQ	4.25E-05	-6.32E-05	0.000128	0.000935***	0.00190***	0.000832	-0.00125***	-0
	(0.00025)	(0.00050)	(0.00041)	(0.00035)	(0.00072)	(0.00078)	(0.00039)	(
TobinQlag1	0.00487***	0.00609***	0.00372***	0.00433***	0.00531***	0.00155*	0.00436***	0.
	(0.00024)	(0.00047)	(0.00042)	(0.00034)	(0.00068)	(0.00083)	(0.00037)	(
salegr	0.0182***	0.0257***	0.0123***	0.0176***	0.0195***	0.00706***	0.0155***	0
	(0.00072)	(0.00152)	(0.00108)	(0.00110)	(0.00221)	(0.00226)	(0.00108)	(
Constant	-0.00574***	-0.0153***	-0.00799**	-0.00787***	-0.0131*	-0.0119***	-0.00661***	-0
	(0.00218)	(0.00550)	(0.00357)	(0.00258)	(0.00674)	(0.00458)	(0.00229)	(
Observations	35,922	10,471	10,046	16,932	5,157	4,608	18,990	
R-squared	0.092	0.134	0.075	0.078	0.103	0.07	0.084	
Number of id	5,980	2,713	2,999	5,036	2,136	2,357	5,193	

In this table, the dependent variable is replace by RD: ($XRD_{i,t}$-$XRD_{i,t-1}$)$\times\Delta r_t/AT_{i,t-1}$. All the other variables are the same as previous tables.

Table 16: Invetment and Interest shocks with long-rate control

	INVESTMENT						
	All			Positive			
VARIABLES	All	Constrained	Nonconstrained	All	Constrained	Nonconstrained	All
$exposure_{i,t-1} \times \Delta r_t$	**-0.216*** **	**-0.225**	**-0.232**	**0.634** **	**0.597**	**0.792**	**-0.216* **
	(0.07110)	**(0.16300)**	**(0.15300)**	**(0.29300)**	**(0.59800)**	**(0.75400)**	**(0.12000)**
$exposure_{i,t-1} \times \Delta r_{t-1}$	**-0.0868**	**-0.268**	**-0.14**	**0.058**	**-0.34**	**-0.0247**	**-0.13**
	(0.07280)	**(0.18900)**	**(0.14800)**	**(0.28000)**	**(0.63200)**	**(0.69000)**	**(0.08590)**
exposure	0.0123***	-0.00348	0.00832*	-0.00314	-0.0047	-0.00925	0.0142***
	(0.00195)	(0.00410)	(0.00433)	(0.00448)	(0.00929)	(0.01080)	(0.00359)
exposure_longrate	0.633***	0.506	1.497***	-0.318	-0.659	0.591	0.631***
	(0.16300)	(0.44200)	(0.34200)	(0.47000)	(0.98900)	(1.15500)	(0.20900)
exposure_longrate1	0.132	0.0954	-0.124	-0.201	0.0723	-0.537	0.0236
	(0.14900)	(0.46200)	(0.30900)	(0.47600)	(1.09100)	(1.13700)	(0.19100)
invstratiolag1	-0.213***	-0.298***	-0.212***	-0.189***	-0.297***	-0.148***	-0.216***
	(0.00488)	(0.01020)	(0.01120)	(0.00817)	(0.01490)	(0.02220)	(0.00704)
leverage	-0.0216***	0.0027	-0.0284***	-0.0203***	-0.00563	-0.0361***	-0.0206***
	(0.00161)	(0.00378)	(0.00403)	(0.00268)	(0.00584)	(0.00785)	(0.00230)
cash	-0.00765***	-0.00789***	-0.0119*	-0.00570*	-0.00609*	-0.00994	-0.0114***
	(0.00215)	(0.00249)	(0.00714)	(0.00315)	(0.00356)	(0.01220)	(0.00350)
cashlag1	0.0354***	0.0184***	0.0421***	0.0349***	0.0205***	0.0487***	0.0350***
	(0.00205)	(0.00236)	(0.00605)	(0.00306)	(0.00350)	(0.01110)	(0.00327)
tangibility	0.0820***	0.0807***	0.0955***	0.0907***	0.0859***	0.103***	0.0691***
	(0.00212)	(0.00592)	(0.00500)	(0.00328)	(0.00770)	(0.00874)	(0.00314)
TobinQ	0.00119***	0.00124***	0.00162*	0.000942**	0.00127**	9.18E-05	0.00106**
	(0.00031)	(0.00039)	(0.00092)	(0.00044)	(0.00056)	(0.00146)	(0.00053)
TobinQlag1	0.00360***	0.00270***	0.00503***	0.00314***	0.00275***	0.00443***	0.00395***
	(0.00029)	(0.00037)	(0.00085)	(0.00043)	(0.00054)	(0.00143)	(0.00048)
salegr	0.0226***	0.0159***	0.0184***	0.0219***	0.0177***	0.0145***	0.0244***
	(0.00081)	(0.00118)	(0.00192)	(0.00127)	(0.00177)	(0.00357)	(0.00130)
Constant	-0.0273***	-0.0184***	-0.0333***	-0.0264***	-0.0158***	-0.00774	-0.0242***
	(0.00185)	(0.00307)	(0.00554)	(0.00223)	(0.00325)	(0.00837)	(0.00215)
Observations	44,106	11,111	10,036	20,697	4,882	4,436	23,409
R-squared	0.165	0.187	0.2	0.143	0.169	0.169	0.163
Number of id	8,176	3,147	4,026	6,725	1,855	2,640	6,970

In this table, all the variables are the same as in Table5, except the additional variable exposure_longrate= $(\text{DLTP}_{i,t}+\text{DLC}_{i,t})\times\Delta rlong_t/\text{AT}_{i,t-1}$, where rlong_t is the long-term risk free interest rate from federal fund reserve. exposure_longratel= $(\text{DLTP}_{i,t}+\text{DLC}_{i,t})\times\Delta rlong_{t-1}/\text{AT}_{i,t-1}$

Monetary Policies and Insurance Companies: Equity Values to Unanticipated Target Interest Rates

Ying Liang*

Working Paper

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Abstract

We study the reactions of insurance companies to the unexpected interest shocks, which are defined by using the level and the slope of future contract interest rates. We find that on average, insurance companies have significantly positive abnormal returns following a positive unexpected shock in the level or the slope of interest rates: a 1% increase in the level or the slope of interest rates will increase the abnormal returns on average by 2.59% and 1.63%, respectively. We also find that insurance firms engage in maturity transformation in the opposite direction of banks: insurance companies, whose long-term debts will maturate in a very long term, will benefit from the increase in interest rate slope shocks rather than banks' riding on the yield curve through a large mismatch between assets and liabilities. The empirical results provide important policy implications: interest rate shocks boost the value of insurance equities, with a decreasing effect on life, property & causality, and multi-line, but not for the reinsurance or insurance brokers.

JEL-Codes: G22, G28, G14, E43, E52

Keywords: Insurance companies, equity value, interest rate shocks, FOMC announcements, maturity, exposure

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1 Introduction

This paper empirically studies the effect of the monetary policy on the insurance industry. Since 2007, interest rates had gradually declined to historical lows and kept that lows until 2015. This prolonged low-interest rate environment had an impact on many segments of the economy, especially in the insurance industry. For instance, life insurers are adversely impacted by interest rates because of the guarantees and policyholder options in many of the products they sell. As a result, life insurers face a considerable amount of interest rate risk, particularly those with a larger amount of interest-sensitive policies in their mix products. Meanwhile, insurance companies are holding large proportions of interest related investment assets, such as sovereign debts and corporate bonds, etc.

After the financial crisis, the Fed implemented a number of unusual monetary policy measures aimed at keeping rates low, including purchasing a number of bonds (quantitative easing) and lengthening the average maturity of treasuries held in its bond portfolios. The goal of these measures was to lower long-term interest rates, resulting in a flatter yield curve, in the hopes of avoiding deflation, reducing the unemployment rate, lowering mortgage rates and stimulating the U.S. economy. Starting from the end of 2015, the target fed rates were re-raised again. The effect of interest rate changes is mainly investigated on banks. However, there is little known about how the interest rate changes affect the insurance companies, which will be analysed by this paper.

Estimating the reactions of equity prices to the monetary policies is complicated by the fact that the market is unlikely to respond to the policy that was already anticipated. Distinguishing between expected and unexpected policies is therefore essential for discerning their effects. In this paper, we estimate the reactions of insurance companies' equity prices to the monetary policies by a measure of "level surprise" interest rate changes and an unexpected slope shock of yield curve, constructed by using Fed funds futures' data, as proposed by Kuttner (2001) and English et al (2014). From the fact that financial institutions may engage with "riding on the yield curve", we know that the difference between annual long-term rate and short-term rate (called slope of the yield curve) can affect financial firms' investment behaviours and profits. Therefore, the surprising changes in the target rates do have shocks on the slope of the yield curve, the so-called slope surprise in this paper. To remove the other effects in the economy, we use the daily abnormal stock returns which exclude the general 3 Fama-French factors.

To summarize, the main contributions of this paper is threefold. Firstly, we empirically document the effect of the shocks in fed funds target rates on the stock returns of insurance companies. Insurance companies are exposed to interest risk: when interest rates increase surprisingly by 1%, it boosts the abnormal returns of insurance companies by around 2.259***%; when the slope of fed rate increases surprisingly by 1%, the insurance companies gain more abnormal returns by 1.627***%. In other words, the firms' equity values increase with the positive slope shocks, which is contrary to the response of banks.

Also, we investigate how the reaction of stock returns to these interest rate surprises varies with insurance firms' characteristics: firm size, profitability, leverage, book-to-market, the difference between short-term assets and debts. Gomez, Landier, Sraer, and Thesmar (2016) construct the income gaps of banks which measure the difference between the bank's assets and liabilities that mature within a year. In this paper, similar to their income gaps, we capture the sensitivity of insurance companies to the interest rates by defining a variable called "exposure, which consists of the short-term assets and liabilities that are sensitive to interest rate variations. We find that insurance firms' abnormal returns respond positively with the high exposure level of the last period to the interest rate, which means that the insurance companies with higher exposure level to the interest rate (defined as "exposure" in the section III.1) will gain more abnormal returns when positive interest shocks come. They found that banks with larger income gaps respond to a monetary policy tightening by lending relatively more and gain more, which is similar to our results on insurance companies. Besides the exposure, we don't find any significant evidence on firms' size, leverage and profitability.

Besides the level of exposure to interest risk, to further examine the transmission of monetary policy to insurance companies through the financing channel, we investigate the extent to which insurance companies' returns vary with the maturity of the debt. We construct a variable called "debt maturity", which is the sum of the product of each long-term debts value and its length of the remaining maturity. We find that firms with long-term debts of longer maturity benefit more if the unanticipated changes of interest rate arrive on a slope rather than on a level.

Moreover, life insurance companies on average have a longer debt maturity compared to multi-line insurance and P&C insurance companies. Life insurance companies are very sensitive to the shocks on both the level and the slope of interest rates. Specifically, for a life insurer with a larger proportion of long-term debt maturating in the long run, a 1% increase on the slope of the interest rates will increase the abnormal returns by around 4.59**%, while P&C companies are not affected through the financing cost of the long-term debt.

Finally, the different reactions to the interest rate shocks between banks and insurance companies, documented in this paper, can be a supportive evidence for the diversification in financial conglomerates. Complementary to the results of English et al (2014), where an unanticipated increase in fed funds rates on both the level and slope will depreciate the banks' share prices, we find a contrary impact on insurance companies. The larger the maturity gap, which measures the mismatch between assets and liabilities, the more the banks will benefit, which confirms the banks' "riding on the yield curve". However, in this paper, we find that insurance companies benefit more from the interest rate shocks if they have a longer maturity of debts. Because the increase of interest rates will lead to a higher cost for firms to generate long-term debts, their values will be depreciated by an increase of financing cost, if they have a long-term debt maturating in the near future. When interest rate shocks arrive, both banks and insurance companies are affected but in a different direction, a benefit from diversification can be obtained for financial conglomerates that are engaging in these two businesses.

Beyond contributing to the literature on the reactions of insurance companies to the interest rate risk, this paper also provides strong implications for policymakers. The transmission of monetary policies on insurance companies is more effective if insurance companies seek financing through long-term floating obligations but less effective if their long-term debt will maturate in the far future. Furthermore, the opposite reactions of banks and insurance companies to the same monetary policy which also be taken into account prudentially. We also find that due to the fact that Euro-zone is not one country, firms in Europe are less sensitive to the monetary policy made by the European Central Banks compared to firms in the US.

The remainder of the paper is organized as follows. Section 2 presents a literature review, and Section 3 describes the data resources and main variables and discusses the baseline results. In Section 4, we turn to the analysis of insurance firms' characteristics and interest rate risk and show the main results. In Section 5, a comparison between banks and insurance companies is discussed. Robustness tests and policy implications are presented in Section 5 and 6, respectively. Section 7 concludes.

2 Literature Reviews

Documenting interest rate shocks on stock returns of financial institution could be a possible channel to reflect the efficiency of monetary policy of central banks. Jensen and Johnson (1995), Jensen et al. (1996), Thorbecke (1997), Rigobon and Sack (2004), Gurkaynak et al.(2005), and Ehrmann and Fratzscher (2006), English et al(2014) claimed that FOMC announcements have significant effects on U.S. equity indexes, as well as other financial asset prices. Even earlier, Flannery and James (1984) supported the conventional wisdom that financial intermediaries are exposed to the interest rate risk because they engage in maturity transformation. These papers contribute more to banks rather than insurance companies, which play a different but also a key role in the financial sector.

Staking and Babbel (1995) studied the relationship between capital structure, interest rate sensitivity and market value in the insurance industry. It is shown that the market value of equity at first grows but then later declines as leverage increases. Interest rate risk has the opposite effect. Equity value first declines with interest rate risk. But then rises at high levels of interest rate risk. This fluctuation is interpreted as a general market aversion to risk that is difficult for the individual investor to hedge at low to medium levels of interest rate risk. However, high levels of interest rate risk are shown to reward those firms that operate in markets characterized by significant information asymmetries regarding the financial condition of individual firms. Different from their paper that measures the equity value by TobinQ, while we will use abnormal returns to measure the variations of insurances' value. But, we can use their measure as a robustness check method to enhance our arguments.

Joskow, P. L. (1973) said that the property-liability insurance industry in the United States is subject to a considerable degree of regulations, many of which are centred on maintaining the solvency of individual insurers and the integrity of the insurance industry. Because regulations have a significant influence on the operations and practices of the insurance industry, if we want to isolate the impact of monetary policies, it's better to find a way to eliminate the potential effect of these regulation effects. But overall, since we are studying the insurance industry that is facing the same regulations, the lack of dealing with the regulation shocks will have no significant influence on our estimates.

When analyzing the interest rate sensitivity of a portfolio of assets, the most widely used measure, in part due to its simplicity, is the Macaulay duration of the portfolio. However, several alternative measures of duration exist. Bierwag (1978) demonstrates that the appropriate duration measure hinges upon the stochastic process underlying interest rate movements. Different measures are appropriate to alternative possible shifts in the yield curve. In addition, default and credit risks have an impact upon a portfolio's effective duration, as analyzed by Babbel, Merrill, and Panning (1997). Further issues of calculating the appropriate duration in the face of spreads between short-term and long-term yields are taken up by Khang (1979) and Bierwag, Kaufman, and Latta (1987). For example, in examining interest rate risk, Staking and Babel (1995) rely on simple Macaulay duration to calculate the duration of assets and liabilities. The "duration of surplus" [D.sub.S] depends upon the duration of the firm's assets and liabilities[1]. As shown in their paper, using [D.sub.S] as a measure of interest rate risk is appropriate if the interest rate associated with the firm's assets is equal to the rate on liabilities. However, if there is a positive spread between the two rates, an alternative specification of interest rate risk is necessary. In this paper, we focus on the channel of long-term debts to study the effect of monetary policies.

Kirti, D. (2017) states that bank-dependent firms exposure to floating rates is a component of the Bernanke & Gertler (1995) balance-sheet channel of monetary policy. Bernanke & Gertler (1995) show that firms financial health weakens when rates rise, as interest expense rises relative to cash flows, and connect this to the effect of monetary policy on business fixed investment. We construct the variable exposure that incorporates the floating debt of firm to verify the interest shocks on insurance companies through this channel.

In this paper, we find opposite response of banks and insurance companies to the same policy, which motivates the thinking of diversification in financial conglomerates which operate both the insurance business and banking business at the same. The conglomerate

[1] $[D.sub.S] = [D.sub.A] - [D.sub.L])A/S + [D.sub.L]$
Where: [D.sub.A]= a weighted-average of the Macaulay durations of the firm's assets, [D.sub.L]= a weighted-average of the Macaulay durations of the firm's liabilities, A = the market value of assets, and S = the market value of surplus, which is the difference between the market value of assets (A) and the market value of liabilities (L).

of companies is a controversial topic. A large number of literatures argue that the benefits of the conglomerate are from different sides: the scale of economies, debt capacity and tax shield and the creation of the internal capital market. Regulators are a bit strict about the cross-sector combinations, especially to those in the finance sector that is a key and sensitive department in the whole economy. At the same time, corporation diversification may bring dark sides as well, such as the agency problem. Until now, some papers are dedicated to the diversification risk and income variations of banks with non-banking activities, while mixed results are obtained on this topic.

On one hand, a number of arguments can be made in favour of a more integrated financial services industry (Fields, Fraser and Kolari (2007), Slijkerman et al (2013)). Boyd, Graham and Hewitt (1993) simulated mergers between BHCs firms in non-banking financial industries and found that banks' mergers with insurance or property & casualty insurance firms may reduce risk. Lelyveld and Knot (2008) found that there was no universal diversification discount for EU. On the other hand, different opinions are offered as well (Denis et al (2007), Schmid and Walter (2006), De Jonghe (2010) and Brunnermeir, Dong, and Palia (2012)). The earlier literature (Lang and Stulz (1994), Servaes (1996)) showed significant diversification discount: firms that engage in multiple activities are valued less. Acharya, Hasan, and Saunders (2006) found that diversification of bank loans across sectors and industries does neither necessarily improve return nor reduce risk.

3 Interest Rate Surprises and Insurance Companies' Stock Returns

In this section, we present the baseline results concerning the reactions of insurance companies' stock returns to unexpected interest target rate changes induced by monetary policy actions. First, we define the interest rate surprises used in the paper and other important variables. Then, we present the baseline results of the interest rate surprises on stock returns.

3.1 Data Resources and Main Variables

3.1.1 Interest Rate Shocks

Our analysis covers the period from 1989 to 2017, which includes 100 interest rate adjustment announcements of FOMC[2]. It's available from Fed fund reserve bank of New York. In next section, we will separate the sample before and after 2008 financial crisis, because the interest rate target level has little variations (0-0.25%) post the crisis (up to 2017) which is generally considered as unconventional policy period.

We decompose the observed target fed funds rate changes $\triangle ff_t$ into two components like English et al.(2014):

$$\triangle ff_t = \triangle ff_t^e + \triangle ff_t^u \tag{1}$$

where $\triangle ff_t^e$ is the expected change and $\triangle ff_t^u$ is the unexpected change in the target rate associated with the FOMC announcement at time t. As stated in Kuttner (2001) the surprise component $\triangle ff_t^u$, called "level surprise", is the difference between the announced new target rate and the expectation derived from federal funds future contract rates [3]. That is, the unexpected change is calculated as the change in current-month federal funds future-contract rate the day before and after the FOMC announcement[4]. Therefore, this

[2] In fact, during this period there are 262 announcement dates related to target fed funds rate by FOMC; only 100 of them are with interest target variations.

[3] Note: the data comes from the website of CME(Chicago Mercantile Exchange) and CBOT(Chicago Board of Trade).The link is: http://www.quandl.com/c/futures/cme-30-day-fed-funds-futures.

[4] As the statement in English et al (2013): the federal funds futures contracts have a payout that is based on the average effective funds rate that prevail over the calender month specified in the contract. These target surprise , as they are commonly referred in the literature, have been used extensively to examine the effects of interest rate changes on asset prices (for example, Bernanke and Kuttner (2005), and Ammer et al. (2010)). However, Piazzesi and Swanson (2008) show some evidences of the risk premiums in the prices of federal funds futures contracts, which implies that these prices may not represent unbiased expectations of the future trajectory of the funds rate. Importantly, they also show that the method due to Kuttner (2001) does not suffer from this bias because any constant risk premium embedded in futures

level surprise can be a validate measure of unanticipated interest target rate shocks.

In Figure 1, the evolutions of fed funds target rates (blue line), effective fed rates (red line in Panel A) and long-term treasury rates (red line in panel B) are presented in panel A and B. Specially in Panel B, we can see a lot of differences between the annual long-term treasury rates (red line) and the annual short-term fed funds target rates (blue line). This makes us think of the famous buying long, then selling as short actions.

Therefore, we are interested on the conventional wisdom riding the yield curve, so we follow the literature to construct a slope shock, defined as the unexpected change in the slope of the yield curve following each FOMC announcement. We define the unexpected slope shock in the following way: the difference between the change of long-term treasury yield and the change of fed funds target rate; that is

$slope\ shock = \triangle y_t^m - \triangle ff_t^u$

where $\triangle y_t^m$ is the unexpected change of of long term treasury rate [5], m=2, 5, 10, 20 years. Reasonable bounds on expected changes in bond yields are on the order of less than one-tenth of a basis point, so we simply use the actual change in the yield to measure its corresponding unanticipated component[6]. In panel C and D we show the evolutions of level surprises ($\triangle ff_t^u$) and slope shocks ($\triangle y_t^m - \triangle ff_t^u$) respectively.

3.1.2 Abnormal Return

In order to verify the reactions of insurance's stock prices to the interest rate shocks, we use the stock daily returns from the CRSP, which includes the stock market information of NYSE, AMEX and NASDAQ. The potential problem of using daily returns to measure the effect of FOMC announcement is that other news occur during the day of FOMC announcement can influence the stock prices of insurance companies. So we need to

prices is effectively differenced out. And although there is evidence that this risk premium is in fact time varying, it appears to fluctuate primarily at business cycle frequencies, a frequency that is far too low to matter over the the narrow window used to calculate the target surprises.

[5] Data resource is the same as fed funds effective rate Board of Governors of Federal Reserve System: http://www.federalreserve.gov/releases/h15/data.htm

[6] From English et al (2013).

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Figure 1: Note: data from Board of Governors of Federal Reserve System and CME. Sample period 1989-2017. Interest level surprise=change of 30-days fed funds future contract rate around the announcement of FOMC. Slope shocks=(change of long term interest rate -unexpected interest shocks)

assume that during the day of announcement there is no other important news affecting the stock market; in the robustness check, we try to remove the dates with big events. Therefore, we are using the abnormal returns from which the effect of market factor and two other common factors are deducted; that is, using the Fama-French 3-factor model[7] to compute the abnormal returns. Using the following model:

$$R_{i,m} - R_{f,m} = \beta_{1,m} \times (R_{m,m} - R_{f,m}) + \beta_{2,m} \times SMB_m + \beta_{3,m} \times HML_m + \epsilon_{i,m} \quad (2)$$

in each month m and the previous 24 monthly returns, we compute the rolling $\hat{\beta}_{i,m}$ $(i = 1, 2, 3)$. Then we obtain the daily abnormal stock returns at each day t:

$$\widetilde{R_{i,t}} = R_{i,t} - R_{f,t} - \hat{\beta}_{1,m} \times (R_{m,t} - R_{f,t}) - \hat{\beta}_{2,m} \times SMB_t - \hat{\beta}_{3,m} \times HML_t$$

Even though we cannot totally eliminate all the other potential news influencing the stock returns on that day, it's still a validate measure to capture the effect of fed funds rate shocks on that day. One possible explanation (Bernanke and Kuttner (2005)) is that the high-frequency interest rate surprises induced by monetary policy actions are uncorrelated with other economic news or developments elsewhere in the economy. Thus, these interest rate shocks allow us to identify more cleanly the response of stock prices to interest rate changes by circumventing the difficult issues of endogeneity and simultaneity that plague the common practice of using the observed interest rate changes, which are correlated with other news about economic conditions (English et al.(2013)). If possible, it's better to use the intra-day stock price, which is around the time point of announcement and the variations of interest rate shocks around the same time point. Because of data limitations, we can't get fully access to these so high-frequency data. However, we can replace them by daily stock returns and daily interest variations around the announcements.

Naturally, in order to measure correctly the effects of fed funds shocks, we drop the

[7] Fama, E. F.; French, K. R. (1993)

extreme values from the sample (upper 1% and lower 1%). We can access the daily 3 factors' data easily from Kenneth website[8]. In addition, in order to compute the abnormal returns we need to compute the rolling beta for each factor; therefore, we eliminate those firms lasting less than 3 years from the sample.

3.1.3 Annual Firm Level Data

Another interesting part of this paper is to investigate the firm characteristics that may affect the sensitivities of stock returns to interest rate shocks. We get access to the firm balance sheet data from Compustat of WRDS[9], which facilitates us to look at whether the size of companies, the extent of financial constraint or the degree of exposure to interest rate risk will affect the insurance companies' responses to those fed rate shocks or not. Since it's impossible to have the firm's total asset, debt level and other balance sheet items month to month, we can only use annual data to examine these sensitivities.

Table 1 and Table 2 in Appendix I provide the summary statistics of all the variables. The first table indicates that the average abnormal return of the sample is insignificant negative (with the mean -0.0092 and standard error 2.293), which is different from the daily stock return with the mean 0.0791 and standard error 3.274. This dissimilarity implies us that it's necessary to eliminate other factors from daily returns in order to look at the effect of monetary policies on insurances' returns. Furthermore, the mean and median value of abnormal returns are quite small and getting close to 0, so we will eliminate the top 1% and bottom 1%. After trimming all these values, we still have 394 companies in insurance industry.

3.2 Baseline Results

In this section, we are showing the basic model used to show the response of stock returns to those interest rate shocks defined in the above section.

[8] http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html
[9] http://wrds-web.wharton.upenn.edu/wrds/

The basic model is specified as below:

$$\widetilde{R_{i,t}} = \gamma_0 + \gamma_1 \triangle ff_t^e + \gamma_2 Level\, Surprise_t + \gamma_3 Slope\, shock_t + \nu_i + i.year + \epsilon_{i,t} \tag{3}$$

where $\widetilde{R_{i,t}}$ is the daily abnormal return of stock i in insurance industry at date t ; $\triangle ff_t^e$ is the expected federal fund interest rate; $\triangle ff_t^u$ is the level surprise (unexpected change) of fed funds target rate; and $(\triangle y_t^m - \triangle ff_t^u)$ is the slope shock of fed funds rate. All these variables[10] are well defined in the previous sub-section. ν_i represents the fixed effect of each firm and $\epsilon_{i,t}$ is the error term.

We estimate this model by OLS. Each announcement of FOMC occurs regularly at 2:15 pm. The current day abnormal return $\widetilde{R_{i,t}}$ will not affect the interest rate target level that will be announced. The problem of possible omitted variables will be discussed more concretely in the next section. For the expected part of the variations $\triangle ff_t^e$, we are expecting to get an insignificant result. Under the assumption that market is efficient, then the expected variations are already included in the asset prices and it will not bring any benefit to our abnormal returns. Therefore, the first hypotheses is $\gamma_1 \simeq 0$.

Notice that our data is regularly spaced daily return, so the error terms might be serially correlated. Meanwhile, at the firm level, it is likely to exhibit a complex pattern of cross-sectional dependence. Therefore, the standard error structure is possible to be heteroskedastic, auto-correlated up to some lags, and possibly correlated between the groups because we are in panel finance world (so the error term can exhibit cross-sectional dependence). So we need to correct the standard error by using some econometric techniques. In our paper, we mainly use HAC estimator for standard error, which are clustered by firms. In the appendix we present other methods, such as Driscoll-Kraay [11] and Newey

[10] All these interest related variables are set to be 0 for those dates without announcement.

[11] Driscoll-Kraay standard errors are robust to very general forms of cross-sectional (”spatial”) and temporal dependence when the time dimension becomes large. This nonparametric technique of estimating standard errors does not place any restrictions on the limiting behavior of the number of panels. Consequently, the size of the cross-sectional dimension in finite samples does not constitute a constraint on feasibility - even if the number of panels is much larger than T. However, note that the estimator is based on large T asymptotic. In our sample, we have 78 periods. Therefore, theoretically, we can

West estimator, to correct the standard error as well.

In the insurance industry, there are 5 types of sub-industries: Insurance Brokers, Life & Health Insurance, Multi-line Insurance, Property & Casualty Insurance and Reinsurance. Insurance brokers are the only one who work as an intermediary in this sector: They provide services to help insurers (real insurance companies who sell the insurance contracts) and policyholders (customers who buy the insurance contracts) to achieve the contracts but not the guys who provide the insurance policies. We are expecting different reactions to interest shocks according to different sub-sectors of industry, which will be discussed later in the next section.

As presented in Table 4, we find that the estimates of expected changes are quite small (compared the absolute values to other variables), closed to 0 and insignificant at all. The positive and consistent constant term shows that the companies in insurance industry have fixed abnormal returns on stock market. In other words, without any other exogenous shocks, the expectation of the insurance stocks' abnormal returns will be positive; the market is not efficient enough to incorporate all the available information. Meanwhile, the unexpected fed funds target shocks do have no positive and significant effect on the abnormal stock returns for all regressions; but it affects insurance companies' values through the slope variations of yield curve. When the yield curve slope increases surprisingly 1% at m=5, it will induce the stock returns of insurance industry gains around 1.223%*** on life insurance companies, and 1.759%*** on P&C firms. The unanticipated level increases 1% would lead to significant increase on abnormal returns on life, multi-line and P&C insurance companies. However, both broker insurance and re-insurance firms are not significantly react to the level surprise and slope shocks of interest rates; therefore, the rest of the analysis will focus on the last three sub-sectors.

In the last two columns of Table 3 in the appendix, I show the results of 3-day cumulative abnormal returns' reactions to the interest shocks. Until now, we can state that

apply this method to an appropriate data set. More details of the applications in Daniel Hoechle (Robust Standard error for panel regressions with cross-sectional dependence).

the unexpected interest rate shocks (including level surprises and slope shocks) induced by the monetary policies do affect the insurance companies' stock returns. When a positive unanticipated interest rate shock arrives, insurance companies' stock returns increase. Contrary to banks' negative reactions to positive interest rate surprises found by English et al(2014), the interesting positive reactions to an increasing interest rate motivates us to further investigate insurance companies' behaviors to these interest rate risk.

4 Insurance Firm Characteristics and Interest Rate Risk

From the dataset we present in Section II.A, in this section we will consider the list of balance sheet variables to figure out how these interest shocks influence stock returns across different insurance companies. Firstly, we will present the related firm characteristic variables. Then we will show the related model and do the estimation and analysis.

4.1 Exposure Level and Interest Rate Risk

One direct possible channel that we are considering is through the debts and assets, which are interest rate related. The total floating debt is the sum of the short-term debt and long-term floating debt (Chava and Purnanandam (2006)):

$$floating\, debt = DLC + DLTP$$

where DLC (in Compustat) is the total amount of short-term debts (due in one year). DLTP represents the amount of long-term debt on which the interest rate fluctuates with the prime interest rate. This item includes any long-term debt tied to a fluctuating or floating interest rate. The interest payments of these two debts depend on the current interest rates. From the definition above, we know that total floating debt measures the extent to which a firm's interest payment are sensitive to interest rate paid changes. If the interest rate paid increases, the borrowing cost increases for firms. The interest payment changes could be measured by the interaction of total floating debt and the change of borrowing rate. We know that the interest-rate paid by the company can be modeled as the risk-free rate plus a risk component (risk premium), which itself incorporates a probable rate of default (and amount of recovery given default). Therefore, we could use total floating debt to measure the part of firm exposure to risk-free rate variations. From Mishkin and Eakin (2009), they measure the impact of short term risk-free rate shocks $\triangle r_t$ on firms by calculating: $total\, floating\, debt \times \triangle r_t$. However, we are studying the insurance companies which are quite different from normal firms (non financial firms). Under the industrial regulation of U.S., insurance companies are constrained a lot on their investment behaviors and current asset holdings. Normally, insurers will hold a large amount of cash, cash equivalents or short-term investment; therefore, we need to capture these possible variables which can affect the interest shock sensitivity of insurance companies. So we will consider

$$exposure = total\, floating\, debt - cash - cash\, equivalence$$

which measures the level exposed to interest rate shocks. At the same time, in order to avoid the individual effects of interest rate change and floating debt (that will disturb the result of $exposure \times \triangle r_t$ effect) , we control for the variations of interest rate and floating debt level. We scale down all the variables by firms' total assets of last period $AT_{i,t-1}$. In summary, in the analysis we will control for $\triangle r_t$ and $exposure_{i,t}$ and consider:

$$exposure_{i,t} \times interest\_shock_t = \left(\frac{total\, floating\, debt_{i,t-1} - cash_{i,t-1} - cash\, equivalence_{i,t-1}}{total\, assets_{i,t-1}} \times \triangle r_t\right)$$

In our paper, $\triangle r_t$ represents the interest related shocks: $\triangle ff_t^u$ or $(\triangle y^m - \triangle ff_t^u)$.

Furthermore, one may claim that we should include the short-term investment assets. The companies that hold a lot of assets sensitive to interest rate would like to buy those derivatives hedging the varied interest rates. On the contrary, the firms that hold a lot of assets, which are not sensitive to interest variations, would not like to use those derivatives to hedge these variations, but prefer those products by gaining profits through the variations. Therefore, we can also consider the exposure level with the short-term investment to check the robustness of the results. That is to say: $exposure = total\,floating\,debt - cash - cash\,equivalence - short\,term\,invertment$. Then the variable of interest becomes:

$$\begin{aligned} exposure_{i,t-1} \times interest\_shock_t =& (total\,floating\,debt_{i,t-1} - cash_{i,t-1} - cash\,equivalence_{i,t-1} \\ & - short\,term\,invertment_{i,t-1}) \times \frac{1}{total\,assets} \times \triangle ff_t^u \end{aligned}$$

Short-term investment[12] includes different kinds of current assets. In the robustness check, we also include last year's long-term debt due[13] in one year into the exposure component, which may capture more exact sensitivity level to interest rates.

Notice that, we are using the floating debts and cash of the last period. Since financial annual reported data is time point data and collected at the last moment of last year, they can present well the initial level of cash and leverage that are exposed to the interest rate shocks at time t.

4.2 Maturity and Interest Rate Risk

The exposure level that we present in last section III.1 is a straightforward measurement to capture the effect of interest rate variations to insurance companies, but it has some limitations. In the literature of monetary policy transmission, researchers propose maturity

[12] Look at the item details in Appendix II D.

[13] $exposure_{i,t} \times interest\_shock_t = (\frac{total\,floating\,debt_{t-\cdot} + long\,debt\,due\,in\,one\,year_{t-1} - cash_{t-1} - cash\,equivalence_{t-1} -}{total\,assets} \times \triangle ff_t^u)$

transformation channel to analyze the interest rate shocks on financial firms. As stated in the literature reviews, it is proved to be a conventional wisdom that financial intermediaries are exposed to interest rate risk because they engage in maturity transformation. Therefore, the mismatch in the maturity or repricing time between firms' assets and their liabilities, the so-called repricing/maturity gap, is to measure the degree to which a firm engages in maturity transformation. Different from the literature, we construct a variable ***Debt Maturity*** to examine the influence of interest rate shocks on insurance companies through the financing channel. In our paper, we measure the average weighted maturity of a firm i's long-term debt as:

$$Maturity_{i,t} = \sum_{n=1}^{N} d_{i,n,t} \times DD_n,$$

where $d_{i,n,t}$ is the amount of long-term debt of firm i maturating in year n at time t over firm i's total debt; DD_n is the rest of the maturity of firm i' $d_{i,n,t}$; n represents the maturity year.

This is another method to measure the effect of interest shocks through balance sheet channel, while it demands a lot of information out of balance sheet.

4.3 Other Variables and Interest Shocks

When facing the shocks from economics, people always look at the behaviors of large firms which can represent the moving direction of the market. For example, at the beginning of 2008 financial crisis, when Lehman Brothers, the fourth-largest investment bank in the US, announced its bankruptcy, people started to be scare and market begun to collapse. Thus, the size of the company does matter a lot in many cases. Naturally, we expect that firm size can affect the extent of valuation sensitivity to interest rate shocks. The expected sign of the effect is ambiguous now, because one may think that large insurance companies will face a higher level of risk (higher internal rate of return are expected, so more risk is taken) and are more sensitive to interest rate shocks. Meanwhile, one can also claim that larger insurers owing better management group, which can hedge well the related interest rate risk, are less sensitive to those interest rate shocks. Therefore, we are not sure yet about the expected sign of size effect on the sensitivity of firm values to interest rate variations.

Similarly, TobinQ (Book to market value) can be related to the effect of interest rate on firm's value. TobinQ can present the investment opportunity, which is proved in Hayashi (1982) q-theory. Therefore, in order to control the effect of investment opportunity on firms' value, we have to consider last period's TobinQ. If the investment opportunities are not controlled, the increase of abnormal returns might be induced by the firms' investment opportunity (which lead to higher and better investment, so higher value can be gained). Thus by eliminating the effect from investment opportunities on firms' abnormal returns, we can have better estimates of interest rate shocks on firms' valuations. In the section of robustness check, we replace TobinQ by sale growth to represent firms' opportunity, and the result is put in the supplementary tables.

We also take into account firms' profitability and leverage ratios to study their reactions to interest rate shocks.

4.4 Results

After the statements of all the variables, now we will specify our model based on the baseline model in Section II. The model in this section is specified as :

$$\widetilde{R_{i,t}} = \gamma_1 + \gamma_2 level\, surprise_t + \gamma_3 slope\, shocks_t + \gamma_4 i.group(FirmCharact_{i,t}) \times \triangle ff_t^u$$

$$+\gamma_5 i.group(FirmCharact_{i,t}) \times slope\, shock_t + \nu_i + i.year + \gamma_i \times X_{i,t} + \epsilon_{i,t} \qquad (4)$$

where $\widetilde{R_{i,t}}$ is the daily abnormal return of stock i in insurance industry at date t (t is the date of announcement by FOMC), $\triangle ff_t^e$ is the expected federal fund rate, $\triangle ff_t^u$ is the level surprise of fed fund rate and $(\triangle y_t^m - \triangle ff_t^u)$ is the slope surprise of fed fund rate. $i.group(FirmCharact_{i,t})$ can be: $i.group(size_{i,t})$, $i.group(mlev_{i,t})$, $i.group(B/M_{i,t})$, $i.group(ROA_{i,t})$[14], $i.group(exposure_{i,t-1})$ and $i.group(Maturity_{i,t-1})$ [15] where we divide firms into 3 groups every year according the firm characteristics. $X_{i,t}$ are other control variable (including log(size), B/M and leverage ROA). ν_i represents the fixed effect of each firm and $\epsilon_{i,t}$ is the error term.

Given the equation above, the parameters of interest are γ_3s and γ_4s; the benchmark group of the estimations is the firms who are grouped into group 1 according to their level of firm characteristics. γ_1 and γ_2 measure the average abnormal return variations of firms in group 1 when there is a 1% increase on level surprises or slope shocks of interest rates.

In Table 5-9 in Appendix I, we present the results that insurance companies abnormal returns vary with their sizes, leverages, profitability, B/Ms and exposures. From Table 5, we have an insignificant estimate on $\gamma_1 = 0.387$, which means that firms whose exposure levels are small are not sensitive to the interest rate shocks. In other words, only firms with a large difference between assets and liabilities that are sensitive to interest rates will be affected by the interest rate shocks. On average, when interest rates are augmented by 1% unanticipatedly, firms in the middle group of exposure will increase their abnormal returns by 2.17%* ($\gamma_1 + \gamma_3^{gr=2} = 0.387 + 1.789$) while firms with the largest exposure level (Exposure gr=3) will have a 2.861%** increase on their abnormal returns around the announcement dates. From the last 3 columns in Table 5, we learn that life insurance companies who have a large exposure to interest rate risk will benefit the most (3.772%**) compared to the other two sub-sectors if there is an increase on the level of interest rate surprisingly. Nevertheless, both multi-line and P&C insurance firms are sensitive to slope shocks in interest rates if they have a large level of exposure ($\gamma_4 = 3.825\%{*}{*}$, $\gamma_4 = 1.727\%{*}$, respectively).

[14]Using the past three years' cumulative ROA to divide the sample into 3 groups every fiscal year.

[15] i.group (exposure) represents 3 dummy variables of the 3 groups; and each dummy group interact with $\triangle ff_t^u$. In robustness check section, we are presenting the results of this model without grouping the sample. That is, using the exposure level itself to do the estimation.

Except for exposure, we dont find any significant evidence of firms abnormal returns varying with other characteristics (γ_3s and γ_4s are insignificant from Table 6 - Table 9). For instance, Table 6 shows that $\gamma_1 = 2.226^{***}$ and $\gamma_3 = 0.276, 0.119$. In other words, the firm of the smallest size on average will increase 2.226***% if level surprise is 1% and firms with larger size (either in size gr2 or 3) show no significant difference, neither statistically (t-values are 0.32 and 0.14) nor economically (0.276 and 0.119). Firms with a higher level of leverage are not more sensitive to interest rate shocks than firms with a lower leverage if these firms are not borrowing at a floating interest rate in the long-run or if the exposure level of their assets is compensating their exposure level of liabilities. Similar results are applied to firms profitability and B-to-M.

In Table 10, we show how the insurance companies sensitivity to interest rate shocks varies with their long-term debt maturity. From column (1) to (5), we add more control (Firm Characteristics $\times \triangle ff_t^e$ and Firm Characteristics $\triangle Slope$) in the regression. We find significant estimates on the slope shocks in interest rates rather than on the level surprises. On average, 1% unexpected increase in interest rate slopes will boost the returns of insurance companies with a long-term debt maturating in the far future more than firms with long-term debts maturating in the next 2 years by 2.393%**. Especially, this effect is very significant for life insurance companies and multi-line firms (4.594%** and 6.811%**, in Table 11). These two tables tell us that, on average, a surprisingly increase in the interest rates slopes will lead to a negative abnormal (-1.111) returns for insurance companies whose long-term debt will maturate soon; however, if insurance companies finance their investments by long-term debts which will maturate in the very far future, the increase in interest rates in slopes wont have a negative effect on them but a significantly positive one. There might be two possible explanations: first, these firms don't have to refinance their investments by paying a higher financing cost in the short run; furthermore, these firms holding a lot of long-term debts may have a lot of assets that benefit from the increase of interest, which may attenuate the positive effect of the interest rate increase.

4.4.1 Negative v.s. Positive Interest Rate Shocks

Interest rate shocks can be positive or negative. In this sub-section, we would like to understand whether firms react differently to positive or negative interest rate shocks or not. In Table 12, we learn that insurance companies are more sensitive to positive interest rate shocks rather than negative shocks. On average, a 1% increase in level surprise or slope shocks will boost insurance companies by 3.088%*** or 1.89%**, both of which are much larger than the estimates overall in Table 3; Table 12 and Table 4 show clearly the difference across sub-sectors. Interestingly, the right columns in Table 12 indicate that only P&C firms are sensitive to negative shocks, and that the rest of the insurance companies are not reactive to the decreases in interest rates. One possible reason is that given the long-term debt held by insurance companies, especially for a life insurer, due to the lower financing costs they don't use more debts to finance new investment, so their values are not affected by the negative shocks.

4.4.2 Conventional and Unconventional Policy

As we all know, monetary policy makers care a lot about the economic evolution, we can not neglect the effect from the economic circle. But we can still do better estimation and forecast by analyzing more details under the economic background. In Lamber and Ueda (2014), they define the conventional monetary policy period as the period before August 2007 while the so-called unconventional policy period to be starting after the collapse of Lehman Brothers on September 16, 2008. They argue that for banks the effects of unconventional policies could differ from those of conventional policies both quantitatively and qualitatively. In this paper, we set the divided point at 2008, i.e., the time before 2008 is conventional policy period and the time after 2008 is unconventional policy period. In Table 17, we see great difference between these two periods, while for conventional period, we have the similar result as those with the whole period. Notice that the unconventional period has much less observations. Furthermore, they have the opposite sign of the parameter of interest. Therefore, we confirm the conclusion as in Lamber and Ueda (2014) that the effects of unconventional policies could differ from those of conventional policies both quantitatively and qualitatively. We also obtain the same conclusion as before: insurance companies take benefit after the unexpected interest shocks.

4.4.3 Sub-sectors in Insurance Industry

As we all know, monetary policies makers care a lot the economic evolution, we can not eliminate all the effect of circle economic. But we can still do better estimation and forecast by analyzing more details under the economic background. In Lamber and Ueda (2014), they define the conventional monetary policy period as the period before August 2007 while the so-called unconventional policy period starts after the collapse of Lehman Brothers on September 16, 2008. They that the effects of unconventional policies could differ from those of conventional policies both quantitatively and qualitatively to banks. In this paper, we set the divided point at 2008; i.e., before 2008 is conventional policy period and after 2008 is unconventional policy. In Table 14, we see a great difference between these two periods across sub-sectors. Both the conventional period and unconventional periods, we have the similar positive result as those with the whole period. Notice that the unconventional period has much fewer observations as a whole.

Before 2008, P&C firms positively reacted to the increase of interest rate shocks in both the level and slope; however, after the financial crisis, the effect disappears and also the number of these firms become smaller. To the opposite, life insurance companies are much more sensitive to interest rate shocks after 2008. In other words, during the period of crisis, the consecutive decreases in interest rates reduced the abnormal returns of the insurance companies. For multi-line firm, they respond positively and significantly to the level surprises in interest rates during the conventional period but then are only sensitive to the slope shocks after the financial crisis. We the same conclusion as before: different sub-sectors of insurance companies do benefit through different channels to the interest rate shocks.

4.4.4 Comparison with Banks

In this sub-section, we extend our analysis to investigate the correlations between all the banks and different types of insurance companies. The matrix below presents the correlations of gross revenue between banks and insurance companies. It shows that, apart from the gross return of banks and full line insurance companies, accounting measures of activity in the banking and various insurance industries do not seem highly correlated; insurance brokerages are even negatively correlated with banks.

	Bank	Full line	Life	P&C	ReIn	Broker
Bank	1					
Full line	0.9204	1				
	0.0000					
Life	0.2562	0.3674	1			
	0.3381	0.1615				
P&C	0.6943	0.7926	0.0553	1		
	0.0028	0.0003	0.8388			
Reinsurance	0.4639	0.5863	0.1627	0.8126	1	
	0.0703	0.0170	0.5471	0.0001		
Broker	-0.5151	-0.3983	-0.2179	0.0780	0.2684	1
	0.0412	0.1265	0.4176	0.7739	0.3149	

In line with the literature, we find that when there is a positive interest rate shock that will depreciate the stock prices of banks. As shown in Table 15, 1% increase in level or in slope will lead a decrease on banks abnormal return around 0.253%* and 1.49%** respectively. The absolute impact are much smaller than what English et al (2014) have found by using intra-day data.

4.4.5 Comparison to Euro-Zone

Interest Rates in EZ The interest rate sample in EZ covers the period 1999-2015 with 119 interest rate announcements, including 21 actual interest rates adjustment. From the two upper graphs in Figure 2, we observe that the short-term interest rates (1-month, 3-month, 1-year, and 2-year rates) follow the same trend as the target rate set by the European Central Bank. Moreover, after the financial crisis, the market interest rates are virtually equal to the target rate. On the other hand, in the lower graph on the left, the evolution of long-term interest rates differs from the evolution of short-term rates: the correlation with the target rate appears weaker. As a result, in our analysis, it is necessary that we investigate not only the role of interest rates but also the role of the slope of the yield curve.

Interest rates and related shocks in Europe 1989-2017

Figure 2: Note: data from European Central Bank website, datastream and CME Interest level surprise=change of 30-days fed funds future contract rate around the announcement of FOMC. Slope shocks=(change of long term interest rate -unexpected interest shocks)

Table 16 presents the baseline results in Euro-zone; it shows that banks and insurance companies react oppositely to the same policy. When there a 1% increase in the level of interest rate, banks' equity values will depreciate by 1.056%*** while those of insurance companies will boost around 0.926%**. Both these two industries are less sensitive to the slope shocks in interest rates. Compared to the US, firms (banks and insurance companies) are less responsive to unexpected policies. One possible reason is that the Euro-zone was created only in 2001, which is pretty short to make the European Central Banks as efficient as the Fed in the US. Another possible reason is that the long-term interest rates of Euro-zone are computed by the average treasury rates across the Euro-zone countries. Every country issues their own sovereign debts and determines their own rates independently. In a word, due to the fact that Euro-zone is not one country, firms in Europe are less sensitive to the monetary policy made by the European Central Banks compared to firms in the US.

5 Robustness check

5.1 Daily returns as dependent variable

In the whole paper, we are using abnormal return which already deduct other information from the market; now we are using daily return as abnormal return in the model. If we are using the noisy measure of the abnormal return, will we have the same robust results as those in Table 5 or not? Theoretically, in continuous time background, the returns within a really short interval can be treated as abnormal return. In many papers, people use hourly intraday return as abnormal return for stocks. Therefore, it is naturally to treat daily return as a rough abnormal return.

Table 2 of Appendix II showing that, we get the same results as those in Table 3-4 (real abnormal returns). That is , when interest rate increase surprisingly, buying insurance companies will gain an abnormal return. But buying firms with higher exposure level will make you gain less abnormal returns. Even though there is a positive slope shocks, insurance companies can not gain by riding on the curve as other financial intermediaries.

5.2 Using different long-term treasury rates

In the main tables, we use 5-year treasury rates to construct the slope shocks; we also replace 5-year rates by 2-year, 10-year and 20-year rates and similar results can be obtained (see Table 17 and Table 20). Other long-terms debt whose maturity is not clear is considered in Table 19.

6 Conclusion

We examine the insurance companies' equity valuations to unexpected interest variations promoted by FOMC announcements. All the results show that those policy-induced slope shocks and level surprises do have a large and significant impact on insurance companies' stock returns. Furthermore, companies with more exposure will have more positive abnormal returns to an unanticipated increase in interest rates than those having less exposure, where exposure is a measure of the difference between interest-related assets and liabilities. We also document the fact that insurance companies whose long-term debt maturating in the longer future will benefit more from the positive interest shocks and those whose long-term debt maturating in the near future will have a negative abnormal return due to an surprisingly increase on interest rate.

Finally, we have the following policy implications for insurance companies. Firstly, we obtain similar implications with the results of Chodorow-Reich, G. (2014, March): the introduction of unconventional policy in the winter of 2008-09 had a strong and beneficial impact on insurers and especially on life and P&C insurance companies, consistent with the positive effect on legacy asset prices dominating any impulse for additional risk taking. However, we find the strong and clear supporting evidence for the difference between conventional monetary policies and unconventional monetary policies on insurance companies. Interestingly, life insurance companies respond the most to these unexpected shocks on the slopes among all the companies; reinsurance and insurance brokers are not affected by these federal fund target rate shocks. Finally, although an increase on slope shocks in interest rate leads to the conventional wisdom riding on the yield curve for banks, which implies a negative relationship between the long-term debts and interest rate increase for banks, insurance companies do the opposite.

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A Appendix

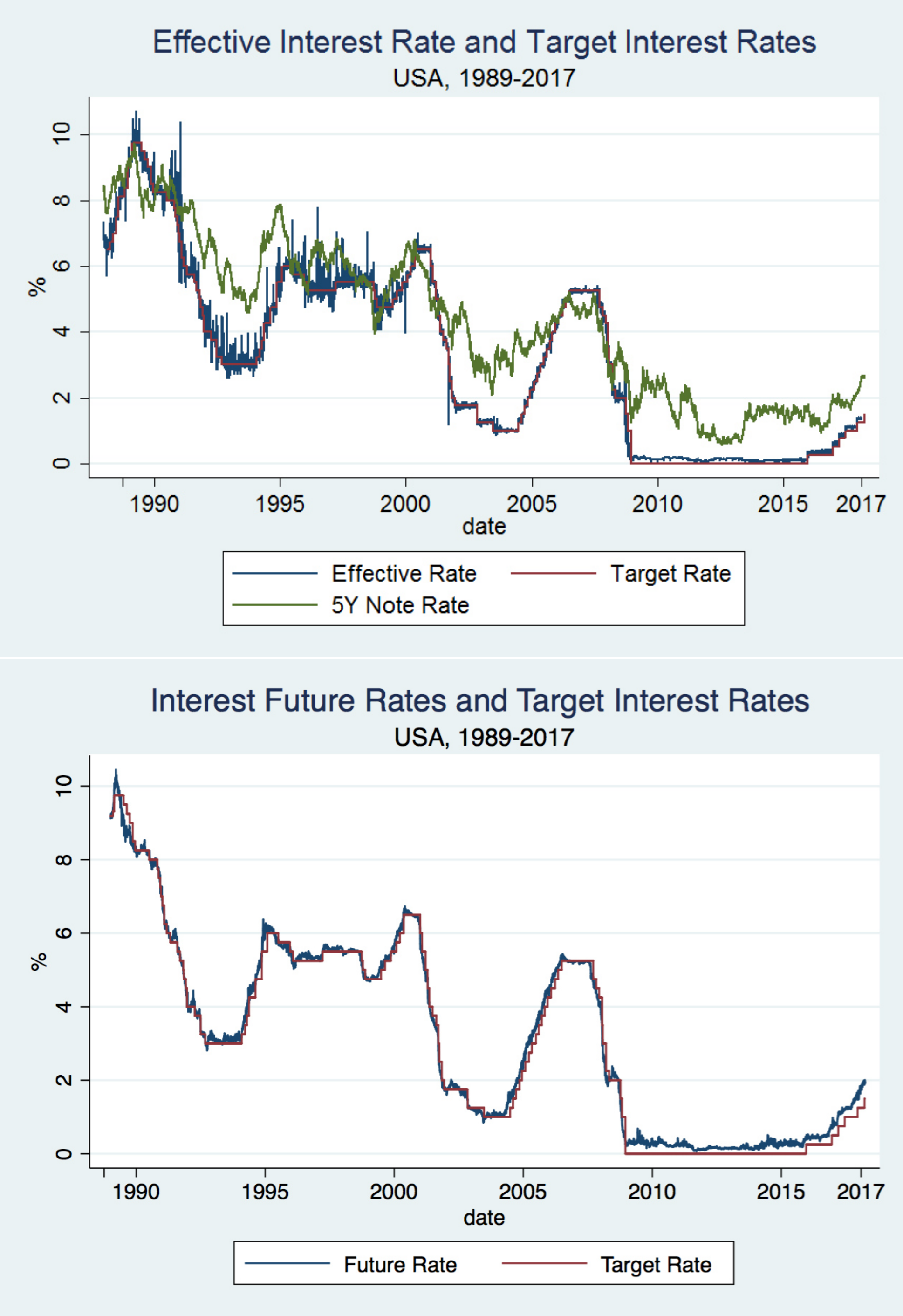

Figure 3: Note: data from Board of Governors of Federal Reserve System and CBOT. Sample period 1989-2017. Future Rate: 30-days fed fund future contract rates.

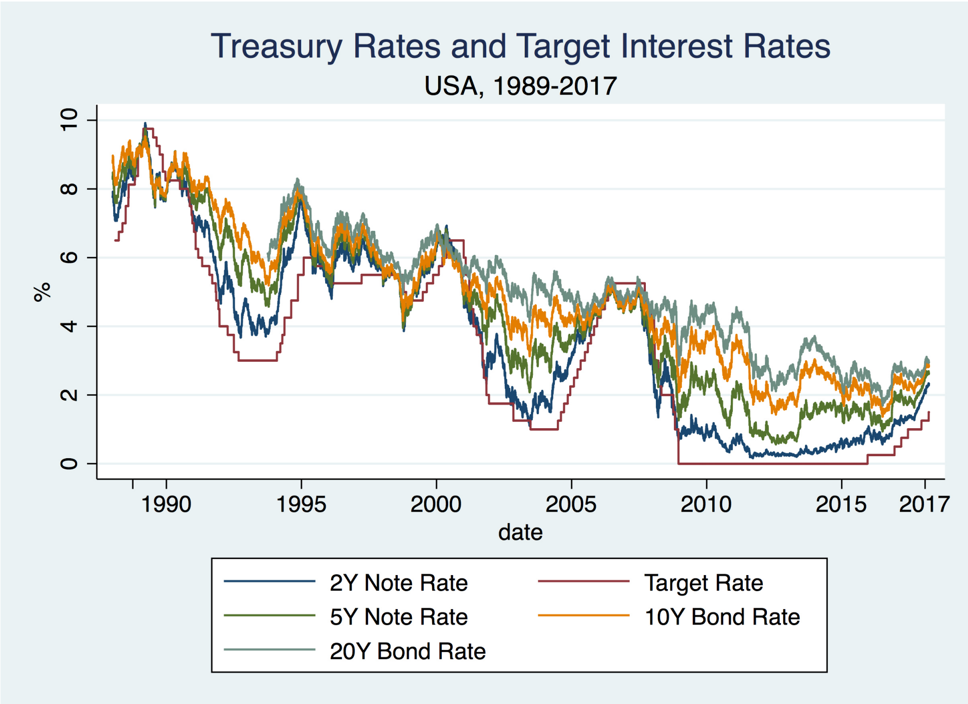

Figure 4: Note: data from Board of Governors of Federal Reserve System. Sample period 1989-2017. Interest rates of treasury securities with different maturities.

Table 1: Summary of Related Interest Rates

Variable	Mean	Std. Dev.	N	P25	P75
Target Rate	3.2641	2.7552	10986	0.2500	5.5000
Effective Rate	5.2812	3.9576	17564	1.7800	7.6700
Future Rate	3.2788	2.6379	7414	0.4518	5.3572
Bill1m	1.2175	1.5380	4165	0.0600	1.7300
Bill3m	3.9909	3.1648	9060	0.9400	5.8800
Bill6m	4.1782	3.2657	9060	1.0200	6.1800
Bond1	5.1879	3.4111	14043	3.0000	7.0500
Bond2	5.4024	3.7818	10451	1.8400	7.7900
Bond3	5.6174	3.2616	14043	3.4400	7.4800
Bond5	5.8893	3.1041	14043	3.7700	7.7000
Bond7	6.3072	3.1374	12173	3.8800	8.0100
Bond10	6.2308	2.8695	14043	4.1600	7.8200
Bond20	4.7476	1.5639	6125	3.3400	5.9500
Bond30	6.9120	2.9939	9279	4.5100	8.7300
Target Change	-0.0270	0.2177	262	-0.2500	0.2500
Diff effective	-0.0603	0.2457	261	-0.1000	0.0100
Level Surprise	-0.0188	0.0739	255	-0.0413	0.0183
Slope Shock2	0.0070	0.0725	255	-0.0249	0.0390
Slope Shock5	0.0089	0.0879	255	-0.0377	0.0457
Slope Shock10	0.0126	0.0912	255	-0.0343	0.0532
Slope Shock20	0.0141	0.0892	201	-0.0321	0.0502
Slope Shock30	0.0150	0.0878	223	-0.0319	0.0529

Summary statistics are based on the daily data from Board of federal fund reserve and CBOT during 1989-2017. All the variables wares % as unit. Std. Dev. is the standard deviation of the variable. N is the number of observations. daily return is the daily stock returns of insurance industry. P25 and P75 are the 25th and 75th percentiles of the data. Target Rate is the target interest rate set by Fed. Effective Rate is the effective interest rate on the market and Future Rate is the 30-days fed fund future contract rates. Bond1 to Bond30 are the return rates of bonds with different maturities.

Table 2: Summary of Stock Returns and Firm Characteristics

Variable	**Mean**	**Std. Dev.**	**N**	**P25**	**P75**
Panel A: Insurance Companies					
AT	15072.62	54511.52	4120	314.19	7638.19
Debt	1031.67	5345.04	4165	3.75	360.29
Fdebt	424.86	3600.77	4185	0.00	69.93
Size	7.3313	2.2531	4130	5.7306	8.9351
ROA	0.0437	0.0580	3429	0.0181	0.0662
BM	0.9199	0.1663	3986	0.8567	1.0234
Cash	0.0450	0.0621	2878	0.0056	0.0608
Blev	0.0797	0.1097	4167	0.0141	0.0965
Mlev	0.1911	0.1921	4159	0.0384	0.2747
Dividend	0.0063	0.0084	3784	0.0000	0.0087
Interest	0.0071	0.0192	3512	0.0012	0.0078
TobinQ	1.1491	0.4088	3986	0.9771	1.1672
Exposure	-0.0064	0.0776	2876	-0.0292	0.0146
Ret	0.0647	2.4744	2248544	-0.8942	0.9615
Retx	0.0571	2.4751	2248658	-0.9036	0.9472
Ab ret	0.0102	2.8364	1640133	-1.1018	1.0500
Panel B: Banks					
AT	6196.47	27845.02	17346	445.76	3418.57
Debt	1166.30	5649.91	16924	31.41	459.10
Fdebt	2285.94	22145.87	17117	7.30	248.31
Size	7.2042	1.5552	17357	6.0978	8.1370
ROA	0.0221	0.0162	16952	0.0167	0.0266
BM	0.9689	0.0628	17283	0.9381	1.0075
Cash	0.0356	0.0313	15249	0.0150	0.0469
Blev	0.1345	0.1121	16922	0.0545	0.1880
Mlev	0.4609	0.2444	16890	0.2820	0.6494
Dividend	0.0033	0.0032	15131	0.0014	0.0047
Interest	0.0286	0.0276	579	0.0054	0.0463
TobinQ	1.0377	0.1045	17283	0.9926	1.0660
Exposure	0.0331	0.0746	15024	-0.0120	0.0634
Ret	0.0559	2.2382	4199460	-0.9605	1.0227
Retx	0.0467	2.2388	4199541	-0.9704	1.0122
Ab ret	0.0070	1.9521	3279089	-1.0102	0.9863

Summary statistics are based on daily stock returns and annual balance sheet variables of US insurance companies during 1989-2017 from WRDS. Std. Dev. is the standard deviation of the variable. N is the number of observations. Ret is the daily stock returns of insurance industry. P25 and P75 are the 25th and 75th percentiles of the data. AT is the total asset of firm i; Fdebt is the floating debt of firm i; Size is the log of the total asset; ROA is the return on asset of firm i; BM is the book-to-market of firm i; cash is the cash over the total asset of firm i; Blev is the book leverage of firm i; Mlev is the market leverage of firm i; dividend is the dividend amount over total asset of firm i; Exposure is the total floating debt net of cash at hand over total asset of firm i. Ret is the daily stock return of firms; Retx is the daily stock return excluding the dividends; Ab ret is the abnormal return excluding the 3 Fama-French factors.

The number of the firms in the sample of different sector: Commercial banks 1,551; Thrifts&Mortgage finance 351; Insurance Brokerage 58 ;Life Insurance 123 ;Multi line 25; P&C Insurance 175; Reinsurance 13

Table 3: Daily stock returns and interest rate shocks in US

	ab ret (1)	ab ret (2)	ab ret 3day (3)	ab ret 3day (4)
Level Surprise	0.741***	0.765***	1.966***	2.259***
	(3.28)	(3.14)	(5.95)	(6.52)
Slopeshock_m	0.723***	0.704***	1.686***	1.627***
	(3.46)	(3.17)	(6.31)	(5.82)
Expected Change	-0.356***	-0.380***	-0.443***	-0.192*
	(-5.55)	(-4.47)	(-5.19)	(-1.83)
Constant	-0.002	0.034	-0.006**	0.060
	(-0.99)	(0.50)	(-2.06)	(0.55)
Year FE	No	Yes	No	Yes
Firm FE	Yes	Yes	Yes	Yes
Observation	23966	23966	22411	22411
R^2	.0160	.0183	.0215	.0264

In this table, the dependent variable in column (1) & (2) is the daily abnormal return of all the companies in Insurance industry in US; it is the daily stocks abnormal returns net of 3 common factors of Fama-French. In the third column, the dependent variable is 3-days cumulative abnormal return. Level surprise ($\triangle ff_t^u$) is the unexpected change of fed fund target rate which are the variations of 30 days fed fund future contract rates. Slopeshock ($\triangle y^m - \triangle ff_t^u$) is the difference of long-term treasury rate (m takes the value 2, 5 or 10; m represents the maturity of long term treasury yield) changes and unexpected level surprise of fed fund target rate.Expected change ($\triangle ff_t^e$) is the variations of fed fund rate expected by people. The standard errors are corrected by HAC estimated and clustered by firms. T-values are in the parentheses. (* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$)

Table 4: Daily stock returns to interest rate shocks in US across sub-industries

	Broker (1)	Life (2)	Multi-line (3)	P&C (4)	Re-insurance (5)
Level Surprise	0.784	1.968***	3.046***	2.529***	1.588
	(0.60)	(3.24)	(3.13)	(4.97)	(0.79)
Slopeshock_m	1.737*	1.223***	1.911	1.795***	0.826
	(1.91)	(2.67)	(1.65)	(4.50)	(0.52)
Expected Change	-0.008	-0.305	-0.060	-0.191	-0.143
	(-0.02)	(-1.57)	(-0.19)	(-1.24)	(-0.26)
Constant	1.033**	0.098	-0.160	-0.054	-0.132***
	(2.28)	(0.76)	(-1.10)	(-0.32)	(-4.97)
Year FE	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes
Observation	1587	6044	2101	11905	774
R^2	.0485	.0292	.0365	.0276	.0572

In this table, the dependent variable is the abnormal stock return of insurance companies in US; it is the stocks return net of 3 common factors of Fama-French. Level surprise ($\triangle ff_t^u$) is the unexpected change of fed fund target rate which are the variations of 30 days fed fund future contract rates. Slopeshock_m ($\triangle y^m - \triangle ff_t^u$) is the difference of long-term treasury rate changes (m can takes the value 2, 5 or 10; m represents the maturity of long term treasury yield) and unexpected level surprise of fed fund target rate. Expected Change ($\triangle ff_t^e$) is the variation of fed fund rate expected by people. The standard errors are corrected by HAC estimated and clustered by firms. T-values are in the parentheses.
(* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$)

Table 5: Daily stock returns to interest rate shocks in US through Exposure

	Insurance (1)	Life (2)	Multi-line (3)	P&C (4)
Level surprise	0.387	-0.033	-1.033	-0.191
	(0.51)	(-0.03)	(-1.28)	(-0.17)
Slopeshock_m	0.717	1.707	-1.107	-0.209
	(1.28)	(1.52)	(-1.34)	(-0.28)
Exposure gr2 × level surprise	1.789*	1.946	0.757	2.657**
	(1.90)	(1.31)	(0.54)	(2.02)
Exposure gr3 × level surprise	2.474**	3.772**	1.868	2.212
	(2.44)	(2.28)	(1.24)	(1.57)
Exposure gr2 × slopeshock5	0.297	-1.375	1.899	1.420
	(0.38)	(-0.93)	(0.89)	(1.55)
Exposure gr3 × slopeshock5	0.856	-0.855	3.825**	1.727*
	(1.09)	(-0.58)	(2.22)	(1.70)
Exposure group2	0.042	0.097	0.056	0.043
	(0.89)	(1.42)	(0.35)	(0.66)
Exposure group3	-0.042	0.051	-0.185	-0.078
	(-0.72)	(0.59)	(-1.23)	(-1.02)
Expected change	-0.142	-0.264	-0.257	-0.074
	(-1.12)	(-1.23)	(-0.55)	(-0.53)
Constant	0.077	-0.060	-0.009	0.114
	(0.90)	(-0.43)	(-0.05)	(1.02)
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Observation	13255	3753	1459	7123
R^2	.0352	.0534	.05521	.0374

In this table, the dependent variable is the abnormal stock return of insurance companies in US; it is the stocks returns net of 3 common factors of Fama-French. Level surprise ($\triangle ff_t^u$) is the unexpected change of fed fund target rate which are the variations of 30 days fed fund future contract rates. Slopeshock_m ($\triangle y^m - \triangle ff_t^u$) is the difference of long-term treasury rate changes (m can takes the value 2, 5 or 10; m represents the maturity of long term treasury yield) and unexpected level surprise of fed fund target rate. Expected Change ($\triangle ff_t^e$) is the variation of fed fund rate expected by people. Exposure measures the level of direct exposure to interest rate variations; firms are divided into 3 groups according to the level of exposure. The standard errors are corrected by HAC estimated and clustered by firms. T-values are in the parentheses. (* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$)

Table 6: Daily stock returns to interest rate shocks in US across firm size

	Insurance (1)	Life (2)	Multi-line (3)	P&C (4)
Level surprise	2.226***	2.008*	2.632	2.274**
	(3.03)	(1.72)	(1.29)	(2.23)
Slopeshock_m	1.434**	2.479**	1.603	0.744
	(2.39)	(2.30)	(0.71)	(0.97)
Size gr2 × level surprise	0.276	-0.564	-1.873	1.045
	(0.32)	(-0.36)	(-0.84)	(0.90)
Size gr3 × level surprise	0.119	0.168	0.405	-0.007
	(0.14)	(0.12)	(0.18)	(-0.01)
Size gr2 × slopeshock5	0.091	-1.904	-2.283	1.637
	(0.12)	(-1.59)	(-0.80)	(1.55)
Size gr3 × slopeshock5	-0.115	-1.791	1.184	0.597
	(-0.16)	(-1.48)	(0.51)	(0.60)
Size group2	-0.057	-0.102	-0.177	-0.031
	(-0.80)	(-0.93)	(-0.90)	(-0.31)
Size group3	-0.168	-0.258	-0.091	-0.157
	(-1.53)	(-1.46)	(-0.33)	(-1.00)
Expected change	-0.161	-0.171	-0.047	-0.174
	(-1.42)	(-0.92)	(-0.14)	(-1.10)
Constant	0.083	0.124	0.098	0.085
	(0.66)	(0.71)	(0.25)	(0.46)
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Observation	18675	5723	1900	11052
R^2	.0278	.0323	.0388	.0302

In this table, the dependent variable is the abnormal stock return of insurance companies in US. Level surprise ($\triangle ff_t^u$) is the unexpected change of fed fund target rate which are the variations of 30 days fed fund future contract rates. Slopeshock_m ($\triangle y^m - \triangle ff_t^u$) is the difference of long-term treasury rate changes (m can takes the value 2, 5 or 10; m represents the maturity of long term treasury yield) and unexpected level surprise of fed fund target rate. Expected Change ($\triangle ff_t^e$) is the variation of fed fund rate expected by people. Size is the total assets of firms; firms are clarified into 3 groups according to the size. Size group2 indicates whether the firm belongs to group 2 or not according to its size. The standard errors are corrected by HAC estimated and clustered by firms. T-values are in the parentheses.
(* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$)

Table 7: Daily stock returns to interest rate shocks in US

	Insurance (1)	Life (2)	Multi-line (3)	P&C (4)
Level surprise	2.313***	0.705	1.745	3.283***
	(4.06)	(0.84)	(0.98)	(4.25)
Slopeshock_m	1.324**	0.221	0.698	2.033***
	(2.46)	(0.27)	(0.33)	(2.91)
Mlev gr2 × level surprise	0.156	1.989	-0.192	-0.831
	(0.20)	(1.43)	(-0.07)	(-0.84)
Mlev gr3 × level surprise	0.054	1.421	2.026	-0.995
	(0.07)	(1.28)	(1.20)	(-0.91)
Mlev gr2 × slopeshock5	0.369	0.759	0.105	0.081
	(0.52)	(0.66)	(0.04)	(0.09)
Mlev gr3 × slopeshock5	-0.119	1.846*	1.962	-1.508
	(-0.16)	(1.72)	(0.82)	(-1.54)
Melv group2	-0.110**	-0.058	-0.274	-0.100*
	(-2.50)	(-0.77)	(-1.51)	(-1.67)
Mlev group3	-0.030	0.049	-0.093	-0.041
	(-0.51)	(0.45)	(-0.52)	(-0.55)
Expected change	-0.160	-0.166	-0.069	-0.176
	(-1.42)	(-0.90)	(-0.21)	(-1.11)
Constant	0.004	-0.006	-0.042	0.010
	(0.04)	(-0.04)	(-0.20)	(0.07)
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Observation	18675	5723	1900	11052
R^2	.0279	.0324	.0389	.0305

In this table, the dependent variable is the abnormal stock return of insurance companies in US. Level surprise ($\triangle ff_t^u$) is the unexpected change of fed fund target rate which are the variations of 30 days fed fund future contract rates. Slopeshock_m ($\triangle y^m - \triangle ff_t^u$) is the difference of long-term treasury rate changes (m can takes the value 2, 5 or 10; m represents the maturity of long term treasury yield) and unexpected level surprise of fed fund target rate. Expected Change ($\triangle ff_t^e$) is the variation of fed fund rate expected by people. Mlev is the debt amount over firms' total assets(market value). The standard errors are corrected by HAC estimated and clustered by firms. T-values are in the parentheses.
(* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$)

Table 8: Daily stock returns to interest rate shocks in US with M-to-B

	Insurance (1)	Life (2)	Multi-line (3)	P&C (4)
Level surprise	2.304***	1.879**	3.022***	2.383***
	(4.59)	(2.23)	(3.42)	(3.34)
Slopeshock	1.009**	0.174	1.302	1.316*
	(1.99)	(0.23)	(1.05)	(1.83)
BM gr2 × level surprise	0.259	0.968	-1.689	0.183
	(0.35)	(0.76)	(-0.96)	(0.18)
BM gr3 × level surprise	-0.145	-0.937	-0.533	0.379
	(-0.19)	(-0.72)	(-0.24)	(0.37)
BM gr2 × slopeshock5	0.735	1.700*	-0.421	0.480
	(1.01)	(1.69)	(-0.21)	(0.46)
BM gr3 × slopeshock5	0.511	1.196	0.641	0.173
	(0.71)	(1.16)	(0.30)	(0.17)
BM group2	0.001	0.020	-0.008	0.003
	(0.01)	(0.19)	(-0.08)	(0.04)
BM group3	0.009	-0.001	-0.179	0.053
	(0.15)	(-0.00)	(-1.29)	(0.68)
Expected change	-0.157	-0.162	0.026	-0.189
	(-1.42)	(-0.86)	(0.09)	(-1.24)
Constant	-0.042	-0.019	-0.110	-0.048
	(-0.38)	(-0.11)	(-0.70)	(-0.30)
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Observation	19275	5797	2032	11446
R^2	.0268	.0324	.0366	.0286

In this table, the dependent variable is the abnormal stock return of insurance companies in US. Level surprise ($\triangle ff_t^u$) is the unexpected change of fed fund target rate which are the variations of 30 days fed fund future contract rates. Slopeshock_m ($\triangle y^m - \triangle ff_t^u$) is the difference of long-term treasury rate changes (m can takes the value 2, 5 or 10; m represents the maturity of long term treasury yield) and unexpected level surprise of fed fund target rate. Expected Change ($\triangle ff_t^e$) is the variation of fed fund rate expected by people. The standard errors are corrected by HAC estimated and clustered by firms. T-values are in the parentheses.
(* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$)

Table 9: Daily stock returns to interest rate shocks in US with ROA

	Insurance (1)	Life (2)	Multi-line (3)	P&C (4)
Level surprise	3.447***	2.382	3.892	3.784***
	(4.44)	(1.62)	(1.39)	(3.91)
Slopeshock_m	1.871***	2.346**	2.590	1.541
	(2.77)	(2.52)	(1.26)	(1.60)
ROA gr2 × level surprise	-0.669	0.085	-3.019	-0.534
	(-0.68)	(0.04)	(-0.99)	(-0.45)
ROA gr3 × level surprise	-1.105	0.473	-0.884	-1.831
	(-1.01)	(0.27)	(-0.22)	(-1.29)
ROA gr2 × slopeshock5	-0.457	-1.260	-2.974	0.287
	(-0.54)	(-0.86)	(-1.38)	(0.24)
ROA gr3 × slopeshock5	-0.942	-0.490	-3.157	-0.891
	(-1.02)	(-0.39)	(-0.99)	(-0.68)
ROA group2	-0.016	0.022	0.022	-0.052
	(-0.26)	(0.19)	(0.18)	(-0.73)
ROA group3	-0.055	-0.295*	0.104	-0.021
	(-0.84)	(-1.89)	(1.19)	(-0.25)
Expected change	-0.150	-0.316	0.193	-0.133
	(-0.94)	(-1.19)	(0.44)	(-0.61)
Constant	-0.008	0.074	-0.198	0.013
	(-0.07)	(0.39)	(-1.51)	(0.08)
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Observation	12863	3474	1478	7911
R^2	.0299	.0351	.0458	.0339

In this table, the dependent variable is the abnormal stock return of insurance companies in US. Level surprise ($\triangle ff_t^u$) is the unexpected change of fed fund target rate which are the variations of 30 days fed fund future contract rates. Slopeshock_m ($\triangle y^m - \triangle ff_t^u$) is the difference of long-term treasury rate changes (m can takes the value 2, 5 or 10; m represents the maturity of long term treasury yield) and unexpected level surprise of fed fund target rate. Expected Change ($\triangle ff_t^e$) is the variation of fed fund rate expected by people. The standard errors are corrected by HAC estimated and clustered by firms. T-values are in the parentheses.
(* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$)

Table 10: Daily stock returns to interest rate shocks in US with different debt maturity

	(1)	(2)	(3)	(4)	(5)
Level surprise	1.845***	1.724*	1.670	1.759	1.782
	(3.00)	(1.69)	(1.33)	(1.26)	(0.88)
Slopeshock	0.289	0.262	0.555	0.023	-1.111
	(0.58)	(0.35)	(0.61)	(0.02)	(-0.67)
Maturity gr2 × level surprise	0.900	0.671	0.696	0.657	0.487
	(1.03)	(0.72)	(0.76)	(0.71)	(0.35)
Maturity gr3 × level surprise	0.681	0.674	0.719	0.680	1.008
	(0.72)	(0.70)	(0.74)	(0.70)	(0.80)
Maturity gr2 × slopeshock5	1.542**	1.422*	1.458*	1.404*	1.671
	(2.17)	(1.76)	(1.84)	(1.77)	(1.43)
Maturity gr3 × slopeshock5	1.761**	1.758**	1.784**	1.718**	2.393**
	(2.14)	(2.11)	(2.15)	(2.09)	(2.27)
Expected change	-0.237*	-0.236*	-0.238*	-0.237*	-0.223
	(-1.75)	(-1.74)	(-1.75)	(-1.75)	(-1.24)
Constant	0.070	0.159	0.089	0.096	0.133
	(0.60)	(1.13)	(0.59)	(0.62)	(0.76)
Size× Interest surprise	No	Yes	Yes	Yes	Yes
Mlev× Interest surprise	No	No	Yes	Yes	Yes
BM× Interest surprise	No	No	No	Yes	Yes
ROA× Interest surprise	No	No	No	No	Yes
Firm Characteristics	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes
Observation	15300	15300	15300	15300	10546
R^2	.0320	.0323	.0325	.0327	.0354

In this table, the dependent variable is the abnormal stock return of insurance companies in US. Level surprise ($\triangle ff_t^u$) is the unexpected change of fed fund target rate which are the variations of 30 days fed fund future contract rates. Slopeshock_m ($\triangle y^m - \triangle ff_t^u$) is the difference of long-term treasury rate changes (m can takes the value 2, 5 or 10; m represents the maturity of long term treasury yield) and unexpected level surprise of fed fund target rate. Expected Change ($\triangle ff_t^e$) is the variation of fed fund rate expected by people. The standard errors are corrected by HAC estimated and clustered by firms. T-values are in the parentheses.
(* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$)

Table 11: Daily stock returns to interest rate shocks in US for life insurance

	Insurance (1)	Life (2)	Multi-line (3)	P&C (4)
Level surprise	1.782	0.179	-1.003	1.008
	(0.88)	(0.04)	(-0.25)	(0.35)
Slopeshock	-1.111	-0.151	-2.212	-1.683
	(-0.67)	(-0.04)	(-0.77)	(-0.71)
Maturity gr2 × level surprise	0.487	-0.885	1.572	0.822
	(0.35)	(-0.35)	(0.79)	(0.44)
Maturity gr3 × level surprise	1.008	1.878	6.604***	0.457
	(0.80)	(0.76)	(3.00)	(0.26)
Maturity gr2 × slopeshock5	1.671	0.908	1.764	1.767
	(1.43)	(0.40)	(0.83)	(1.10)
Maturity gr3 × slopeshock5	2.393**	4.594**	6.811**	1.060
	(2.27)	(2.29)	(2.23)	(0.77)
Expected change	-0.223	-0.459*	0.046	-0.147
	(-1.24)	(-1.71)	(0.10)	(-0.54)
Constant	0.133	0.309	-0.720**	0.165
	(0.76)	(1.03)	(-2.27)	(0.65)
Size×Interest surprise	Yes	Yes	Yes	Yes
Mlev× Interest surprise	Yes	Yes	Yes	Yes
BM×Interest surprise	Yes	Yes	Yes	Yes
ROA× Interest surprise	Yes	Yes	Yes	Yes
Firm Characteristics	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Observation	10546	2890	1419	6237
R^2	.0354	.0548	.0645	.0390

In this table, the dependent variable is the abnormal stock return of insurance companies in US. Level surprise ($\triangle ff_t^u$) is the unexpected change of fed fund target rate which are the variations of 30 days fed fund future contract rates. Slopeshock_m ($\triangle y^m - \triangle ff_t^u$) is the difference of long-term treasury rate changes (m can takes the value 2, 5 or 10; m represents the maturity of long term treasury yield) and unexpected level surprise of fed fund target rate. Expected Change ($\triangle ff_t^e$) is the variation of fed fund rate expected by people. Maturity is the weighed maturity of long-term debts; the sample is divided into 3 groups according to the level of debt maturity. Interest surprise includes the level surprises and slope shocks of interest rates; Size is the log of total assets at last period; Mlev is the market leverage of firms at last period; Firm Characteristics incorporates Size, Mlev, ROA, BM of last period. The standard errors are corrected by HAC estimated and clustered by firms. T-values are in the parentheses.
(* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$)

Table 12: Daily stock returns to positive and negative interest rate shocks

	Positive			Negative		
	Life	Multi-line	P&C	Life	Multi-line	P&C
	(1)	(2)	(3)	(4)	(5)	(6)
Level Surprise	2.541 **	5.505*	3.681***	2.256	1.796	-2.690*
	(2.01)	(1.86)	(3.25)	(1.21)	(0.66)	(-1.89)
Slopeshock_m	1.307*	3.769**	2.203***	0.052	-2.036	0.599
	(1.75)	(2.42)	(3.54)	(0.03)	(-0.65)	(0.62)
Expected Change	-0.556**	-0.458	-0.413*	0.700	2.767	-1.972***
	(-2.)	(-0.97)	(-1.95)	(0.70)	(1.36)	(-3.15)
Constant	0.061	-0.136	-0.049	0.708	-0.115	0.760
	(0.49)	(-0.94)	(-0.29)	(0.85)	(-0.23)	(1.46)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Observation	4947	1769	9813	1097	332	2092
R^2	.0368	.0448	.0337	.1144	.1824	.1013

In this table, the dependent variable is the abnormal stock return of insurance companies in US; it is the stocks return net of 3 common factors of Fama-French. Level surprise ($\triangle ff_t^u$) is the unexpected change of fed fund target rate which are the variations of 30 days fed fund future contract rates. Slopeshock_2 ($\triangle y^m - \triangle ff_t^u$) is the difference of 2-year treasury rate changes and unexpected level surprise of fed fund target rate; Slopeshock_10 is the difference of 10-year long-term treasury rate changes and unexpected level surprise of fed fund target rate Expected Change ($\triangle ff_t^e$) is the variation of fed fund rate expected by people. The standard errors are corrected by HAC estimated and clustered by firms. T-values are in the parentheses.
(* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$)

Table 13: Daily stock returns to positive and negative interest rate shocks

	Positive			Negative		
	Life	Multi-line	P&C	Life	Multi-line	P&C
	(1)	(2)	(3)	(4)	(5)	(6)
Level surprise	-3.513	1.409	5.061	-0.762	-13.513	-4.755
	(-0.36)	(0.22)	(1.26)	(-0.10)	(-1.47)	(-0.91)
Slopeshock	-3.637	4.707	-0.513	-6.629	-18.582*	-0.010
	(-0.54)	(1.11)	(-0.18)	(-1.04)	(-2.13)	(-0.00)
Maturity gr2 × level surprise	0.366	-10.224	-3.979	-4.036	18.487***	4.767
	(0.08)	(-1.69)	(-1.25)	(-0.90)	(4.58)	(1.37)
Maturity gr3 × level surprise	2.368	2.962	-1.271	-7.079	11.793*	0.642
	(0.46)	(0.59)	(-0.43)	(-1.38)	(2.15)	(0.20)
Maturity gr2 × slopeshock5	1.869	-10.249**	-0.125	-0.271	25.459***	3.018
	(0.54)	(-2.40)	(-0.07)	(-0.07)	(6.95)	(1.05)
Maturity gr3 × slopeshock5	6.014*	4.388	0.646	-2.999	14.380**	1.355
	(1.97)	(1.54)	(0.39)	(-0.67)	(2.80)	(0.51)
Expected change	-1.141***	-0.840	-0.544	2.798*	4.600**	-1.661*
	(-3.24)	(-1.60)	(-1.62)	(1.75)	(2.28)	(-1.74)
Constant	0.222	-0.691**	0.091	0.271	-2.492	0.914
	(0.67)	(-2.41)	(0.33)	(0.22)	(-1.56)	(0.78)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Observation	2495	1260	5493	518	197	985
R^2	.0619	.0756	.0480	.2499	.4298	.1871

In this table, the dependent variable is the abnormal stock return of insurance companies in US; it is the stocks return net of 3 common factors of Fama-French. Level surprise ($\triangle ff_t^u$) is the unexpected change of fed fund target rate which are the variations of 30 days fed fund future contract rates. Slopeshock_2 ($\triangle y^m - \triangle ff_t^u$) is the difference of 2-year treasury rate changes and unexpected level surprise of fed fund target rate; Slopeshock_10 is the difference of 10-year long-term treasury rate changes and unexpected level surprise of fed fund target rate Expected Change ($\triangle ff_t^e$) is the variation of fed fund rate expected by people. The standard errors are corrected by HAC estimated and clustered by firms. T-values are in the parentheses.
(* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$)

Table 14: Daily stock returns to positive and negative interest rate shocks

	Before 2008			After2008		
	Life	Multi-line	P&C	Life	Multi-line	P&C
	(1)	(2)	(3)	(4)	(5)	(6)
Level Surprise	1.201*	3.283**	2.877***	4.758**	0.104	1.293
	(1.76)	(2.83)	(4.79)	(2.27)	(0.04)	(1.03)
Slopeshock_m	0.431	1.676	2.070***	9.333***	7.311***	0.316
	(0.86)	(1.38)	(4.47)	(3.49)	(3.16)	(0.20)
Expected Change	-0.205	-0.197	-0.203	-0.590	-0.254	-0.160
	(-0.88)	(-0.40)	(-1.12)	(-1.23)	(-0.35)	(-0.45)
Constant	0.363**	-0.064	0.156	0.057	-0.158	-0.006
	(2.53)	(-0.23)	(1.33)	(0.46)	(-1.21)	(-0.03)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Observation	4779	1387	8857	1265	714	3048
R^2	.0315	.0385	.0286	.0503	.0507	.0430

In this table, the dependent variable is the abnormal stock return of insurance companies in US; it is the stocks return net of 3 common factors of Fama-French. Level surprise ($\triangle ff_t^u$) is the unexpected change of fed fund target rate which are the variations of 30 days fed fund future contract rates. Slopeshock_2 ($\triangle y^m - \triangle ff_t^u$) is the difference of 2-year treasury rate changes and unexpected level surprise of fed fund target rate; Slopeshock_10 is the difference of 10-year long-term treasury rate changes and unexpected level surprise of fed fund target rate Expected Change ($\triangle ff_t^e$) is the variation of fed fund rate expected by people. The standard errors are corrected by HAC estimated and clustered by firms. T-values are in the parentheses.
(* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$)

Table 15: Banks' Daily stock returns to positive and negative interest rate shocks

	ab ret (1)	ab ret 3days (2)
Level surprise	-0.253*	-0.460**
	(-1.80)	(-2.52)
Slopeshock	-1.494***	-1.489***
	(-10.31)	(-8.44)
Expected change	-0.099***	-0.031
	(-2.59)	(-0.65)
Constant	-0.020*	-0.122***
	(-1.69)	(-3.92)
Year FE	Yes	Yes
Firm FE	Yes	Yes
Observation	2871883	2725324
R^2	.0012	.0039

In this table, the dependent variable is the abnormal stock return of insurance companies in US; it is the stocks return net of 3 common factors of Fama-French. Level surprise ($\triangle ff_t^u$) is the unexpected change of fed fund target rate which are the variations of 30 days fed fund future contract rates. Slopeshock ($\triangle y^m - \triangle ff_t^u$) is the difference of 5-year treasury rate changes and unexpected level surprise of fed fund target rate. Expected Change ($\triangle ff_t^e$) is the variation of fed fund rate expected by people. The standard errors are corrected by HAC estimated and clustered by firms. T-values are in the parentheses.
(* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$)

Table 16: Daily stock returns to positive and negative interest rate shocks in EZ

	Banks (1)	Insurance (2)
Level surprise	-1.056***	0.926**
	(0.208)	(0.441)
Slopeshock	-0.298	0.608
	(0.196)	(0.421)
Expected change	-0.448***	0.220
	(0.060)	(0.127)
Constant	-0.107***	-0.090**
	(0.020)	(0.044)
Year FE	Yes	Yes
Firm FE	Yes	Yes
Observation	55551	11385
R^2	.0012	.0039
Num of firm	2292	411

In this table, the dependent variable is the abnormal stock return of insurance companies in Euro-zone; it is the daily stocks return net of 3 common factors of Fama-French. Level surprise ($\triangle ff_t^u$) is the unexpected change of fed fund target rate which are the variations of 30 days fed fund future contract rates. Slopeshock ($\triangle y^m - \triangle ff_t^u$) is the difference of 5-year treasury rate changes and unexpected level surprise of fed fund target rate. Expected Change ($\triangle ff_t^e$) is the variation of fed fund rate expected by people. The standard errors are corrected by HAC estimated and clustered by firms. Standard errors are in the parentheses.
(* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$)

Table 17: Robustness Tests with Different Long-term Treasury Rates

	Life	Multi-line	P&C	Life	Multi-line	P&C
	(1)	(2)	(3)	(4)	(5)	(6)
Level Surprise	1.847***	3.025***	2.320***	1.954***	2.644**	2.584***
	(3.46)	(3.87)	(4.97)	(2.85)	(2.17)	(4.26)
Slopeshock_2	1.183***	2.028**	1.692***			
	(2.63)	(2.19)	(4.36)			
Slopeshock_10				1.140**	1.373	1.760***
				(2.07)	(0.95)	(3.48)
Expected Change	-0.346*	-0.110	-0.230	-0.254	0.027	-0.120
	(-1.75)	(-0.35)	(-1.48)	(-1.34)	(0.09)	(-0.78)
Constant	0.107	-0.146	-0.042	0.099	-0.159	-0.053
	(0.83)	(-0.99)	(-0.25)	(0.78)	(-1.09)	(-0.32)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Observation	6044	2101	11905	6044	2101	11905
R^2	.0292	.0368	.0275	.0290	.0352	.0271

In this table, the dependent variable is the abnormal stock return of insurance companies in US; it is the stocks return net of 3 common factors of Fama-French. Level surprise ($\triangle ff_t^u$) is the unexpected change of fed fund target rate which are the variations of 30 days fed fund future contract rates. Slopeshock_2 ($\triangle y^m - \triangle ff_t^u$) is the difference of 2-year treasury rate changes and unexpected level surprise of fed fund target rate; Slopeshock_10 is the difference of 10-year long-term treasury rate changes and unexpected level surprise of fed fund target rate Expected Change ($\triangle ff_t^e$) is the variation of fed fund rate expected by people. The standard errors are corrected by HAC estimated and clustered by firms. T-values are in the parentheses.
(* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$)

Table 18: Robustness test: Time Trend

	ab ret (1)	ab ret (2)	ab ret 3 days (3)	ab ret 3 days (4)
Target Change	-0.003***	-0.001	-0.153***	-0.021
	(-7.52)	(-1.33)	(-5.28)	(-0.37)
SMB	0.004***	0.006***	0.325***	0.435***
	(18.92)	(12.04)	(18.78)	(15.34)
HML	0.005***	0.008***	0.359***	0.513***
	(19.99)	(12.09)	(20.05)	(14.93)
Market	0.006***	0.009***	0.452***	0.726***
	(32.33)	(24.34)	(32.17)	(29.61)
Constant	0.001***	0.000**	0.048***	0.001
	(15.71)	(2.49)	(13.88)	(0.19)
Firm FE	No	Yes	No	Yes
Observation	129,038	29,709	125,975	28,968
R^2	.1021	.1479	.0898	.1722

In this table, the dependent variable is the abnormal stock return of insurance companies in US; it is the stocks return net of 3 common factors of Fama-French. Target Change is the variations of Fed funds target interest rates on the FOMC announcement dates. SMB, HML and Market are the daily 3 Fama-French factors. T-values are in the parentheses.
(* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$)

Table 19: Robustness: with other long-term debt

	Insurance (1)	Life (2)	Multi-line (3)	P&C (4)
Level surprise	2.525	-1.802	-4.535	5.127
	(0.82)	(-0.27)	(-0.50)	(1.17)
Slopeshock	0.080	-3.397	4.285	1.853
	(0.04)	(-0.74)	(0.68)	(0.58)
Maturity gr2 × level surprise	-0.215	0.483	4.587	-1.609
	(-0.14)	(0.17)	(1.46)	(-0.78)
Maturity gr3 × level surprise	1.288	5.510	9.070**	-1.088
	(0.72)	(1.54)	(2.19)	(-0.42)
Maturity gr2 × slopeshock5	1.062	2.282	0.595	0.108
	(0.84)	(0.92)	(0.29)	(0.06)
Maturity gr3 × slopeshock5	2.202	8.228***	4.129	-0.275
	(1.61)	(3.28)	(1.32)	(-0.15)
Other × level surprise	-0.587	5.230	4.143	-4.676
	(-0.28)	(1.29)	(0.68)	(-1.42)
Other × slopeshock5	-0.962	5.983**	-7.705*	-3.676
	(-0.58)	(2.01)	(-1.86)	(-1.46)
Expected change	-0.200	-0.496*	0.027	-0.072
	(-1.08)	(-1.69)	(0.06)	(-0.26)
Constant	0.111	0.363	-0.742**	0.124
	(0.59)	(1.10)	(-2.33)	(0.45)
Size×Interest surprise	Yes	Yes	Yes	Yes
Mlev× Interest surprise	Yes	Yes	Yes	Yes
BM×Interest surprise	Yes	Yes	Yes	Yes
ROA× Interest surprise	Yes	Yes	Yes	Yes
Firm Characteristics	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Observation	9820	2760	1365	5695
R^2	.03881011	.0592482	.07206968	.04463542

In this table, the dependent variable is the abnormal stock return of insurance companies in US. Level surprise ($\triangle ff_t^u$) is the unexpected change of fed fund target rate which are the variations of 30 days fed fund future contract rates. Slopeshock_m ($\triangle y^m - \triangle ff_t^u$) is the difference of long-term treasury rate changes (m can takes the value 2, 5 or 10; m represents the maturity of long term treasury yield) and unexpected level surprise of fed fund target rate. Expected Change ($\triangle ff_t^e$) is the variation of fed fund rate expected by people. The standard errors are corrected by HAC estimated and clustered by firms. T-values are in the parentheses.
(* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$)

Table 20: Robustness: taking m=10

	Insurance (1)	Life (2)	Multi-line (3)	P&C (4)
Level surprise	0.703	-2.354	-11.027	2.788
	(0.20)	(-0.37)	(-1.13)	(0.59)
Slopeshock	-1.724	-3.813	-2.929	-0.453
	(-0.64)	(-0.81)	(-0.40)	(-0.12)
Maturity gr2 × level surprise	0.280	1.328	6.229	-1.211
	(0.15)	(0.41)	(1.55)	(-0.48)
Maturity gr3 × level surprise	2.201	6.559	11.784**	-0.357
	(1.02)	(1.54)	(2.57)	(-0.12)
Maturity gr2 × slopeshock5	1.450	2.938	2.217	0.384
	(0.95)	(1.04)	(0.79)	(0.17)
Maturity gr3 × slopeshock5	2.998*	8.827***	6.573*	0.531
	(1.71)	(2.75)	(1.85)	(0.22)
Other × level surprise	0.468	3.921	9.784	-2.840
	(0.25)	(1.14)	(1.70)	(-1.04)
Other × slopeshock10	0.208	4.563*	-0.845	-1.793
	(0.15)	(1.86)	(-0.20)	(-0.89)
Expected change	-0.163	-0.537*	0.082	-0.004
	(-0.87)	(-1.84)	(0.16)	(-0.02)
Constant	0.107	0.352	-0.734**	0.125
	(0.57)	(1.07)	(-2.37)	(0.45)
Size×Interest surprise	Yes	Yes	Yes	Yes
Mlev× Interest surprise	Yes	Yes	Yes	Yes
BM×Interest surprise	Yes	Yes	Yes	Yes
ROA× Interest surprise	Yes	Yes	Yes	Yes
Firm Characteristics	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Observation	9820	2760	1365	5695
R^2	.03826786	.05924775	.06729506	.04367973

In this table, the dependent variable is the abnormal stock return of insurance companies in US. Level surprise ($\triangle ff_t^u$) is the unexpected change of fed fund target rate which are the variations of 30 days fed fund future contract rates. Slopeshock_m ($\triangle y^m - \triangle ff_t^u$) is the difference of long-term treasury rate changes (m can takes the value 2, 5 or 10; m represents the maturity of long term treasury yield) and unexpected level surprise of fed fund target rate. Expected Change ($\triangle ff_t^e$) is the variation of fed fund rate expected by people. The standard errors are corrected by HAC estimated and clustered by firms. T-values are in the parentheses.
(* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$)

European Stress Tests and Banks' Risk-taking

Ying Liang*

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Abstract

I investigate how the 2011 and 2014 EU stress tests affect the risk-taking of European banks. I document a non-monotonic relationship between banks' risk-shifting resulting from regulatory arbitrage and the tightness of their capital constraint (i.e., the distance between their ex-ante capital ratio and the regulatory level): banks with capital ratios marginally above the regulatory level do more regulatory arbitrage than banks with a level of capital ratio significantly below or above the regulatory level. I also study the indirect effect of the tests on the financing costs of banks which are excluded from the tests: their financing costs on the corporate bond market increase with the level of negative information released in the country in which they are located.

JEL-Codes: G21, G18, E58

Keywords: Bank, stress test, risk-shifting, regulatory arbitrage, sovereign bonds, corporate bonds

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1 Introduction

In this paper, I conduct an empirical analysis of the changes in banks' risk-taking due to stress tests which act as tighter regulatory constraints. After the financial crisis in 2008, both US and European authorities conducted a series of stress tests to limit the risk-taking of banks and to strengthen their capital structures. However, the regulator's objective of limiting risk-taking may not be aligned with the bank's private interests, which may then lead to regulatory arbitrage: if banks face tighter constraints on their investments, they may wish to strategically take more risks which deviates from the regulator's aim. Therefore, understanding the impact of potential new constraints on banks' risk-taking is critical for both regulators and policymakers.

The European market suffered a sovereign debt crisis during 2010-2011, resulting in sustained negative effects on the real economy. In 2013, the GDP of all 17 Eurozone countries fell by 0.5% and the Eurozone was mired in recession.[1] The Eurozone sovereign debt crisis[2] highlighted the nexus between governments and banks with potential adverse consequences in the supply of credit to the real economy. Therefore, the European Banking Authority (EBA[3]) was mandated to conduct EU-wide stress tests in a bottom-up fashion, using consistent methodologies, scenarios and key assumptions developed in cooperation with the European Systemic Risk Board (ESRB), the European Central Bank (ECB) and the European Commission (EC).

In the 2011 stress test, regulators start to incorporate EU sovereign risk into the banks' risk measures, using two test scenarios: a baseline scenario and an adverse scenario. In the adverse scenario,[4] most of the sovereign bonds are downgraded below their current credit rating levels as *hypothetical shocks* in order to increase banks' risk exposure: AAA sovereigns (no downgrade), AA and A (two notch downgrades), BBB or below (four notch

[1] See Acharya and Steffen (2014).
[2] See Altavilla, Pagano, and Simonelli (2017).
[3] In this paper, I use EBA to represent the banking union (EBA, ESRB, EC, and ECB).
[4] See the Methodological Note - Additional guidance of 2011 stress test (Page 5-6) and more in Appendix 3 C.1.

downgrades). In the 2014 test,[5] the measure[6] of sovereign risk is also linked to their credit ratings.

Since the EBA includes the EU sovereign risk in the measure of banks' risk exposure and requests banks to recapitalize, the stress tests act as tighter regulations imposed on banks' investments. In this paper, I develop a model along the lines of Glasserman and Kang (2014) to understand the potential effect of the stress tests on banks' risk-taking. The model predicts that banks which are marginally regulatory constrained (i.e., closer to the binding regulatory constraint) do more regulatory arbitrage than unconstrained banks (safe banks, i.e., far above the binding constraint) and fragile banks (i.e., below the binding constraint) after the tests.

Using the EBA database, I test the model's predictions with a difference-in-difference approach. After the announcement of the test, if banks are able to raise capital before submitting their test reports to the central banks, then this recapitalization is included into the final CET 1 (Common Equity Tier 1) ratio, which is called the adjusted CET 1 ratio. In the 2011 test,[7] banks fail the test if their adjusted CET 1 ratio under adverse scenario is lower than 5%; banks are said by the EBA to "marginally pass the test" if they have an adjusted CET 1 ratio of 5%-6%; and banks successfully pass the test if their adjusted CET 1 ratios are larger than 6%.

In the literature, Boyson, Fahlenbrach, and Stulz (2016), Efing (2016), Becker and Ivashina (2015), and Ellul et al. (2011) use the capital ratios to define two groups: regulatory constrained firms and unconstrained firms. Instead, I divide tested banks into three groups according to their CET 1 ratios without including the recapitalization conducted after the announcement of the tests. An additional group of "marginal banks" (i.e., banks

[5]See the Methodological Note EU-wide stress test 2014, page 15 and more in Appendix 3 C.2.

[6]The sovereign risk is incorporated into the Risk Weighted Assets directly through the parameter of the model. Probability of Default (PD) and Loss Given Default (LGD) were calculated for five portfolios (financial institutions, sovereign, corporate, consumer credit retail, and retail real estate) by using regression model elasticities linked to the macro variables, national supervisory inputs, the ECB Monetary and Financial Institutions database, and the LGD database at Moody's.

[7]The criteria of the 2014 test can be found in Section 3. In the 2014 test, the criteria to pass the test is based on the unadjusted CET 1 ratios

that are marginally regulatory constrained according to the EBA) is very important in order to test for a non-monotonic relationship between banks' regulatory arbitrage and the tightness of their capital constraint. Banks are supervised differently by local central banks after the release of test results based on whether banks successfully pass the test, marginally pass the test or fail the test.

Banks engage in regulatory arbitrage on the investment of sovereign bonds by shifting their holdings of sovereign bonds with the same credit rating from low-yield (lower than the median) to high-yield. This is because, on a given credit rating, banks can choose assets with higher yields without increasing the level of risk measured by the regulations. For instance, consider two sovereign bonds with an AA credit rating in the market: French and Belgian sovereign bonds. Belgian sovereign bond yields are higher than those of the French. Suppose that prior to the test, a marginal bank M holds 70% French and 30% Belgian sovereign bonds and a safe bank S holds 60% French and 40% Belgian sovereign bonds. Assume that after the test, bank M shifts to hold 30% French and 70% Belgian sovereign bonds, while bank S continues to hold 60% French and 40% Belgian sovereign bonds in its basket. Then, bank M does regulatory arbitrage on the AA credit sovereign bonds while bank S does not, and this shifting is not incorporated into the risk exposure and CET 1 ratios.

The contribution of this paper can be summarized as follows. First, I find that marginal banks do risk-shifting more aggressively on sovereigns with the same credit rating than safe banks and fragile banks: on average, they hold 146.9 and 172.4[8] more basis points of riskier sovereign bonds over total sovereigns than the other two groups respectively. Given that the average percentage of EU sovereigns over total assets in the sample is 12.68%, such risk-shifting can be executed on this important proportion of banks' assets.

Secondly, this paper also provides evidence that the home bias in EU sovereigns is driven not only by pressure from local governments but also by the banks' appetite for

[8]Both of these two estimates are statistically significant at the 5% significance level.

risk; as evidenced by the fact that banks gamble for the resurrection to earn extra returns, as in Acharya and Steffen (2015), Crosignani (2015) and Altavilla, Pagano, and Simonelli (2017). For instance, in the same country with a poor economy, the marginal banks are holding more risky home sovereigns than the safe banks.

Thirdly, I find that crowding out between sovereigns and corporate lending exists among the tested banks. Fragile banks cut their lending to corporates 6.27%* more than safe banks after the 2014 test. Banks increase the investment proportion of sovereigns (with very low risk-weights) while they decrease the proportion of loans (with very high risk-weights).

Finally, this paper also detects an indirect effect of stress tests in the corporate bond market on banks which are not tested. I find that if an untested bank is located in a country with negative information shocks from the stress test, then its financing cost on the corporate bond market will be higher than a bank which is located in a country with positive information shocks.

The findings in this paper have implications for policymakers. In particular, my findings show the potentially perverse effect of rating-based risk measures. Under the extended Basel III to be executed in 2018, the leverage ratio which is not a rating-based measure, becomes a mandatory part. This will prevent banks doing regulatory arbitrage within the risk-weighting categories. The existence of banks' regulatory arbitrage identified in this paper favors the implementation of this regulation.

The remainder of the paper is organized as follows. Section 2 presents a literature review, and Section 3 describes the stress test. In Section 4, I discuss the data, while in Section 5, I develop the theoretical predictions and summarize the testable hypothesis. The econometric strategies and main results on banks' risk-taking are shown in Section 6. The analysis of corporate bond market and stock market reactions are discussed in Section 7 with robustness tests in Section 8. Section 9 concludes.

2 Literature Review

2.1 Risk Shifting and Regulatory Arbitrage

Since Jensen and Meckling (1976) highlighted the shareholder's incentive to engage in risk-shifting behavior to transfer wealth from bondholders, many studies have attempted to identify the ways to mitigate this agency problem. These include debt covenants (Smith and Warner (1979)), debt maturity (Barnea et al. (1980)), convertible debt (Green (1984)), and managerial compensation (Brander and Poitevin (1992); John and John (1993)). Landier, Sraer, and Thesmar (2015) provide the empirical evidence on risk-shifting in the lending behavior of a large subprime mortgage originator. The implication of my paper that marginal banks under the stress test engage in risk-shifting to the depositors on the sovereign bonds is consistent with their paper. Landier, Sraer, and Thesmar (2015) also show that firms would like to choose the assets whose returns are more correlated with their probability of default. New Century originated more loans in regions where real estate prices are correlated with the return of its "legacy" assets. In my paper, the fact that banks will shift the risk into the assets (e.g., home sovereign bonds) that are related to their survival is consistent with the results of Landier, Sraer, and Thesmar (2015).

Banks are able to do risk-shifting without violating the regulations by increasing the level of risk, which is called *regulatory arbitrage*. The evidence that certain financial firms use regulatory arbitrage to increase risk can be found in different types of investments. Efing (2016) provides evidence for regulatory arbitrage within the class of asset-backed securities based on the individual asset holding data of German banks. Conditional on ratings, insurance companies choose insurance portfolios which are systematically biased toward higher yield and higher CDS bonds (Becker and Ivashina (2015)). Banks can also take more risks by putting assets off-balance sheet (Acharya, Schnabl, and Suarez (2013)). Boyson, Fahlenbrach, and Stulz (2016) predict that banks wanting to take more risks than permitted by capital regulations (constrained banks) use regulatory arbitrage. Besides, Houston, Lin, and Ma (2011) find strong evidence that banks have transferred funds to markets with fewer regulations. This paper studies banks' risk-shifting on sovereign bond investments.

It is evident that banks may do regulatory arbitrage. However, there is no single driving force behind regulatory arbitrage that is widely accepted. On the one hand, Spamann (2010) argues that regulatory arbitrage is driven by misaligned managerial incentives that lead banks to take on excessive risk. Other researchers argue that exploiting too-big-to-fail subsidies is a major determinant of regulatory arbitrage by large banks (Acharya and Richardson (2009), Carbo-Valverde, Kane, and Rodriguez-Fernandez (2013)). On the contrary, Boyson, Fahlenbrach, and Stulz (2016) find strong evidence that the too-big-to-fail status is not the main driver of regulatory arbitrage. I find no evidence to support the concept that larger banks would do more regulatory arbitrage, which supports the findings of Boyson, Fahlenbrach, and Stulz (2016).

2.2 Holding of EU Sovereigns and Home Bias in EU

The significant increase in the holdings of home sovereigns from 2010 to 2015 in EU banks is noticeable and well documented. There are two main branches of explanations for this trend. Uhlig (2014) proposes the "moral suasion" hypothesis whereby the banks' rapidly increasing balance sheet exposures to the domestic sovereign debt during the Eurozone sovereign debt crisis led both academics and policymakers to speculate that this development was partly the result of domestic sovereigns putting pressure on some banks to extend material support to the government. The estimates of Ongena, Popov, and Van Horen (2016) consistently suggest that collusion between banks and sovereigns (or "moral suasion") took place during the sovereign debt crisis. De Marco and Macchiavelli (2016) and Becker and Ivashina (2014) also support the "moral suasion" theory.

Other researchers suggest that banks follow a "carry trade" strategy to gamble for the resurrection to earn extra returns, as suggested by Acharya and Steffen (2015) and

Crosignani (2015). Altavilla, Pagano, and Simonelli (2017) show the evidence that in GIIPS[9] countries, the banks with low regulatory capital increase their holdings of distressed public debt more than the others. In my paper, I show that not only would the banks in the GIIPS countries with low regulatory capital increase their holdings of distressed public debt more than the others, but also the banks with low regulatory capital outside the GIIPS countries.

2.3 Stress Testing and Information Disclosure

There are two distinct channels documented by the literature through which financial shocks propagate across institutions. The first channel is the *direct linkage* between banks: when two parties write a financial contract such as a swap agreement, a negative shock to one party can be transmitted to the other as soon as one is unable to honor the contract Giglio et al. (2011). Direct linkages of this type can propagate distress, because, once defaulted upon, the creditor bank may lack the funds required to deliver on its obligations to third parties (Duffie (2013), Kallestrup, Lando, and Murgoci (2016), Diebold and Yılmaz (2014)).

The second channel is the *indirect linkage* between banks through the common assets held across banks. Tressel (2010) claims that cascade effects can be triggered by bank losses or contractions of interbank lending activities. After the shocks on assets or on the liabilities of banks, global de-leveraging of international banking activities can occur. Also, Greenwood, Landier, and Thesmar (2015) show that fire sales propagate shocks across bank balance sheets.

The information released by EBA on the stress tests is vast, and how it is transmitted and affects the market is highly relevant. Camara, Pessarossi, and Philippon (2016) show that the stress tests are informative. Petrella and Resti (2013) focus on the 2011 EU-wide stress test by using the event study method, and they find that stress tests

[9] Portugal, Italy, Ireland, Greece and Spain

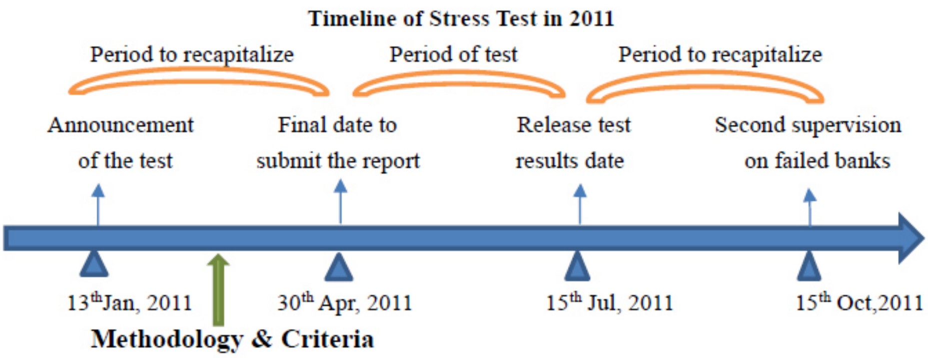
produce valuable information for market participants and can play a role in mitigating bank opaqueness. Goldstein and Sapra (2012) emphasize that the disclosure of stress test results can achieve the macro-prudential role of helping to stabilize the financial system as a whole, but may not necessarily achieve the micro-prudential role of providing market discipline for specific individual banks.

Cardinali and Nordmark (2011) study the stock market reaction to the 2010 and 2011 EU stress tests. They find that the test results in 2010 are relatively uninformative for investors and that the announcement of the methodology to be used in 2011 triggers negative CARs (cumulative abnormal returns) for tested banks, while non-tested institutions are roughly unaffected. Also, Petrella and Resti (2013) show that the abnormal returns of tested banks are strongly related to some stress test outputs and that stress tests have provided investors with relevant information. On the contrary, Candelon and Sy (2015) show that the 2011 EU exercise is the only EU-wide stress test that results in a significantly negative market reaction. The comparison with past exercises suggests that the qualitative aspects of the governance of stress tests may matter for stock market participants more than the technical elements, such as the level of the minimum capital adequacy threshold or the extent of data disclosure. In this paper, I also assess the direct effect and indirect effect of the information disclosure from the stress test on the corporate bond market.

3 EU-wide Stress Tests

The stress tests are run under general macro-economic scenarios across all countries in the EU. The results shed light on the sensitivities of the European banking sector to a general economic downturn and movements in external variables, such as interest rates, economic growth and the unemployment rate.

There are two types of scenarios in the tests: (1) *a baseline scenario*, which is primarily based on the European Commission forecast, and (2) *an adverse scenario*, which assumes the existence of a series of external economic shocks, such as a set of EU shocks tied to the persistence of the ongoing sovereign debt crisis, a global negative demand shock originating in the US, and a USD depreciation to all currencies. Based on these two types of scenarios, EBA calculates the exposure levels of banks to different types of risk in future years, including credit risk, market risk, sovereign risk, and securitization risk. [10]



After the announcement of the test in Jan 2011, banks have three months to raise new capital (recapitalization) before submitting their reports to the local central banks. The EBA then releases the test results on 15th July 2011 and re-supervises banks who have not successfully passed the test. A similar time line for the 2014 EU stress test can be found in Appendix II B.

Criteria to pass the test. The criteria to pass the test is based on the Common Equity Tier 1 (CET 1) ratio, which is defined as:

$$CET1 \quad ratio = \frac{CET1}{RWA},$$

where Common Equity Tier 1 (CET 1) is assessed according to the Basel III,[11] and RWA, referring to risk weighted asset,[12] consists of exposure to the debtors, probability of default and loss given default.

[10]Based on the static balance sheet in 2010, the 2011 EU-wide test provided exposures to different risks in 2011 and 2012. The 2014 EU-wide stress test, based on the 2013 balance sheet data, provided the exposure values in the years 2014, 2015 and 2016.

[11]Basel III: A global regulatory framework for more resilient banks and banking systems (December 2010), page 13.

[12]See definition of RWA of 2011 test and 2014 in CRR/CRD 3 and CRR/CRD 4 respectively.

Criteria to pass the tests

CET 1	Successfully passed	Marginally passed	Failed
2011 test	$> 6\%$	$5\% \sim 6\%$	$\leqq 5\%$
2014 test	$> 6.5\%$	$5.5\% \sim 6.5\%$	$\leqq 5.5\%$

For a bank to pass the 2011 stress test, the adjusted CET 1 ratio under the adverse scenario for the bank has to be greater than 5%. If the CET 1 ratio is between 5% and 6%, the bank is said to marginally pass the test. If the CET 1 ratio is greater than 6%, the bank is defined by the EBA to pass the test successfully. Meanwhile, a bank passes the 2014 stress test if its CET 1[13] ratios under adverse scenarios and baseline scenarios are greater than 5.5% and 8% respectively. A bank marginally passes the 2014 test if its CET 1 ratio under the adverse scenario is between 5.5% and 6.5%, and successfully passes the 2014 test if the ratio is higher than 6.5%.

After the 2011 test, the EBA recommends that marginally passed banks whose CET 1 ratios under the adverse scenario are above but close to 5%, and which have sizable exposure to EU sovereigns under stress, take specific steps[14] to strengthen their capital positions. These banks are expected to plan remedial actions within three months. The plans need to be fully implemented within nine months (by April 2012).

In contrast, failed banks whose final CET 1 ratios are below the 5% threshold, must first promptly remedy the capital shortfall. Then national supervisors should ensure that these banks are requested to present a plan to restore the capital position to their competent authorities within three months. The remedial measures that should be agreed with the competent authority have to be fully implemented by end of 2011. Similar actions are taken after the 2014 stress test.

[13]Unlike the 2011 test, in the 2014 test the criteria of passing the test is based on the CET 1 ratio before the recapitalization.

[14]Including necessary restrictions on dividends, de-leveraging, issuance of fresh capital or conversion of lower quality instruments into CET1 capital.

4 Summary Statistics

Banks' investment portfolios during 2010-2015 are available from the EBA[15] public database. European sovereign bond yields to maturity and daily stock returns can be extracted from DataStream during the same period. In addition, the European sovereign debt auctions, corporate bonds daily returns from 2007 to 2016 and sovereign bond outstanding amounts from the Eikon database are available. The Infinancial database and the Oribis bank focus provide most of the European banks balance sheet data. Finally, three daily Fama-French European factors are extracted from Kenneth French website.

4.1 Sample of Banks in the Dataset

There are two stress tests in the estimation sample, which are performed in 2011 and 2014 respectively. The EBA requires local central banks to capture at least 50% of the national banking sectors in each EU member state, as expressed in terms of total consolidated assets. In the end, the 2011 EU-wide stress test is carried out on a group of banks covering over 65% total assets of the EU banking system and the 2014 stress test covers more than 70% of total EU banking assets.

Banks have been included in the tests in descending order of their market shares based on the total assets of each Member State. As the tests are conducted at the highest level of consolidation, the tests cover all subsidiaries and branches operating in foreign countries. If the total assets of the tested banks in every Member State are more than 50% then no other bank has to be included from that Member State; unless they wish to do so on a voluntary basis.

Ninety banks[16] are tested in 2011 and 123 banks are tested in 2014; 72 banks are both included in the two tests and 51 new banks appear in the 2014 test. In other words, 18 banks are excluded from the sample in 2014, due either to bankruptcy or mergers. Using

[15] http://www.eba.europa.eu/risk-analysis-and-data/eu-wide-stress-testing

[16] The list of tested banks is in Appendix III.

the database provided by EBA, we can trace the portfolios held by 71 tested banks[17] after the test. In September 2011, December 2011, June 2012, and December 2012, the EU capital exercise provides us with further information about the banks after the 2011 stress test. Also, for the second test, the EBA releases the banks' data in the following months: June 2013, December 2013, December 2014, and June 2015.

4.2 Distribution of Banks across Regions

After the announcement of the test in 2011, tested banks can re-capitalize new funds to increase their current CET 1 ratios. Between January and April 2011, a further net amount of EUR 50 billion[18] of capital is raised. This evidence shows that banks know their CET 1 ratios before submitting reports to the national central banks, and they can raise capital before submitting their final and adjusted CET 1 ratios. In this paper, I divide the sample into three groups according to the CET 1 ratios before the recapitalization: safe banks (CET 1 ratio higher than 6%), marginal banks (CET 1 ratio between 5%-6%), and fragile banks (CET 1 ratio below 5%). This ratio does not include the re-capitalization induced by the test; in other words, the grouping CET 1 ratio does not depend on the test.

As shown in the time-line in the last section, banks may carry out recapitalization after the announcement of the test. In the released reports, the results of the test are based on the CET 1 ratios computed after the adjustment (i.e., including the re-capitalization amount before the end of April 2011). If the tested banks have not adjusted their capital after the announcement of the test, 20 banks would have failed the test and 13 banks

[17]Six Greek banks were addressed in the Greek program so the their data is not available immediately after the 2011 test (in September 2011, December 2011).

[18]EUR 46 bn net of reimbursement of capital support was received from governments, as shown in the report of the results in 2011 from http://www.eba.europa.eu/documents/10180/15935/EBA_ST_2011_Summary_Report_v6.pdf. This was achieved through: (i) the issuance by the banks of common equity in the private market; (ii) government injections of capital or the provision of other public facilities; (iii) conversion of lower-quality capital instruments (such as hybrid instruments) into CET1; and (iv) restructuring plans approved by all competent authorities and fully committed which was factored into the results.

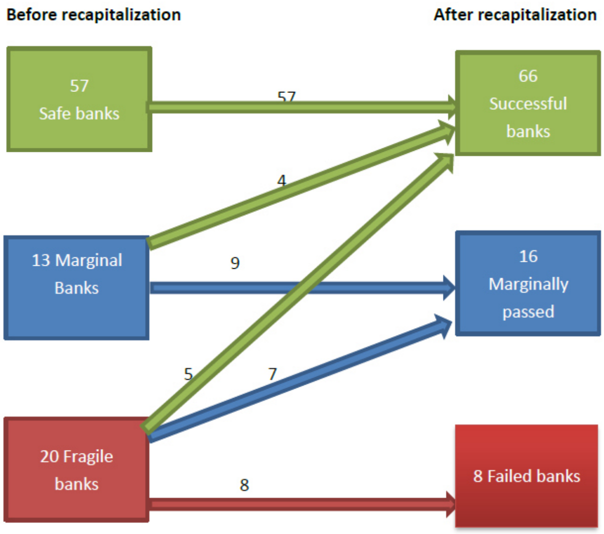


Figure 1: Test results before and after recapitalization
Note: On the left-hand side, CET 1 ratio before re-capitalization; on the right-hand side, the test results of 2011 stress test, adjusted CET 1 ratio including the recapitalization during Jan and Apr, 2011.

would have marginally passed the test. More details are shown in Figure 1. Similarly, in the 2014 stress test (see Appendix 2 B), the unadjusted CET 1 ratio is lower than the adjusted value on average. Differing from the 2011 test, the test results in the 2014 test are not based on the adjusted CET 1 ratios, but on the unadjusted values.

Taking into account these capital-raising actions implemented by the end of April 2011, eight banks fall below the capital threshold of 5% CET 1, with an overall CET 1 shortfall of EUR2.5 bn. In the 2014 test, there are 24 banks with a CET 1 below 5.5% before the recapitalization and only 14 banks below the threshold after the recapitalization during the period from January to September, 2014.

After the 2008 financial crisis, banks located in different countries face different challenges, especially the five Eurozone nations that are considered to have a weaker economy: Portugal, Italy, Ireland, Greece and Spain (called GIIPS in this paper). On 10th May 2010, European leaders approved a 750 billion Euro stabilization package to support these nations. Figure 2[19] shows the number of different groups of banks distributed in GIIPS

[19] The distribution of the 2014 test can also be found in Appendix 2 B.

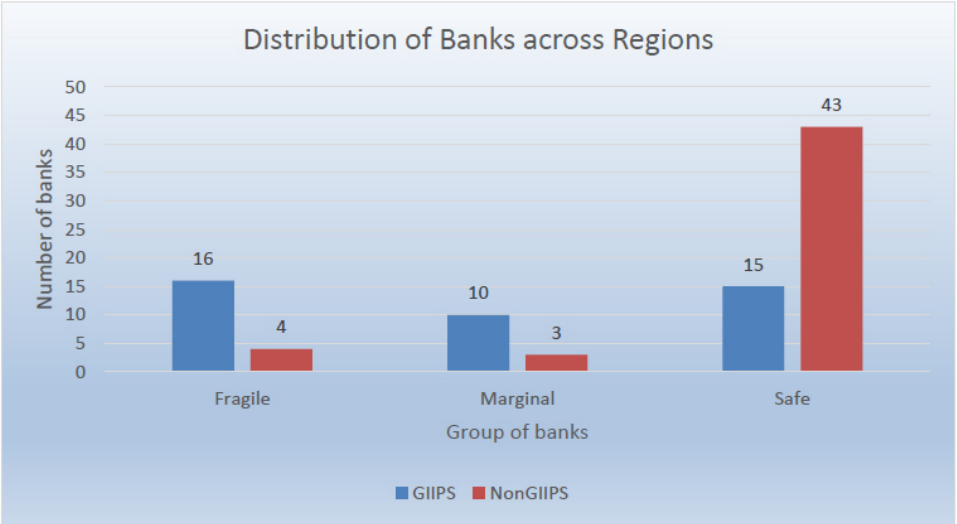


Figure 2: Distribution of banks across regions
Note: Fragile banks' CET 1 ratio (before re-capitalization) lower than 5 % under the adverse scenario in the 2011 test; marginal banks' CET 1 ratio between 5 % and 6 %; safe banks' CET 1 ratio higher than 6 %.

and non-GIIPS countries.

4.3 Annual Accounting Variables

Safe banks are on average much larger than marginal banks, which are in turn slightly larger than fragile banks. The growth of total assets is similar across groups prior to the tests (see Figure 3). Furthermore, fragile banks have much higher ratios of loans to total assets compared to the other banks (0.7, 0.6688 and 0.5734, respectively). Regulatory constrained banks lend more but have lower return rates on assets.

From the criteria to pass the stress test, we know that if a bank wants to increase its capital ratio, it has several options: first, increasing its capital ratio by generating new funds; and second, cutting RWA by either selling risky assets or shifting assets from risky ones into less risky ones. Both the generation of new funds and the re-balancing of portfolios are very costly and time-consuming, while selling risky assets is the fastest way to re-increase the capital ratio. After selling risky assets whose expected returns are

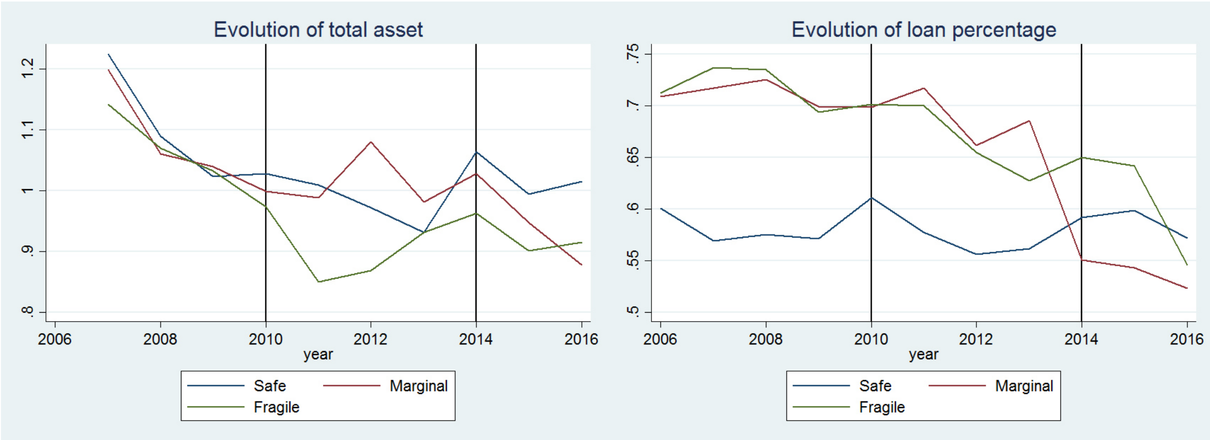


Figure 3: The evolution of some variables in tested banks
Note: The left graph shows the evolution of total asset at t scaled down by last year's total asset $\frac{TA_{i,t}}{TA_{i,t-1}}$. The right graph shows the evolution of $\frac{loan_{i,t}}{TA_{i,t}}$.

generally high, banks can pay back the debt holders and may end up with smaller sizes. There are two possible reasons to do so: either to lower the leverage ratio or to avoid the high cost when keeping low return assets. From Figure 3, we find that after two tests, the total size and the return on asset[20] of the fragile banks are smaller, and the lending rate is decreasing, which may infer that those banks sell assets with high risk-weights.

4.4 Credit Exposures

Banks are required to assess the impact of given macroeconomic scenarios (baseline and adverse) on their future credit risk losses and credit qualities. There are seven classes of credit exposure defined according to the counter-parties, shown as follows: central governments or central banks, institutions, corporates, retail, equity, securitization, and others. After the 2011 test, there is no further data disclosed on the credit exposure. Since this data is available after 2014 test, I focus more on the second test in the analysis of banks' credit exposure.

From Figure 7 in Appendix 2 , we see the decreasing trend of credit exposures to central

[20] In Figure 6

banks or government, corporates and retails. The above figure explains that fragile banks and marginal banks keep the exposure to central banks or local government around the test, while safe banks decrease this percentage after the test. Fragile banks cut their lending to financial institutions around 10% while the other two groups of banks hold it almost unchanged. All groups of banks reduce their holdings of retail loans after the test which are in general of shorter maturity compared to corporate loans. Interestingly, fragile banks reduce their exposure to corporates (from 24% to 16.5%) more than safe banks (from 19% to 17%).

4.5 Sovereign Exposures

Unlike the other types of banks' credit exposures, such as exposures to corporates, retails and institutions, the sovereign exposures of banks differ in that the counter-parties of the sovereigns are the same for every bank. Therefore, a shock to the sovereign bond i will produce the same effect for every bank.

Figure 8 of Appendix II shows the average of $(\frac{Sovereign_{i,t}}{totalasset_{i,t}})$. The average percentages of gross sovereign exposures, loans and advances, asset for sales and held for trading are constant for all banks. However, the following graphs show that banks are changing the maturity structure of the portfolios; after the stress tests, banks are increasing the percentage of longer term sovereigns and shorting more on the short-term assets. The bottom graphs in Figure 8 shows that the amount of assets for sale drives the maturity of sovereign exposures to the longer term, while those of loans and advances which represent a large percentage of sovereign exposures are much less volatile across time. As shown in Figure 9 of Appendix II, safe banks are holding their shares of long-term sovereigns constant.

In Table 1, I present the average percentages of higher yield sovereigns over total sovereigns within one credit rating[21] across groups, before and after the tests. Marginally

[21]There are six credit ratings: AAA, AA, A, BBB, B and C.

Table 1: Summary of sovereign bonds

	Before		**After**		**Difference**	
Group	Mean	S.D.	Mean	S.D.	Diff(t)	t-value
Safe banks						
RA=1	17.006	18.213	26.502	30.698	9.49**	1.944
RA=0	82.994		73.498			
Marginal banks						
RA=1	31.504	22.661	68.471	45.127	36.97***	2.351
RA=0	68.496		31.529			
Fragile banks						
RA=1	27.714	22.024	30.034	36.218	2.32	0.229
RA=0	72.286		69.966			
DID (2-1)	14.497*	8.183	41.97***	11.152	27.47**	1.99
DID (2-3)	3.789	10.355	38.44**	14.645	34.647*	1.93

The sovereign bonds defined as RA=1 are those sovereign bonds with higher yields than the median in one credit rating, while the sovereign bonds defined as RA=0 have yields lower than the median prior to the test. The first two columns are the mean and standard deviation of sovereign bond percentages $\frac{Sovereign(i,t,RA=1)}{TotalSovereign_{i,t}}$ prior to the test; the middle two columns are the percentages of sovereign bonds after the test; the last two columns present the differences between before and after the test and their t-values. DID(2-1) shows the difference-in-difference between marginal banks and safe banks. DID(2-3) includes the difference-in-difference between marginal banks and fragile banks.

constrained banks have increased much more aggressively on the holding of higher yield sovereigns on one credit rating than other groups.

In Figures 10 and 11 of Appendix II, I observe that the number of GIIPS sovereign exposures is not decreasing; while it even shows a slightly increasing trend over the period, especially for the marginal banks and failed banks. Constrained banks (fragile banks and marginal banks) tend to take more risky assets. In the right-hand graph of Figure 10 the percentages of the risky debts are at first decreasing then increasing afterwards among the constrained banks.

Meanwhile, I also document the variations of non-GIIPS sovereign bond holdings. Apparently, safe banks are holding less non-GIIPS sovereign bonds after the test, while on average the remaining marginal banks are not decreasing their shares of those sovereign bonds. The holding variations between groups again confirms the different investment strategies taken by banks when they face a poor economy or strict supervision from regulators.

4.6 Summary of Corporate Bond Market

In Table 5, the summary statistics of banks' corporate bonds are presented. The corporate bond yields of tested banks are on average lower than those of non-tested banks; similar results are shown between non-constrained and constrained banks. Two different bid-ask spreads (in percentage) are also presented in the summary table. The first spread is computed using composite prices[22] and the second spread using evaluated prices.[23]

5 Economic Hypothesis

I develop the economic hypothesis in this section based on an extension of the model of Glasserman and Kang (2014). In contrast to their model, I introduce fragile banks and punishment from regulators into the model. Banks' risk-taking behavior can be explained by a standard version of maximizing expected payoffs given different levels of appetite for risk. There are two periods and N assets in the economy.

5.1 Banks without Regulatory Constraints

Without regulatory constraints, banks maximize their value function V by choosing an optimum portfolio x ($x \in \mathbb{R}_+^N$) at time $t = 0$ according to Glassman and Kang (2014):

$$\max_{x} \quad V(x) = \mu^T x - \frac{\gamma}{2} x^T \Sigma x.$$

The parameter γ reflects the unregulated bank's concern for risk, μ is the expected excess return of banks' assets and Σ represents assets' covariance matrix. Banks have the optimal portfolio x_0^* if they are unregulated:

[22] Thomson Reuters receives bond prices from multiple contributors. The bid and ask (CMPB & CMPA) composite values will be the average from all the available contributors' bid and ask quotes.

[23] Thomson Reuters Pricing Service (TRPS) evaluated prices are provided daily for a global universe of fixed income securities using evaluation models developed and maintained by the Fixed Income Pricing Service team at Thomson Reuters.

$$\Rightarrow x_0^* = \frac{\Sigma^{-1}\mu}{\gamma}$$

5.2 Regulator's Objective

The regulator's objective is to stabilize the market by minimizing the risk in the banks' portfolios. This minimization problem is equivalent[24] to the maximization function under regulation constraints at $t = 1$ (the model is shown in Appendix 3 C.3). The optimal portfolios chosen by the regulators, denoted y_1^* (see C.3.1), can be implemented by imposing a required capital ratio on banks and assigning different risk-weights (w) to banks' assets.

5.3 Banks under Regulatory Constraints

In the stress tests, banks that cannot meet the regulatory constraints will be punished by the regulators through the reconstruction of their capital under force. Under the reconstruction process, failed banks have to either generate new capital at a high cost or sell risky assets at depreciated prices. Six of the eight failed banks in the 2011 tests were eventually acquired or merged with other banks.

In this setting, banks that cannot meet the regulatory constraints may face a punishment P with probability $1 - \pi$, where $\pi \in [0, 1)$,[25] and P can be the loss from capital reconstruction. K is the required capital level and w is the risk-weights assigned to the assets in order to exercise the regulators' optimal choice.

The objective function for all types of banks at $t = 1$ becomes:

$$\max_x \quad V(x) = \pi(\mu^T x - \frac{\gamma}{2} x^T \Sigma x) + (1 - \pi)P$$
$$\begin{cases} \pi = 1 & if \quad x^T w \leq K \\ \pi \in [0,1) & if \quad x^T w > K \end{cases}.$$

[24]Under the assumption that the return of x is normally distributed. Regulators' minimization of banks' probability of default can be transformed into the minimization problem of risk level.

[25]P and π can be a function of x. To simplify the solutions of the model, I assume that P is independent of x and π is a constant.

At $t = 1$, for banks that are able to meet the regulatory constraints, the objective function under regulation constraints is:

$$\max_x \quad \mu^T x - \frac{\gamma}{2} x^T \Sigma x$$
$$s.t. \quad x^T w \le K$$
$$\Rightarrow x_1^* = \tfrac{1}{\gamma}\Sigma^{-1}\mu - \tfrac{(w^T\Sigma^{-1}\mu - \gamma K)^+}{w^T\Sigma^{-1}w}\tfrac{1}{\gamma}\Sigma^{-1}w.$$

If the regulatory constraints are not binding, then banks choose $x_1^* = x_0^*$. Banks are very solid from the regulators' viewpoint (holding enough adequate capital), in the sense that whether the regulations[26] arrive or not will not affect those banks' optimal portfolio choices.

However, if the regulatory constraints are binding, we have $x_1^* \neq x_0^*$. Regulators can set optimal risk-weights[27] $w^* = \alpha\mu$, which allows x_1^* to meet the following two conditions at the same time:

(1) $x_1^* = y_1^*$, banks choose the portfolios which coincide with regulators' optimal choice;

(2) $x_1^* = \frac{K\Sigma^{-1}\mu}{\alpha\mu^T\Sigma^{-1}\mu}$ is proportional to $x_0^* = \frac{\Sigma^{-1}\mu}{\gamma}$, banks' relative mix of assets unchanged.

5.4 Banks' Regulatory Arbitrage

Practical obstacles prevent the implementation of $w^* = \alpha\mu$ in the real economy. In the Basel framework, regulators design the risk-weights ($w = \alpha\delta$) linear to the standard deviation of the category of assets δ rather than their expected returns μ. Therefore, binding banks can always take extra risks by selecting the assets with higher yields within the same risk-weights without making the constraint tighter (See C.3.3). The deviation choice of the portfolio allows banks to take the extra risk without violating the regulations in the real economy; we call this *banks' regulatory arbitrage*. That is equivalent to say that banks do risk-shifting within the same risk-weights asset categories.

[26]It can also be applied to the tighter regulations case.
[27]Proposition 1 in Glasserman and Kang (2014).

Proposition 1: *(i) If banks' regulation constraints are not binding (unconstrained by regulations), then* $x_1^* = x_0^*$*. Banks' optimal portfolios are not changed by the regulations; (ii) If banks' constraints are binding and the optimal weights are linear to the risk,* $w = \alpha\delta$*, then* $x_1^* \neq x_0^*$*. Constrained banks can deviate from regulators' optimal choice* y^* *by conducting regulatory arbitrage.*

Given these results, I expect that marginally regulatory constrained banks will conduct more regulatory arbitrage than safe banks after the stress tests in the empirical studies. Safe banks in this paper have relatively higher capital ratios than regulatory constrained banks; a similar application can be found in the literature.[28] In contrast to the literature (only regulatory constrained banks and regulatory unconstrained banks are defined), I define safe banks, marginally constrained banks and fragile banks in this paper. Fragile banks have a capital ratio below the threshold required by the regulators.

If banks are fragile and have difficulty in meeting the regulatory constraints, they will maximize the piecewise utility function within the second interval at $t = 1$. Proof is shown in Appendix 3. At the optimal, there are two possible cases.

Proposition 2: *(i) If* $P < \bar{P}$[29]*, or* $\frac{\Sigma\mu^{-1}w}{K} > \gamma > \bar{\gamma}$*, fragile banks shift their portfolio x (within the red line domain on the left-hand graph of Figure 4) in order to get a capital level closer to K; (ii) If* $P > \bar{P}$ *or* $\gamma < \bar{\gamma}$*, fragile banks keep their optimal* $x_1^* = x_0^*$ *just as under the maximization case without constraints.*

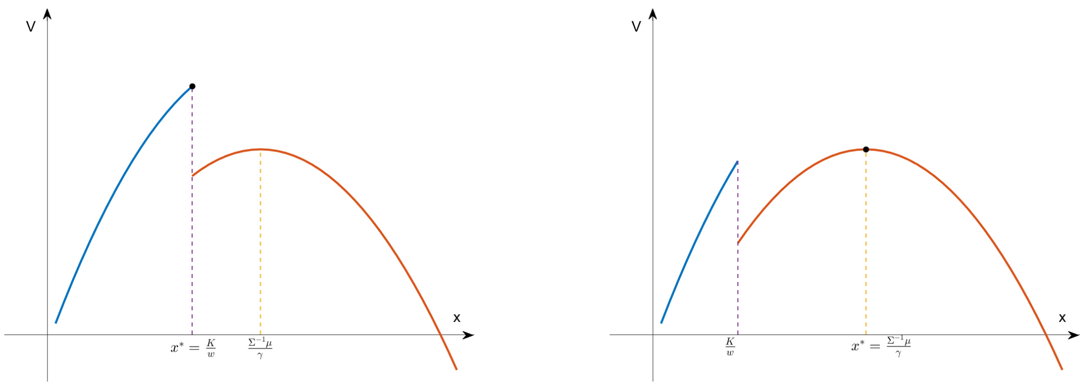
That is, fragile banks are not necessarily doing more regulatory arbitrage under the punishment framework. If both P and π depend explicitly on x, the results still hold.

Taking the special case $\pi = 0$, the payoffs are similar to the typical risk-shifting theory. Shareholders are protected by limited liability and want to take risks to maximize their option-like payoff (Jensen and Meckling (1976)). The expected payoff of banks' shareholders behaves like a call option value, with its value increasing in the standard deviation of the underlying assets x.

[28] Boyson, Fahlenbrach and Stulz (2016), Efing (2016), Becker and Ivashina (2015), Ellul et al (2011)

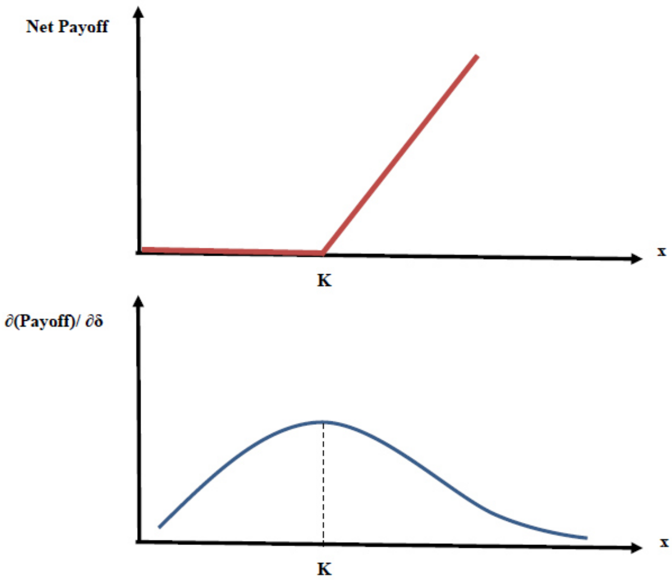
[29] $\bar{P} = \frac{V((x=\frac{K}{w}))-V(x=x_0^*))}{1-\pi}$, $\bar{\gamma} = \frac{(\frac{K}{W})^T\Sigma(\frac{K}{W})-\pi(x_0^*)^T\Sigma x_0^*}{2((1-\pi)P-\frac{K}{W}\mu)-\pi x_0^*\mu)}$

Figure 4: **Banks' V value and current asset values**



Case (i) of Proposition 2 on the left-hand graph, Case (ii) of Proposition 2 on the right-hand graph. Value function V is on the y-axis and asset portfolios x on the x-axis.

Figure 5: **Banks' expected net payoff and current bank value**



The x-axis of the graphs is the current asset portfolio x; the y-axis of the upper graph is shareholders' net expected payoff; the y-axis of the lower graph is the derivative of the shareholders' expected net payoff with respect to the standard deviation of their portfolios.

As shown in Figure 5, banks prefer to take the most risk when their bank values are closed to the strike price K[30] (the required capital level); if regulatory constraints are imposed on their investments, risk-shifting may occur. However, banks with underlying asset values much smaller than K would have a relatively lower appetite for risk than banks with relatively higher bank values. Banks[31] with a much higher franchise value, located on the right-hand side of the graph, take less risk and hold more capital, because these banks have more to lose if they fail.

In summary, marginally regulatory constrained banks will engage in more regulatory arbitrage after the stress test (acting as a tighter regulation imposed on banks) than unconstrained banks. Since doing regulatory arbitrage may not make a difference on fragile banks' expected net payoffs, they may not do so. Fragile banks may want to take less risky assets or generate more capital so as to meet the regulatory constraints. Therefore, I have the following hypotheses to test:

Hypothesis 1**:** Due to the stress tests, safe banks will conduct less regulatory arbitrage than marginal banks which are more regulatory constrained compared to safe banks; the difference in regulatory arbitrage between marginal banks and safe banks will be greater in the 2014 test.

Hypothesis 2**:** Fragile banks do less regulatory arbitrage than other banks after the stress test, and may take less risk than other banks.

[30] K is the outstanding debt amount under the classical option value theory. Here K is the required capital level.

[31](Demsetz, Saidenberg, and Strahan (1996), Repullo (2004)).

6 Main Results on Banks' Risk-taking

6.1 Econometric Strategy

I test the hypotheses stated in the last section as follows. Consider the following linear fixed effect model:

$$\begin{aligned}\frac{Sovereign_{i,j,t}}{TS_{i,t}} =& \beta_1 Post \times Group_i \times RA_j + \beta_2 Post \times Group_i + \beta_3 Group_i \times RA_j \\ &+ \beta_4 Post \times RA_j + FE + Controls + \varepsilon_{i,j,t},\end{aligned}$$

where $Sovereign_{i,j,t}$ is the amount of sovereign bonds of country j owned by bank i at time t, and $TS_{i,t}$ denotes the total sovereign bonds of bank i at time t. The variable $Post$ is the time dummy such that $Post = 0$ if the time t is one year before the stress test and $Post = 1$ otherwise. For each test, the time window is three years: (1) in the first test, t=2010, 2011, 2012; (2) in the second test, t=2013, 2014, 2015. The group dummy $Group_i$ indicates three groups of banks which are divided according to their core capital ratios under the adverse scenario before recapitalization: safe($>= 6\%$), marginal($5\% - 6\%$) and fragile($< 5\%$). I define $RA_j = 1$ if, the yield spread of sovereign bond j is higher than the median within the same risk-weighting category, and $RA_j = 0$ otherwise. For instance, in December 2010, the credit ratings of Spanish and Belgian sovereign bonds are AA+/Aa1 according to the Moody & Fitch reports. After computing the average spread yields of Spanish and Belgian sovereign bonds by using the last year's yields,[32] we know that the average yields of the Spanish sovereign bonds are greater than the average yields of the Belgian bonds. Then, we have $RA_j = 1$ if the sovereign bond is the Spanish bond and $RA_j = 0$ if the sovereign bond is the Belgian bond.

When estimating the parameters, I set marginal banks as the benchmark, so that β_1 measures the difference between safe banks (or fragile banks) and marginal banks in

[32] In the robustness check, the last three-month or six-month yields are used to define the variable RA.

terms of the shifting of sovereign bonds within one credit rating before or after the test. According to the hypotheses in the last section, I expect that the (2×1) column vector of β_1 should be negative. Banks' fixed effect (FE) is absorbed, and the standard errors are clustered at bank level.

6.2 Control Variables

Home bias effect. I define the dummy $local\_country = 1$ if the sovereign bond is local and $local\_country = 0$ otherwise. In the regression, I include $local\_country$ and its interaction term with time trend $local\_country \times TimeTrend$ to rule out the home bias effect.

Sovereign bond fixed effect. I use the dummy $sovereign_j$ and its interaction with time trend ($sovereign_j \times TimeTrend$) to control for the sovereign bond fixed effect. In the robustness check concerning the price shocks or supply shocks on the sovereign bonds, I also include the price evolution and issued amount of the sovereigns to verify my results.

Credit rating. I define the dummy $ratingLevel$ indicating six levels of credit ratings of the sovereign bonds: AAA, AA, A, B, BBB and C. Then I use it to interact with $Group_i \times Post$ to control for banks' appetite for each credit rating.

Bank characteristics. Previous bank size $logsize_{i,t-1}$, deposit rates $\frac{deposit_{i,t-1}}{size_{i,t-1}}$ and loan percentages $\frac{loan_{i,t-1}}{size_{i,t-1}}$ which may affect the holding of the sovereign bonds are controlled in the robustness check.

6.3 Main Results

In this subsection, I present the results of the empirical analysis of the banks' risk-shifting on sovereign bond investments. The holding of sovereign bonds captures an important proportion of around 12.68% of the total assets in a bank.

6.3.1 Risk-taking on Sovereign Bond Investments

Difference across groups after the tests. From Proposition 3, I expect that the coefficient β_1, which measures the preference of high yield sovereign bonds over low yield sovereign bonds, with the same crediting rating before and after the test across the groups, is significantly negative. Table 8 shows that, compared to fragile banks, marginal banks have on average shifted 21.4** more basis points (scaled down by total assets, 1.209 % if scaled down by total sovereigns) from less profitable sovereign bonds to more profitable sovereign bonds within the same credit rating after the 2011 test. This indicator of the effect is the same but not pronounced in the comparison between safe banks and marginal banks after the test.

Difference across groups prior to the tests. Prior to the stress test, banks can take the level of EU sovereign bonds without constraints. Banks' investment strategies are different across the groups and they choose different optimal levels of the sovereign bonds. Marginal banks may prefer Belgian government bonds to French government bonds to the extent that are not necessarily different from safe banks prior to the 2011 test. In other words, within the same credit rating of sovereigns, I expect that the banks' coefficient of the $RA \times Safe$ (or $RA \times Fragile$) is not significant prior to the 2011 test. As shown in Tables 6 and 26, the estimates are close to 0 (0.053 and 0.092) and insignificant (t-value: 0.34 and 0.55). There is no significant difference in the holding of sovereign bonds between safe banks and marginal banks (or between marginal banks and fragile banks) due to the preference of high-yield sovereign bonds or low-yield sovereign bonds in the same credit rating. These estimates coincide with the summary statistic results in Table 1.

However, after the 2011 test, banks may change the investment strategies of EU sovereign bonds for two main reasons. Firstly, due to the fact that EU sovereign bonds become riskier, banks may want to re-balance their portfolios. Therefore, they may change their holdings across different credit-rating categories instead of within the same credit ratings. For instance, shifting from a German bond to a Netherlands bond will not change much in terms of the level of risk or future yields on their portfolios, since German bonds and Netherlands bonds are all rated as AAA by different credit agencies. However, by selling the Greek bonds (with a B rating) and buying the German bonds (AAA rating), banks shift their portfolios across different credit ratings. Secondly, the constraints of investment on these sovereign bonds becomes tighter. The EBA asks banks to provide provisions on these bonds, which affects banks' sovereign holdings and may motivate constrained banks to perform regulatory arbitrage. Therefore, in the 2014 test, the estimates of $RA \times Safe$ (or $RA \times Fragile$) may be significant. Table 8 shows that given sovereign bonds with the same credit rating, marginal banks on average have around 35.4** to 36.1** more basis points in the holding of high yield ones than safe banks and fragile banks.

Difference between first and second tests. In the 2014 stress test, the EBA values the EU sovereign bond risk to be more important: the influence of the EU sovereign risk on the risk parameters in the model directly affects every bank's RWA value and CET 1 ratio. In other words, the regulation becomes tighter on the sovereign bond risk. Therefore, I expect to have larger estimates of parameters in the 2014 test which are confirmed by the results in Table 8. After the 2014 test, marginal banks conduct more regulatory arbitrage on sovereign bonds than safe banks, by holding more than 1.729 %** in sovereign bonds with higher yields than those with lower yields. This percentage, which represents the shifting from low yield to high yield within the same credit rating, is almost doubled compared to that in the 2011 test. Similar results can be found when marginal banks and fragile banks are compared. These estimates test the hypotheses: banks that are marginally constrained can take more risk by conducting more regulatory arbitrage than unconstrained banks (safe banks), while fragile banks do not conduct more regulatory arbitrage than other banks because they are unable to make a positive net payoff by shifting risk while leave the credit rating risk unchanged.

6.3.2 What Drives the Home Bias?

When banks' fixed effects are not included (column (1) in Table 6 and Table 7), the estimate of β_1 is significantly more negative than those discussed in the last two paragraphs. This estimate is reduced by half after the home bias effect is controlled for. One explanation is that the home bias effect is very pronounced in EU sovereign bonds, especially after the EU sovereign crisis. Becker and Ivashina (2014) state that at the end of 2013, the share of government debt held by the domestic banking sectors of Eurozone countries has more than doubled its level of 2007.

Is it the pressure from local government that leads banks to aggressively hold more local sovereign bonds than previously held, as stated in Steven, Alexander, Neeltje (2016)? Or do banks prefer to hold more sovereigns and follow a "carry trade" strategy to gamble for the resurrection to earn extra returns, as suggested by Acharya and Steffen (2015)?

In my paper, I find that the estimate coefficient of the local dummy is 6.5%*, which explains around 50% of the sovereign bond holdings.[33] If it is only the pressure from the local central banks that makes the banks hold more their home sovereign bonds, then the estimates of $local_c \times Group_j \times Post$ should be insignificant. That is to say, there is no difference between safe banks and marginal banks in the holdings of local sovereign bonds before or after the test. In Tables 10 to 13, I present the home bias preference across different groups in the two tests.

We find that marginal banks hold on average 3.869%* more home sovereign bonds in total assets than safe banks located in the same country after the 2011 test. Similar results can be found if I scale down bank i's amount of sovereigns in country j by its total sovereign bonds (presented in Table 11). However, fragile banks have a similar preference on home sovereigns after the test as marginal banks, since the percentages of

[33] On average, banks hold 12.68% sovereign bonds in total assets.

home sovereigns in total sovereigns are not significantly different (-6.04%, with t-value -0.71 in Table 11).

Up to 2013, the holding of home sovereigns is very high (around 67.34%) on average. Therefore, we expect the home bias effect will be insignificantly different across groups in the 2014 test. The results in Table 12 confirm that the difference in the percentages of local sovereigns in total assets between groups is not pronounced.

My results favor the ideas of Acharya and Steffen (2015), where banks bet on the resurrection on sovereigns from the government in order to earn extra returns. Besides the pressure from the local government, the banks' preference for risk also plays a role in the holdings of home sovereigns. Marginal banks have a greater appetite in the risk of local sovereigns than safe banks.

6.3.3 Which Credit Rating of Sovereigns is Most Preferred Among Banks?

The estimates of $Post \times Safe \times Level$ will show which credit rating the sovereigns belong to are most preferred by banks after the test. Recall that *Level* indicates the credit ratings of sovereigns. As shown in Table 8, banks have no distinct preference for the different credit ratings of sovereigns after the 2011 tests. Marginal banks most prefer the sovereigns in the BBB credit rating with the A[34] credit rating preferred second compared to safe banks after the 2014 test. In other words, they carry out more risk-shifting in these two categories of sovereigns. Compared with safe banks, marginal banks hold on average around 2.865%** and 1.185%** more in the sovereigns of credit rating BBB and A respectively after the 2014 test. Additionally, marginal banks hold sovereigns more aggressively (around 2.682%*) in the credit rating BBB than fragile banks after the test.

When the credit rating of the sovereigns is controlled, the β_1 is still significantly negative and the absolute effect in 2014 is still larger than in the previous test.

[34] The sovereigns in Czech, Malta, Poland and Slovakia have the A credit rating in both tests; those of Bulgaria, Iceland, Latvia are also in both tests.

6.3.4 Crowding out Corporate Lending?

The crowding out effect between sovereigns and lending to corporates is investigated in the literature. The more a bank holds in sovereigns, the less it can invest in industrial firms given the level of available funds. I have found that marginal banks are more active in shifting the investment of sovereigns than the other two groups. In proposition 1, I predict that safe banks are not going to decrease their optimal portfolios due to the arrival of the test. They may not cut their loans, as they are considered as risky assets and assigned higher risk-weights than sovereigns. In this regression, the benchmark is the safe bank. According to the regulations, we have six categories of credit exposure: central bank and local government,[35] institutions,[36] corporates, retail, equity and securitization. In the following, I analyze the evolution trend of the different types of credit exposure across groups.

In Table 15, the last two columns present the variations of lending to corporates across groups after the 2014 test. The $Marginal \times Post$ and $Fragile \times Post$ capture the difference in credit exposure across groups after the test.

I find that fragile banks cut their lending to corporates 6.27%* more than safe banks. The difference between marginal banks and safe banks for lending to corporates stays the same. After the test, safe banks increase their credit exposure to corporates by 2.71%*. One possible explanation is that fragile banks try to move their portfolios to safe positions (K/W stated in Section Economic Hypothesis) by cutting their risky loans; the business given up by fragile banks may be taken over by safe banks. An alternative explanation is that fragile banks may be affected by a negative demand shock to loans from their clients, so fragile banks have to involuntarily lower their lending amounts. Since the counter-parties of corporates are different across groups, it cannot be concluded that the variations on lending across groups are driven by the test. However, from Tables 15 and 16, we can see the variations of different types of credit exposures across different groups

[35] Central governments or central banks + regional governments or local authorities.

[36] Public sector entities + multilateral development banks + international organizations + institutions.

before or after the test. Safe banks engage in fewer securitization activities after the test, and expand their investments on lending to corporates, institutions and government.

7 Corporate Bond Market Reactions

The information released by the EBA on the stress tests is rich, and understanding how the information is transmitted and affects the market is critical. Camara, Pessarossi, and Philippon (2016) prove that the stress tests are informative. The reaction to stress tests on the stock has been documented by different papers: Petrella and Resti (2013), Cardinali and Nordmark (2011), and Candelon and Sy (2015). In this section, I investigate whether or not corporate bond markets react in the same way as the stock market to the information shocks from the stress tests.

7.1 Tested Banks' Reactions

In this paper, I use the daily corporate bond yields issued by banks on the OTC market to approximate banks' financing costs.[37] The higher the required return on bonds of bank i on the market, the more banks need to pay to new bondholders so as to issue new bonds. In the OTC market, Euro-denominated bonds are traded on average four times a day and Sterling bonds are traded 1.5 times a day (Biais and Declerck (2013)). They also find that it takes at least five trading days for the information content of a trade to be fully impounded in market pricing. In this event study, the time-window around the released information dates is from five days before to five days after. In the robustness check, time windows vary from five days to three months.

Tested banks are affected by the direct information shocks from the tests on the released report dates, 15th July 2011 and 26th October 2014 respectively. I define the bank level information shocks as the difference between real CET 1 ratios and the expected

[37] I also use the issuance costs of banks to conduct the robustness check.

CET 1 ratios, i.e., $Shock_{i,t} = CET1_{i,t} - E_{t-1}(CET1_{i,t})$, where $E_{t-1}(CET1_{i,t})$ is based on the passed CET 1 ratios released by EBA and all the CET 1 ratios are the forecasted capital ratios in two years under some hypothetical shocks. A positive $Shock_{i,t}$ means a good information shock for bank i, indicating that bank i has a solid capital structure from the regulators' view and has less difficulty in refinancing on the market than other banks affected by negative information shocks. Consider the following equation:

$$\begin{aligned} r(i,j,t) =& \beta_1 Shock_{i,t} \times Post + IssueSize_{i,t} + SovereignYield_{j,t} + lsize_{i,t-1} + ROA_{i,t} \\ &+ FE + Trend + i.Location \times Trend + \epsilon_{i,j,t}. \end{aligned}$$

The dependent variable $r(i,j,t)$ is the daily corporate bond yield of bank i at date t located in country j. Post is the time dummy indicating before or after the test. $IssueSize_{i,t}$ is the market size of bond i at time t; $SovereignYield_{j,t}$ is the sovereign bond yield of bank i that is located in country j at date t. $lsize$ is the log of total asset of bank i and ROA is the return on assets of bank i. $Trend$ controls for the time trend, and $location \times Trend$ captures the country level time trend effect. FE controls for the banks' fixed effect.

From Table 17, we see that $r(i,j,t)$ is negative; for a tested bank, its financing cost will decrease 90.6* basis points within five days around the released report date if its real tested CET 1 ratio is higher than the expected ratio of 1%. I also consider the following regression to investigate the different levels of sensitivities to shocks across groups:

$$\begin{aligned} r(i,j,t) =& \beta_1 Shock_{i,t} \times Safe + \beta_2 Shock_{i,t} \times Fragile + IssueSize_{i,t} \\ &+ SovereignYield_{j,t} + lsize_{i,t-1} + ROA_{i,t} + FE + Trend \\ &+ i.Location \times Trend + \epsilon_{i,j,t}. \end{aligned}$$

Marginal banks are treated as benchmarks. I expect that safe banks are less sensitive to shocks compared to other group of banks, i.e., $\beta_1 < 0$, and that the fragile banks are more sensitive to the information shocks than marginal banks i.e., $\beta_2 > 0$. Table 19 shows that if banks have a 1% higher CET 1 ratio than expected, then marginal banks' financing costs will be around 48.6** basis points lower, while the fragile banks' financing costs on the corporate bond market will decrease only 10.1* basis points. On the contrary, if the real CET 1 is 1% lower than expected, then the marginal banks need to pay 48.6** more basis points, and fragile banks need to pay 86.7* more basis points if they want to finance on the corporate bond market.

7.2 Untested Banks

I expect that the untested banks may be affected by the information shock at country level. For instance, given other factors as constant, an untested bank located in Spain where five banks fail the test will face a higher financing cost after the 2011 test than an untested bank of similar size located in Germany where no banks fail the test.

I define different information shocks to all the banks of country j using the information of the tests:

(1) an average CET 1 shock: $Shock^{(1)} = CET1_{j,t} - E_{t-1}(CET1_{j,t})$;

(2) the number of marginally passed banks (M) and failed banks (F): $Shock^{(2)} = M + F$;

(3) the percentage of marginally passed banks and failed banks (with equal weights): $Shock^{(3)} = (M + F)/Totalbanks$;

(4) the percentage of marginally passed banks and failed banks with double weights: $Shock^{(4)} = (M + F \times 2)/Totalbanks$.

The results of the first regression in this section (see Table 19), show that for untested banks located in a country where there is an unexpected decrease in CET 1 ratio, their financing cost will be 11.8* basis points higher than the untested banks located in a country without negative information shocks. Column (2) of Table 21 implies that if there is a bank which fails the test, the untested banks face an increase of 5.7** basis points on the financing cost which is not economically statistically significant. In the last column of Table 21, we learn that if 1% of tested banks fail the tests in a particular country, the untested banks located in that country will face an increase in financing costs, of around 55.3* basis points, compared with other banks in countries with no shocks.

8 Robustness Check

In this section, I conduct a series of robustness checks to verify the consistency of the main results.

8.1 Other Dependent Variables

In the same credit rating, I define the dependent variable as the difference between the sum amounts of the sovereigns with higher yields and those with lower yields, $S_{1,i,t} - S_{0,i,t}$, scaled down by the total sovereigns or the total assets. The dependent variable is an approximation of the extent of risk-shifting in one credit rating. Consider the following equation:

$$\begin{aligned}\frac{S_{1,i,t} - S_{0,i,t}}{AT_{i,t}} =& \beta_1 Post \times Group_i + \beta_2 Post \times Level + \beta_3 Level + CountryFE_i \times Post \\ &+ FE + Controls + \varepsilon_{i,t},\end{aligned}$$

where $S_{1,i,t}$ is the sum amount of sovereigns whose yields are higher than the median in one credit rating, and $S_{0,i,t}$ is the sum amount of sovereigns whose yields are lower than the median in one credit rating. In Tables 24 and 25, the estimate of β_1 shows the same negative sign as that in the regression in Section 5 (see Table 8). Also, I scale down the dependent variable by its total assets in order to check the robustness of the main results (see Tables 26 and 27).

8.2 Restricted to Banks with Low Variation on CET 1

I only include banks without changing groups after recapitalization so as to rule out possible endogeneity problems from grouping. It may be of some concern that the results are driven by the fact that banks that are closed to fail the test need to aggressively increase their CET 1 ratios by adjusting all of their assets. Therefore, I keep only those banks that have not adjusted CET 1 ratios to switch into other groups. If we only consider banks that have not adjusted their CET 1 ratio more than 1 %, the results still hold (see Table 28).

8.3 Combine Two Tests

I perform the estimation for each test separately in the main results due to the fact that the samples are not exactly the same in the two tests. Now, I run the regression combining the two tests. I define Post=0 if the dates are before the 2011 test, Post=1 if the dates are between the first and the second test, and Post=2 if the dates are after the 2014 test. In Tables 29 and 30, $PostTest1 \times RA \times Safe$ and $PostTest1 \times RA \times Fragile$ are the estimates of β_1 in the 2011 test. $PostTest2 \times RA \times Safe$ and $PostTest2 \times RA \times Fragile$ are the difference of estimates of β_1 in the 2014 test compared with the 2011 test. Both results are consistent with the main results.

8.4 Time-dependent Credit Rating

Do sovereigns become riskier during the test? Specifically, since the credit ratings of the sovereigns of Greece, Iceland and Ireland decrease after the 2011 test, it might therefore be inappropriate to treat them in the same credit rating levels. However, most of the sovereigns stay in the same category of credit ratings (see the summary in Table 35) throughout the tests. To eliminate the concern that a small fraction of sovereigns with time-dependent credit ratings may bias the estimates, I replace the time-independent

RA by the time-dependent RA. In Tables 31 and 32, the results confirm that β_1 is still significantly negative with the effect stronger in the 2014 test.

8.5 Time Trend Effect

I test the time trend effect on the holding of sovereigns across groups of banks. One potential problem is that the significant estimates are not driven by the test but only by the time trend of holdings on some sovereigns. Therefore, in the following regression, I investigate the evolution of different holdings of sovereigns across groups from 2010 to 2015.

$\frac{Sovereign_{i,j,t}}{AT_{i,t}} = \beta_1 TimeTrend \times Safe + \beta_2 TimeTrend \times Fragile + \beta_3 Group_i \times RA + \beta_4 TimeTrend \times RA + FE + TimeTrend + lsize_{i,j,t} + localCountry + LocalCountry * Post + i.sovereign_j * Post + i.sovereign_j + TimeTrend + \varepsilon_{i,t}$.

If β_1 and β_2 are not significant, then there is no significant difference on holding one specific sovereign across groups. In Table 33, the estimates of the coefficients on $TimeTrend \times Safe$ and $TimeTrend \times Fragile$ are insignificant. In other words, the fact that marginal banks conduct more regulatory arbitrage than safe banks is not driven by the time trend effect of some sovereigns.

9 Conclusion

In this paper, I empirically show that marginally regulatory constrained banks (whose regulatory constraint is closed to binding) shift their investment to those sovereign bonds with higher yields in the same risk-weighting credit rating more aggressively than unconstrained banks (safe banks, i.e., whose capital ratio is far above the regulatory level) after the stress test. Such divergence of holdings across bank groups confirms the classical regulatory arbitrage theory.

Interestingly, marginally constrained banks conduct more regulatory arbitrage than fragile banks (i.e., whose capital ratio is below the regulatory level), and are willing to perform risk-shifting in one credit rating. Also, compared to safe banks and marginally constrained banks, fragile banks engage in less lending to corporates, which is assigned a much higher risk weighting according to the Basel III Accord when computing the capital ratios. These noteworthy facts demonstrate that safe banks are less constrained when choosing their optimal portfolios and have no need to stop their long-term investments in order to pass the regulators' tests.

Furthermore, the home bias sovereign holdings are not entirely explained by pressure from local government. The fact that banks gamble for the resurrection in order to earn extra returns also plays a role in terms of the sovereign home bias.

Finally, besides tested banks, untested banks that are located in the country with negative information shocks from the test will bear higher financing costs than banks that are located in a country with positive information shocks; thus providing banking sectors with an indirect means to transmit the effects of the stress test.

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A Appendix 1

Table 2: Summary credit exposure 1

Variable	Mean	Std. Dev.	Min.	Max.	N
Total	88411.656	112844.99	175.214	608658.563	459
Central	28443.738	39499.842	0.043	192846.422	451
Institution	12194.521	19228.164	2.69	112147.148	446
Corporate	17554.668	30513.429	0.383	220334.609	452
Retail	14284.066	24990.431	0.496	177929.813	440
Equity	1114.658	1817.761	0.044	15336.038	380
Securitization	1288.998	2407.65	0	18246.969	237
Others	6589.929	13243.329	0	120423.648	424

This table presents different classes of credit exposure values: Central (central banks and local government), institutions (financial institutions), corporates, retail, equity(private equity), securitization.

Table 3: Summary risk exposure amount 1

Variable	Mean	Std. Dev.	Min.	Max.	N
Total	36678.898	55917.456	62.147	317099.469	459
Central	1707.37	4094.434	0	29846.299	392
Institution	2166.636	4091.896	0	32045.1	446
Corporate	15831.729	27662.784	0.383	206555.078	452
Retail	8735.306	15452.46	0.201	112248.703	440
Equity	1591.457	2913.149	0.044	22770.42	379
Securitization	940.676	1902.56	0	13042.757	237
Other	4344.977	8171.403	0	72820.070	421

This table presents the risk exposure amounts (computed by adding risk weights)of different credit exposure: Central (central banks and local government), institutions (financial institutions), corporates, retail, equity(private equity), securitization.

Table 4: Summary credit exposure in groups

Variable	Mean	Std. Dev.	Min.	Max.	N
Panel A		Safe banks			
Total	98347.048	123744.88	175.214	608658.563	343
Central	31650.827	42261.407	236.972	192846.422	336
Institution	13526.181	20162.067	2.69	112147.148	334
Corporate	18922.946	33295.672	23.266	220334.609	341
Retail	16275.589	27838.373	0.575	177929.813	327
Equity	1232.384	2003.683	0.044	15336.038	283
Secutization	1506.424	2659.665	1.848	18246.969	181
Others	7614.16	15070.752	0	120423.648	312
Panel B		Marginal banks			
Total	120721.976	89694.871	1997.403	301014.156	32
Central	42262.049	43826.642	9.664	145510.297	32
Institution	14737.563	25242.799	151.021	77775	32
Corporate	27731.162	29988.821	243.977	100017.555	32
Retail	16928.12	18558.242	34.9	59769.918	32
Equity	1527.813	1586.817	20.494	4971.985	26
Securitization	1121.95	1362.821	49.39	4212.173	25
Other	5753.89	7094.668	0.095	22295.063	32
Panel C		Fragile banks			
Total	35318.974	23172.457	4326.869	88774.023	82
Central	10162.144	9251.352	0.043	38112.262	81
Institution	5702.688	8157.159	22.465	53133	78
Corporate	7077.155	5845.307	0.383	24330.85	77
Retail	5270.17	5801.456	0.496	22696.471	79
Equity	497.852	561.881	6.777	2675.38	69
Securitization	154.225	183.068	0	816.218	31
Other	2864.983	2688.696	0.012	10318.343	78

Table 5: Summary Corporate bond yields

Panel A			
Variable	**Mean**	**Std. Dev.**	**N**
ry	4.033	2.142	88357
spread1	-2.629	6.645	77355
spread2	-1.38	4.684	80977
MV	2212.806	22551.888	102698
Panel B	Untested banks		
ry	4.324	2.083	10847
spread1	-3.568	8.178	11847
spread2	-1.795	5.998	10723
MV	10018.465	63312.776	12414
Panel B	Tested banks		
ry	3.993	2.148	77510
spread1	-2.46	6.314	65508
spread2	-1.317	4.446	70254
MV	1139.532	4226.114	90284
Panel C	Safe banks		
ry	3.99	2.204	32821
spread1	-2.299	4.63	32765
spread2	-1.238	2.731	31505
MV	1817.313	6097.206	38842
Panel D	Marginal banks		
ry	5.164	2.628	4405
spread1	-4.358	12.511	4880
spread2	-3.202	12.377	4086
MV	505.359	899.739	5349
Panel E	Fragile banks		
ry	4.538	2.252	5829
spread1	-5.3	7.355	6510
spread2	-2.366	2.936	5745
MV	531.569	613.485	8388

Ry is the corporate bonds yields of banks (%). Spread1 and spread2 are the bid-ask spread percentage of the corporate bonds; computed by different measures. MV is the total market value of the corporate bonds.

Table 6: European banks Regulatory Arbitrage in 2011 test

VARIABLES	(1) $\frac{Sovereign_{i,j,t}}{TS_{i,t}}$	(2) $\frac{Sovereign_{i,j,t}}{TS_{i,t}}$	(3) $\frac{Sovereign_{i,j,t}}{TS_{i,t}}$	(4) $\frac{Sovereign_{i,j,t}}{TS_{i,t}}$
Post×Safe×RA	-2.463	-2.288	-1.172*	-1.221*
	(1.821)	(1.836)	(0.591)	(0.617)
Post×Fragile×RA	-4.048*	-4.027*	-1.719**	-1.773**
	(2.154)	(2.166)	(0.675)	(0.703)
Post×Safe	0.829	1.022	0.445*	0.465*
	(0.706)	(0.739)	(0.231)	(0.241)
Post×Fragile	1.537*	1.691*	0.604**	0.625**
	(0.861)	(0.908)	(0.273)	(0.286)
Safe×RA	-1.577*	-1.577*	-0.731*	-0.715*
	(0.841)	(0.844)	(0.418)	(0.416)
Fragile×RA	-0.530	-0.530	-0.319	-0.315
	(1.005)	(1.009)	(0.470)	(0.466)
Post×RA	3.571**	3.531*	2.937***	1.889**
	(1.770)	(1.779)	(0.528)	(.7669162)
RA	-1.191	-1.191	-2.110***	1.903**
	(0.776)	(0.779)	(0.374)	(0.942)
Post	-1.222*	-1.445**	-2.165***	1.274**
	(0.684)	(0.714)	(0.221)	(0.605)
lsize	0.0883**	0.577	0.146	0.133
	(0.0405)	(0.370)	(0.240)	(0.245)
Local_c			29.07***	29.61***
			(2.085)	(1.960)
Local_c×Post			34.28***	32.60***
			(2.610)	(2.519)
Constant	2.230***	-3.117	1.383	-3.044
	(0.494)	(4.471)	(2.914)	(3.056)
Bank FE	No	Yes	Yes	Yes
sovereign FE	No	No	Yes	Yes
sovereign FE×Post	No	No	No	Yes
Observations	7380	7380	7380	7380
R-squared	0.007	0.007	0.656	0.803

The dependent variable $\frac{Sovereign_{i,j,t}}{TS_{i,t}}$ is the sovereign j held by bank i scaled down by its total sovereigns during 2010 and 2012; Post=1 if after the 2011 stress test,otherwise Post=0. RA=1, if the sovereign bonds' spread yield is higher than the median within one risk-weighting category. The benchmark is marginal bank whose capital ratio is between 5 %-6%. Fragile bank's capital ratio is lower than 5 %. Safe banks' capital ratio is higher than 6%. Local_c=1 if bank i holds its own country's sovereign bond. T-values are in parentheses. (*** p<0.01, ** p<0.05, and p<0.1)

Table 7: European banks Regulatory Arbitrage in 2014 test

VARIABLES	(1) $\frac{Sovereign_{i,j,t}}{TS_{i,t}}$	(2) $\frac{Sovereign_{i,j,t}}{TS_{i,t}}$	(3) $\frac{Sovereign_{i,j,t}}{TS_{i,t}}$	(4) $\frac{Sovereign_{i,j,t}}{TS_{i,t}}$
Post×Safe×RA	-2.133***	-2.132***	-1.087*	-1.079*
	(0.594)	(0.595)	(0.563)	(0.551)
Post×Fragile×RA	-3.002***	-3.000***	-1.487**	-1.486**
	(0.732)	(0.735)	(0.643)	(0.629)
Post×Safe	0.897***	0.868***	0.162*	0.167*
	(0.267)	(0.266)	(0.0897)	(0.0902)
Post×Fragile	1.468***	1.195***	0.179	0.197
	(0.309)	(0.328)	(0.279)	(0.268)
Safe×RA	-0.112	-0.113	0.618	0.576
	(1.429)	(1.434)	(1.108)	(1.118)
Fragile×RA	0.462	0.460	0.606	0.559
	(1.748)	(1.755)	(1.244)	(1.258)
RA	-0.505	-0.505	-1.229	-1.850
	(1.340)	(1.345)	(1.052)	(2.131)
Post	-1.071***	-1.068***	-0.0206	0.0389
	(0.257)	(0.255)	(0.0702)	(0.361)
lsize	0.00113	0.00127	-0.0158	-0.0158
	(0.00773)	(0.00119)	(0.0174)	(0.0174)
Post×RA	2.499***	2.499***	1.022*	1.762**
	(0.563)	(0.564)	(0.530)	(.651)
Local_c			58.66***	57.82***
			(4.420)	(4.513)
Local_c ×Post			-6.421**	-6.719**
			(2.858)	(2.834)
Constant	2.514***	2.487***	1.326***	0.536
	(0.520)	(0.165)	(0.254)	(0.747)
Observations	7308	7308	7308	7308
R-squared	0.001	0.001	0.668	0.689

The dependent variable $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$ is the sovereign j held by bank i scaled down by total assets during 2013 and 2015; Post=1 if after the 2014 stress test,otherwise Post=0. RA=1, if the sovereign bonds' spread yield is higher than the median within one risk-weighting category. The benchmark is marginal bank whose capital ratio is between 5 %-6%. Fragile bank's capital ratio is lower than 5 %. Safe banks' capital ratio is higher than 6%. Local_c=1 if bank i holds its own country's sovereign bond.T-values are in parentheses. (*** p<0.01, ** p<0.05, and p<0.1)

Table 8: European banks Regulatory Arbitrage

VARIABLES	2011 $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$	2011 $\frac{Sovereign_{i,j,t}}{TS_{i,t}}$	2014 $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$	2014 $\frac{Sovereign_{i,j,t}}{TS_{i,t}}$
Post×Safe×RA	-0.284*	-1.209**	-0.596**	-1.729**
	(0.155)	(0.541)	(0.253)	(0.795)
Post×Fragile×RA	-0.214**	-1.752***	-0.465*	-1.706*
	(0.0990)	(0.624)	(0.253)	(0.875)
Post×Safe	0.138	0.734	0.525**	1.393***
	(0.151)	(0.477)	(0.260)	(0.514)
Post ×Fragile	0.00713	0.261	0.180	0.701
	(0.0735)	(0.562)	(0.202)	(0.483)
Safe×RA	0.106	-0.633*	-0.354**	-1.206
	(0.146)	(0.347)	(0.158)	(0.793)
Fragile×RA	0.0139	-0.505	-0.361*	-2.134**
	(0.0721)	(0.392)	(0.193)	(1.047)
RA	0.0939	0.959	0.690***	2.715*
	(0.167)	(0.714)	(0.228)	(1.556)
Post	0.291***	1.108**	0.203	0.632
	(0.109)	(0.480)	(0.146)	(0.503)
Local_c	6.055***	29.56***	6.562***	56.52***
	(1.149)	(1.955)	(0.651)	(4.248)
Local_c×Post	-0.668	33.09***	1.291	-6.242**
	(1.096)	(2.488)	(0.781)	(2.703)
lsize	-0.248***	-0.128	-1.752***	-0.00935
	(0.0775)	(0.314)	(0.193)	(0.0455)
Post×Safe×Level2	-0.841	-0.875	-0.0966	-0.262
	(0.592)	(1.179)	(0.142)	(0.636)
Post×Safe×Level3	0.163**	-0.401	-0.198	-1.185**
	(0.0757)	(0.876)	(0.262)	(0.509)
Post×Safe×Level4	0.0550	-0.0221	-0.785**	-2.865**
	(0.0508)	(0.324)	(0.352)	(1.184)
Post×Safe×Level5	0.0741	0.0485	-0.0872	-0.712
	(0.0605)	(0.437)	(0.227)	(0.569)
Post×Safe×Level6			0.191	0.513
			(0.224)	(0.481)
Post×Fragile×Level2	-0.272	-0.555	-0.0663	0.104
	(0.324)	(1.724)	(0.117)	(0.590)
Post×Fragile×Level3	0.137*	0.0950	0.00459	-0.162
	(0.0705)	(1.042)	(0.0696)	(0.442)
Post×Fragile×Level4	0.105	1.867*	-0.509	-2.682*
	(0.103)	(0.984)	(0.349)	(1.477)
Post×Fragile×Level5	0.0581	0.331	0.205	-0.0866
	(0.0576)	(0.441)	(0.425)	(1.464)
Post×Fragile×Level6			0.303*	0.635
			(0.164)	(0.501)

Continue Table 3

Table 9: Continue Table 8: European banks Regulatory Arbitrage

	(1)	(2)	(3)	(4)
Constant	2.787***	1.036	20.60***	-2.812
	(0.963)	(3.975)	(2.371)	(1.973)
Leveli	Yes	Yes	Yes	Yes
Safe×i.Level	Yes	Yes	Yes	Yes
Safe×i.Level	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes
sovereign FE	Yes	Yes	Yes	Yes
sovereign FE×Post	Yes	Yes	Yes	Yes
Observations	7,830	7,830	7,308	7,262
R-squared	0.483	0.787	0.455	0.735

The first two columns contain the results of 2011 test and the last two columns present those of 2014. The dependent variable $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$ is the sovereign j held by bank i scaled down by total assets and $\frac{Sovereign_{i,j,t}}{TS_{i,t}}$ is the sovereign j held by bank i scaled down by his total sovereigns. Before the test Post is equal to 0, otherwise equal to 1. Level i, where i=1,2,3,4,5,6, indicates the credit ratings of sovereigns: AAA, AA, A, BBB, B, C. The benchmark is marginal bank whose capital ratio is between 5 %-6%. Fragile bank's capital ratio is lower than 5 %. Safe banks' capital ratio is higher than 6%.

Table 10: European banks Home Bias on sovereign in 2011 test

VARIABLES	(1) $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$	(2) $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$	(3) $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$
Local_c×Safe×Post	-3.769*	-3.947*	-3.869*
	(2.011)	(2.309)	(2.155)
Local_c×Fragile×Post	-1.557	-1.472	-1.843*
	(1.128)	(1.208)	(1.007)
Post×Local_c	2.286**	2.517**	2.313**
	(0.951)	(1.125)	(0.951)
Local_c×Safe	0.968	1.320	1.164
	(2.056)	(2.298)	(2.225)
Local_c×Fragile	0.473	0.584	0.518
	(1.254)	(1.250)	(1.275)
Local_c	5.468***	5.006***	5.150***
	(0.928)	(1.049)	(1.019)
Post×Safe	0.165	0.167	0.252
	(0.116)	(0.120)	(0.201)
Post×Fragile	0.0236	0.0202	0.0691
	(0.0492)	(0.0490)	(0.0678)
Safe×RA	0.0862	0.0735	0.0826
	(0.123)	(0.116)	(0.112)
Fragile×RA	-0.00645	-0.0126	-0.00388
	(0.0653)	(0.0693)	(0.0673)
Safe×RA×Post	-0.227*	-0.218*	-0.214*
	(0.123)	(0.115)	(0.109)
Fragile×RA×Post	-0.113**	-0.112*	-0.104*
	(0.0556)	(0.0593)	(0.0539)
Post	-0.0369	0.207**	0.132**
	(0.0407)	(0.101)	(0.0606)
lsize	-0.240***	-0.240***	-0.274***
	(0.0794)	(0.0797)	(0.0916)
Constant	2.889***	2.678***	3.089***
	(0.980)	(1.004)	(1.135)
RA	Yes	Yes	Yes
RA×Post	Yes	Yes	Yes
$Group_i$×i.Level	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes
sovereign FE	Yes	Yes	Yes
sovereign FE×Post	No	Yes	Yes
$Group_i$×i.Level×Post	No	No	Yes
Observations	7,830	7,830	6,322
R-squared	0.475	0.491	0.463

The dependent variable $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$ is the sovereign j held by bank i scaled down by total assets during 2010 and 2012. Post=1 if after the 2011 stress test,otherwise Post=0. RA=1, if the sovereign bond's spread yield is higher than the median within one risk-weighting category. The benchmark is marginal bank whose capital ratio is between 5 %-6%. Fragile bank's capital ratio is lower than 5 %. Safe banks' capital ratio is higher than 6%. Local_c=1 if bank i holds its own country's sovereign bond. Level i, where i=1,2,3,4,5,6, indicates the credit ratings of sovereigns: AAA, AA, A, BBB, B, C. Clustered standard errors are in parentheses. (*** p<0.01, ** p<0.05, and p<0.1)

Table 11: European banks Home Bias on sovereign in 2011 test

VARIABLES	(1) $\frac{Sovereign_{i,j,t}}{TS_{i,t}}$	(2) $\frac{Sovereign_{i,j,t}}{TS_{i,t}}$	(3) $\frac{Sovereign_{i,j,t}}{TS_{i,t}}$
Local_c×Safe×Post	-11.31**	-10.69**	-12.42*
	(4.653)	(4.989)	(6.939)
Local_c×Fragile×Post	-1.098	-0.254	-6.041
	(6.147)	(6.315)	(8.458)
Post	0.231*	0.923*	0.384
	(0.120)	(0.495)	(0.480)
Post×Local_c	43.28***	42.16***	45.41***
	(3.795)	(4.311)	(6.435)
Local_c×Safe	-14.52***	-13.87***	-13.92***
	(4.169)	(4.128)	(4.217)
Local_c× Fragile	-4.190	-3.890	-4.038
	(4.926)	(4.787)	(4.891)
Post×Safe	0.900***	0.893***	1.580***
	(0.225)	(0.231)	(0.423)
Post×Marginal	0.349	0.343	0.763
	(0.272)	(0.273)	(0.481)
Local_c	40.71***	39.86***	39.97***
	(3.338)	(3.376)	(3.503)
RA	0.128	0.499	0.550
	(0.126)	(0.592)	(0.595)
Safe×RA	-0.303	-0.321	-0.367
	(0.233)	(0.238)	(0.222)
Fragile×RA	-0.236	-0.250	-0.330
	(0.212)	(0.222)	(0.210)
Safe×RA×Post	-1.249***	-1.274***	-1.309***
	(0.332)	(0.338)	(0.370)
Fragile×RA×Post	-1.229***	-1.273***	-1.382***
	(0.454)	(0.455)	(0.459)
lsize	-0.114	-0.114	0.0982
	(0.313)	(0.315)	(0.236)
Constant	1.904	1.111	-1.502
	(3.851)	(3.950)	(2.997)
RA	Yes	Yes	Yes
RA×Post	Yes	Yes	Yes
$Group_i$×i.Level	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes
sovereign FE	Yes	Yes	Yes
sovereign FE×Post	No	Yes	Yes
$Group_i$×i.Level×Post	No	No	Yes
Observations	7,830	7,830	6,322
R-squared	0.794	0.803	0.808

The dependent variable $\frac{Sovereign_{i,j,t}}{TS_{i,t}}$ is the sovereign j held by bank i scaled down by his total sovereigns during 2010 and 2012. Post=1 if after the 2011 stress test,otherwise Post=0. RA=1, if the sovereign bond's spread yield is higher than the median within one risk-weighting category. The benchmark is marginal bank whose capital ratio is between 5 %-6%. Fragile bank's capital ratio is lower than 5 %. Safe banks' capital ratio is higher than 6%. Local_c=1 if bank i holds its own country's sovereign bond. Level i, where i=1,2,3,4,5,6, indicates the credit ratings of sovereigns: AAA, AA, A, BBB, B, C. Clustered standard errors are in parentheses. (*** p<0.01, ** p<0.05, and p<0.1)

Table 12: European banks Home Bias on sovereign in 2014 test

VARIABLES	(1) $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$	(2) $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$	(3) $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$
Local_c×Safe×Post	-3.441	-3.574	-3.520
	(2.488)	(2.283)	(2.363)
Local_c×Fragile×Post	-3.540	-3.578	-3.523
	(2.921)	(2.773)	(2.832)
Post×Local_c	4.336*	4.379**	4.316*
	(2.284)	(2.081)	(2.167)
Local_c×Safe	-2.518	-2.594	-2.272
	(3.793)	(3.682)	(3.699)
Local_c× Fragile	1.571	1.404	1.643
	(4.274)	(4.133)	(4.151)
Local_c	8.832**	8.775**	8.433**
	(3.720)	(3.607)	(3.624)
Post×Safe	0.372***	0.378***	0.379***
	(0.132)	(0.128)	(0.131)
Post×Fragile	0.118	0.121	0.121
	(0.126)	(0.120)	(0.123)
Safe×RA	-0.431	-0.430	-0.396
	(0.336)	(0.339)	(0.342)
Fragile×RA	-0.377	-0.377	-0.399
	(0.351)	(0.354)	(0.354)
Safe×RA×Post	-0.429**	-0.431**	-0.437**
	(0.185)	(0.188)	(0.188)
Fragile×RA×Post	-0.396***	-0.400***	-0.404***
	(0.105)	(0.107)	(0.105)
Post	-0.200*	0.184	0.189
	(0.113)	(0.152)	(0.158)
lsize	-1.833***	-1.833***	-1.833***
	(0.133)	(0.134)	(0.134)
Constant	22.31***	21.53***	21.54***
	(1.662)	(1.651)	(1.650)
RA	Yes	Yes	Yes
RA×Post	Yes	Yes	Yes
$Group_i$×i.Level	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes
sovereign FE	Yes	Yes	Yes
sovereign FE×Post	No	Yes	Yes
$Group_i$×i.Level×Post	No	No	Yes
Observations	5,771	5,771	5,771
R-squared	0.438	0.456	0.456

The dependent variable $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$ is the sovereign j held by bank i scaled down by total assets during 2013 and 201. Post=1 if after the 2014 stress test,otherwise Post=0. RA=1, if the sovereign bond's spread yield is higher than the median within one risk-weighting category. The benchmark is marginal bank whose capital ratio is between 5 %-6%. Fragile bank's capital ratio is lower than 5 %. Safe banks' capital ratio is higher than 6%. Local_c=1 if bank i holds its own country's sovereign bond. Level i, where i=1,2,3,4,5,6, indicates the credit ratings of sovereigns: AAA, AA, A, BBB, B, C. Clustered standard errors are in parentheses. (*** p<0.01, ** p<0.05, and p<0.1)

Table 13: European banks Home Bias on sovereign in 2014 test

VARIABLES	(1) $\frac{Sovereign_{i,j,t}}{TS_{i,t}}$	(2) $\frac{Sovereign_{i,j,t}}{TS_{i,t}}$	(3) $\frac{Sovereign_{i,j,t}}{TS_{i,t}}$
Local_c×Post×Safe	-9.017**	-8.972***	-8.597***
	(3.505)	(3.090)	(3.178)
Local_c×Post×Fragile	-13.48**	-13.04**	-12.71**
	(6.296)	(6.047)	(6.002)
Local_c ×Post	5.972**	5.597**	5.194**
	(2.788)	(2.201)	(2.306)
Local_c ×Safe	-9.581	-10.07	-10.21
	(15.80)	(15.15)	(15.41)
Local_c ×Marginal	10.73	10.06	9.577
	(17.19)	(16.45)	(16.77)
Local_c	65.99***	65.55***	65.44***
	(14.99)	(14.39)	(14.69)
Post×Safe	0.358*	0.355*	0.343
	(0.206)	(0.205)	(0.207)
Post×Fragile	0.717**	0.707**	0.697**
	(0.281)	(0.279)	(0.274)
Safe×RA	-0.724	-0.716	-0.650
	(0.803)	(0.805)	(0.787)
Fragile×RA	-0.797	-0.787	-0.782
	(0.780)	(0.793)	(0.779)
Safe×RA×Post	-0.247	-0.244	-0.246
	(0.327)	(0.334)	(0.342)
Fragile ×RA×Post	-0.805**	-0.818**	-0.820**
	(0.361)	(0.367)	(0.385)
Post	-0.301*	0.0462	0.0760
	(0.179)	(0.424)	(0.413)
lsize	0.0142*	0.0142*	0.0142*
	(0.00822)	(0.00825)	(0.00825)
Constant	1.059***	-2.989	-2.972
	(0.357)	(1.829)	(1.818)
RA	Yes	Yes	Yes
RA×Post	Yes	Yes	Yes
$Group_i$×i.Level	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes
sovereign FE	Yes	Yes	Yes
sovereign FE×Post	No	Yes	Yes
$Group_i$×i.Level×Post	No	No	Yes
Observations	5,742	5,742	5,742
R-squared	0.733	0.748	0.750

The dependent variable $\frac{Sovereign_{i,j,t}}{TS_{i,t}}$ is the sovereign j held by bank i scaled down by his total sovereigns during 2013 and 2015;Post=1 if after the 2014 stress test,otherwise Post=0. RA=1, if the sovereign bonds' spread yield is higher than the median within one risk-weighting category. The benchmark is marginal bank whose capital ratio is between 5 %-6%. Fragile bank's capital ratio is lower than 5 %. Safe banks' capital ratio is higher than 6%. Local_c=1 if bank i holds its own country's sovereign bond. Level i, where i=1,2,3,4,5,6, indicates the credit ratings of sovereigns: AAA, AA, A, BBB, B, C. Clustered standard errors are in parentheses. (*** p<0.01, ** p<0.05, and p<0.1)

Table 14: Credit exposure

VARIABLES	(1) CreditEX	(2) CreditEX	(3) CreditEX	(4) CreditEX
post	0.288***	0.283***	0.246***	0.249***
	(0.0290)	(0.0650)	(0.0415)	(0.0695)
Marginal×post	-0.0587	-0.0585	-0.0701	-0.0701
	(0.0893)	(0.0840)	(0.0517)	(0.0459)
Fragile×post	0.250***	0.249***	0.515***	0.515***
	(0.0761)	(0.0860)	(0.102)	(0.124)
post×GIIPS			0.127**	0.123**
			(0.0466)	(0.0469)
Marginal×post×GIIPS			0.168	0.175
			(0.280)	(0.282)
Fragile×post×GIIPS			-0.458***	-0.454***
			(0.119)	(0.128)
lsize	0.0672	0.0542	0.128	0.123
	(0.0934)	(0.105)	(0.0885)	(0.106)
Constant	-0.611	-0.445	-1.359	-1.286
	(1.141)	(1.299)	(1.081)	(1.317)
Year Effect	No	Yes	No	Yes
Bank Effect	Yes	Yes	Yes	Yes
Observations	228	228	228	228
R-squared	0.737	0.741	0.748	0.751

Clustered standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Dependent variable is the total credit exposure value of each bank. Post=1 after the 2014 test(year 2015) and post=0 before the test(2013). lsize is the log of last year total asset. Benchmark banks are safe banks.

Table 15: Credit exposure to different types

VARIABLES	(1) Central	(2) Central	(3) Institution	(4) Institution	(5) Corporate	(6) Corporate
Marginal×Post	0.0186	0.0262	-0.00958	-0.00600	-0.0179	-0.0127
	(0.0224)	(0.0199)	(0.00767)	(0.00988)	(0.0251)	(0.0162)
Fragile× Post	0.0758**	0.0210	0.0795**	-0.0124	-0.0516***	-0.0627*
	(0.0309)	(0.0830)	(0.0375)	(0.0113)	(0.0141)	(0.0355)
Post	0.0599***	0.0533**	0.0358***	0.0334***	0.0526***	0.0271***
	(0.0177)	(0.0251)	(0.00868)	(0.00962)	(0.0160)	(0.00912)
Post×GIIPS		0.0192		0.00457		0.0429***
		(0.0221)		(0.00822)		(0.0118)
Marginal×post×GIIPS		-0.0285		-0.0208		0.00542
		(0.0810)		(0.0241)		(0.0729)
Fragile×post×GIIPS		0.0746		0.137**		-0.00146
		(0.0914)		(0.0524)		(0.0357)
lsize	0.00531	0.00670	0.0475**	0.0416*	-0.0143	-0.000304
	(0.0365)	(0.0305)	(0.0222)	(0.0226)	(0.0461)	(0.0491)
Constant	-0.00555	-0.0229	-0.556*	-0.483*	0.225	0.0650
	(0.450)	(0.377)	(0.275)	(0.280)	(0.572)	(0.595)
Date Effect	Yes	Yes	Yes	Yes	Yes	Yes
Bank Effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	228	228	228	228	228	228
R-squared	0.522	0.529	0.677	0.708	0.690	0.700

Clustered standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Central is the credit exposure to Central banks and central governments scaled down by total assets; Institution is the credit risk amount exposed to institutions scaled down by total assets; Corporate is the credit exposure to corporates scaled down by total assets. GIIPS is a location dummy, GIIPS=1 if a locate locate in GIIPS country(Greece, Italy, Ireland, Portugal, Spain).

Table 16: Credit exposure to different types

VARIABLES	(1) Retail	(2) Retail	(3) Equity	(4) Equity	(5) Securi	(6) Securi
Marginal×post	-0.0315	-0.0161	-0.00257*	-0.00183***	0.00115	0.00126
	(0.0338)	(0.0112)	(0.00141)	(0.000564)	(0.00075)	(0.00096)
Fraigile ×post	-0.00369	0.00708	0.00229	0.00151*	0.000348	0.000320
	(0.0240)	(0.0591)	(0.00165)	(0.000793)	(0.00116)	(0.00146)
Post	0.0178	0.0145	0.00294***	0.00296***	-0.00048	-0.000709
	(0.0179)	(0.0143)	(0.000413)	(0.000718)	(0.00102)	(0.00132)
Post×GIIPS		-0.0257		-0.000181		0.000759
		(0.0154)		(0.00104)		(0.000989)
Marginal×Post×GIIPS		-0.102		-0.00420		1.84e-06
		(0.108)		(0.00450)		(0.00165)
Fragile ×Post×GIIPS		-0.00663		0.00120		-0.000284
		(0.0581)		(0.00247)		(0.00102)
lsize	0.0133	0.00107	0.00835**	0.00806**	0.00055	0.000803
	(0.0533)	(0.0511)	(0.00308)	(0.00297)	(0.00172)	(0.00199)
Constant	-0.112	0.0495	-0.1000**	-0.0964**	-0.00496	-0.00812
	(0.658)	(0.622)	(0.0379)	(0.0365)	(0.0203)	(0.0236)
Date Effect	Yes	Yes	Yes	Yes	Yes	Yes
Bank Effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	228	228	228	228	228	228
R-squared	0.634	0.643	0.810	0.812	0.350	0.351

Clustered standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Retail is the credit exposure to retails scaled down by total assets; Equity is the credit risk amount exposed to Equity scaled down by total assets; Securi is the credit exposure to securitization scaled down by total assets. GIIPS is a location dummy, GIIPS=1 if a locate locate in GIIPS country(Greece, Italy, Ireland, Portugal, Spain).

Table 17: Corporate bond yields' reaction to information shocks

VARIABLES	(1) $r_{i,t}$	(2) $r_{i,t}$	(3) $r_{i,t}$	(4) $r_{i,t}$	(5) $r_{i,t}$	(6) $r_{i,t}$	(7) $r_{i,t}$
shock1	-0.164***	-0.174***	-0.0683*	-0.130***	-0.146***	-0.0630*	-0.0906*
	(0.0541)	(0.0511)	(0.0354)	(0.0464)	(0.0434)	(0.0371)	(0.0545)
Sovereign	0.692***	0.626***	-0.0936	0.753***	0.741***	-0.0192	0.714***
	(0.141)	(0.179)	(0.137)	(0.255)	(0.255)	(0.237)	(0.228)
Bond_size		-0.290	-0.102	-0.256	-0.247	-0.0939	-0.204
		(0.294)	(0.268)	(0.302)	(0.296)	(0.267)	(0.272)
lsize		2.072*	0.701		1.851	0.634	1.481*
		(1.103)	(0.640)		(1.142)	(0.675)	(0.835)
ROA				14.55	9.625	2.056	5.645
				(12.91)	(13.09)	(8.893)	(13.20)
Post							-0.859**
							(0.360)
Trend			-0.0753***	-.0643428***	-.0631627***	-0.0726***	
			(0.00783)	(.00424)	(.00445)	(0.00921)	
GIIPS×Trend						0.00152	
						(0.0170)	
Constant	2.802***	-20.46	-1.790	4.162**	-18.25	-1.236	-13.48
	(0.185)	(13.38)	(7.941)	(1.808)	(13.80)	(8.376)	(10.17)
Bank EF	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Location×Post	No	No	No	No	No	No	Yes
Observations	3,719	3,021	3,021	2,854	2,854	2,854	2,854
R-squared	0.724	0.763	0.872	0.774	0.780	0.873	0.833

The dependent variable is the corporate bond yield of bank i at day t; $shock_{i,t} = CoreTierRatio_{i,t} - E_{t-1}(CoreTierRatio_{i,t})$ which represents the information shock to the market is the difference of real core capital ratio under adverse scenario and its expectation;

Table 18: Corporate bond yields' reaction to information shocks(3m)

VARIABLES	(1) $r_{i,t}$	(2) $r_{i,t}$	(3) $r_{i,t}$	(4) $r_{i,t}$	(5) $r_{i,t}$	(6) $r_{i,t}$	(7) $r_{i,t}$
shock1	-0.315***	-0.328***	-0.186***	-0.164***	-0.331***	-0.176***	-0.152***
	(0.0675)	(0.0664)	(0.0533)	(0.0544)	(0.0651)	(0.0537)	(0.0455)
Sovereign	0.473***	0.387***	0.0828	0.110	0.389***	0.113*	0.0941*
	(0.123)	(0.112)	(0.0643)	(0.0692)	(0.135)	(0.0638)	(0.0505)
issue_size		-0.420	-0.208	-0.199	-0.402	-0.192	-0.207
		(0.298)	(0.264)	(0.266)	(0.297)	(0.263)	(0.262)
ROA				8.640	-2.574	5.874	-30.52*
				(6.741)	(8.665)	(8.044)	(17.91)
lsize		2.342*	1.237*		2.437*	1.064	1.089*
		(1.320)	(0.678)		(1.463)	(0.727)	(0.558)
Trend			-0.0628***	-0.0643***		-0.0633***	-0.0676***
			(0.00394)	(0.00424)		(0.00445)	(0.00894)
GIIPS×Trend						0.000287	
						(0.0127)	
Constant	3.520***	-22.34	-8.202	6.803***	-23.74	-6.245	-6.577
	(0.195)	(16.06)	(8.381)	(1.546)	(17.84)	(8.976)	(6.851)
Bank EF	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Location×Trend	No	No	No	No	No	No	Yes
Observations	31,744	24,327	24,327	22,928	22,928	22,928	22,928
R-squared	0.645	0.707	0.825	0.825	0.711	0.827	0.848

The dependent variable is the corporate bond yield of bank i at day t; $shock_{i,t} = CoreTierRatio_{i,t} - E_{t-1}(CoreTierRatio_{i,t})$ which represents the information shock to the market is the difference of real core capital ratio under adverse scenario and its expectation;

Table 19: Untested banks' corporate bond yields' reaction to information shocks

	(1)	(2)	(3)	(4)
Shock	-0.226***	-0.193***	-0.117*	-0.118*
	(-3.81)	(-5.17)	(-2.09)	(-2.21)
own_sovereign_yield	0.293*	-0.011	-0.231***	-0.123
	(1.73)	(-0.24)	(-3.48)	(-0.83)
issue_size		-12.088***	-7.686***	-7.468***
		(-9.79)	(-4.82)	(-4.48)
lsize		-2.202	-0.700	-0.386
		(-0.88)	(-0.45)	(-0.23)
ROA				-126.567
				(-0.80)
Constant	3.576***	82.943**	48.159*	43.901
	(13.55)	(2.78)	(2.10)	(1.78)
Bank FE	Yes	Yes	Yes	Yes
Time Trend	No	No	Yes	Yes
Observation	713	345	345	345
R^2	.8076365	.9109562	.95518349	.96047013

The dependent variable is the corporate bond yield of bank i at day t; $shock_{i,t} = CoreTierRatio_{i,t} - E_{t-1}(CoreTierRatio_{i,t})$ which represents the information shock to the market is the difference of real core capital ratio under adverse scenario and its expectation;

Table 20: Untested banks' Corporate bond yields' reaction to information shocks(3 months)

	(1)	(2)	(3)	(4)
Shock	-0.331***	-0.224***	-0.171***	-0.174***
	(-4.75)	(-5.78)	(-4.36)	(-4.35)
own_sovereign_yield	0.349**	0.013	-0.078	0.025
	(2.27)	(0.27)	(-1.46)	(0.33)
issue_size		-11.861***	-9.790***	-9.318***
		(-10.26)	(-5.06)	(-5.50)
lsize		-2.020	-1.226	-0.740
		(-0.77)	(-0.56)	(-0.36)
ROA				-200.905*
				(-2.07)
Constant	3.738***	81.182**	63.639*	56.682*
	(13.81)	(2.68)	(2.11)	(2.00)
Bank FE	Yes	Yes	Yes	Yes
Time Trend	No	No	Yes	Yes
Observation	5912	2890	2890	2890
R^2	.75155182	.88236829	.9046281	.92606128

The dependent variable is the corporate bond yield of bank i at day t; $shock_{i,t} = CoreTierRatio_{i,t} - E_{t-1}(CoreTierRatio_{i,t})$ which represents the information shock to the market is the difference of real core capital ratio under adverse scenario and its expectation;

Table 21: Untested banks' Corporate bond yields' reaction to information shocks(different shocks)

	(1)	(2)	(3)	(4)
Shock	-0.117*			
	(-2.09)			
Shock2		0.057**		
		(2.58)		
Shock3			0.552	
			(1.80)	
Shock4				0.533*
				(2.14)
own_sovereign_yield	-0.231***	-0.275***	-0.262***	-0.260***
	(-3.48)	(-3.67)	(-3.25)	(-3.33)
issue_size	-7.686***	-6.270***	-6.780***	-6.707***
	(-4.82)	(-3.65)	(-3.95)	(-3.94)
lsize	-0.700	-0.211	-0.115	-0.136
	(-0.45)	(-0.15)	(-0.08)	(-0.09)
Constant	48.159*	36.743	37.961	37.856
	(2.10)	(1.73)	(1.69)	(1.71)
Bank FE	Yes	Yes	Yes	Yes
Time Trend	Yes	Yes	Yes	Yes
Observation	345	345	345	345
R^2	.95518349	.95052136	.94675209	.94763693

The dependent variable is the corporate bond yield of bank i at day t; $cshock_1 = CoreTierRatio_{i,t} - E_{t-1}(CoreTierRatio_{i,t})$ which represents the information shock to the market is the difference of real core capital ratio under adverse scenario and its expectation; $cshock_{j,t}(2)$ is the total number of marginal banks and fragile banks; $cshock_{j,t}(3)$ is the percentage of marginal banks and fragile banks over the total banks of country j; (D) $cshock_{j,t}(4)$ can be the percentage of marginal banks and fragile banks, while fragile banks is put double weights compared to marginal banks.

Table 22: Stock market reaction: GIIPS exposure

Variable	AR(1d) (1)	AR(3d) (2)	AR(5d) (3)
Post*GIIPS	-1.206***	-2.645***	-1.351
	(-4.07)	(-4.05)	(-1.45)
Post	0.297***	0.518**	-0.682**
	(3.46)	(2.38)	(-2.16)
GIIPS	0.380	0.478	0.477
	(1.32)	(0.58)	(0.40)
Constant	-0.039	0.226	0.427
	(-0.38)	(0.78)	(1.04)
Bank FE	Yes	Yes	Yes
Time Trend	Yes	Yes	Yes
Observation	2023	1974	1937
R^2	.02442846	.06554179	.08554726

The dependent variable is the abnormal stock return of bank i at day t; the column(1) is the daily AR; the column(2) is the 3 days cumulative AR; the column(3) is the 5 days cumulative AR; GIIPS is the percentage of Greek sovereign bonds over total sovereign bonds of bank i.

Table 23: Stock market reaction: Greek sovereign bond exposure

Variable	AR(1d) (1)	AR(3d) (2)	AR(5d) (3)
Post*Greece	-1.881***	-3.431***	-1.385
	(-3.49)	(-3.68)	(-1.07)
Post	0.024	-0.085	-1.021***
	(0.31)	(-0.46)	(-3.89)
Greece	0.464	0.622	-0.832
	(0.89)	(0.37)	(-0.41)
Constant	0.070*	0.363***	0.633***
	(1.94)	(3.82)	(5.27)
Bank FE	Yes	Yes	Yes
Time Trend	Yes	Yes	Yes
Observation	2023	1974	1937
R^2	.02180617	.05919952	.08426775

The dependent variable is the abnormal stock return of bank i at day t; the column(1) is the daily AR; the column(2) is the 3 days cumulative AR; the column(3) is the 5 days cumulative AR; GIIPS is the percentage of GIIPS sovereign bonds over total sovereign bond of bank i.

Table 24: Robustness test: Dependent variable

VARIABLES	(1) $\frac{S_{1,i,t}-S_{0,i,t}}{TS_{i,t}}$	(2) $\frac{S_{1,i,t}-S_{0,i,t}}{TS_{i,t}}$	(3) $\frac{S_{1,i,t}-S_{0,i,t}}{TS_{i,t}}$	(4) $\frac{S_{1,i,t}-S_{0,i,t}}{AT_{i,t}}$	(5) $\frac{S_{1,i,t}-S_{0,i,t}}{AT_{i,t}}$	(6) $\frac{S_{1,i,t}-S_{0,i,t}}{AT_{i,t}}$
Post×Safe	-6.051*	-5.238	-4.304**	-0.412	-0.441	-0.575**
	(3.411)	(3.343)	(1.828)	(0.274)	(0.278)	(0.232)
Post×Fragile	-7.259*	-8.586**	-5.430**	-0.428	-0.381	-0.624***
	(3.793)	(3.796)	(2.126)	(0.321)	(0.326)	(0.224)
Post	1.919	0.378	1.172	0.132	0.188	0.0596
	(3.284)	(3.322)	(2.685)	(0.248)	(0.254)	(0.306)
Level2	29.23***	29.18***	29.16***	3.186***	3.188***	3.191***
	(7.264)	(7.277)	(7.316)	(0.963)	(0.963)	(0.966)
Level3	19.41***	19.49***	19.72***	1.822***	1.819***	1.828***
	(6.391)	(6.376)	(6.417)	(0.629)	(0.631)	(0.635)
Level4	15.02*	15.01*	15.14*	2.533**	2.533**	2.543**
	(8.160)	(8.183)	(8.186)	(1.100)	(1.099)	(1.099)
Level5	24.86**	24.90**	25.00**	2.403**	2.402**	2.402**
	(9.880)	(9.873)	(9.884)	(1.058)	(1.060)	(1.063)
Safe×Level2	-20.20**	-20.16**	-20.15**	-2.358**	-2.359**	-2.364**
	(8.233)	(8.249)	(8.289)	(1.078)	(1.079)	(1.082)
Safe×Level3	-6.885	-6.961	-7.122	-0.888	-0.885	-0.897
	(7.278)	(7.260)	(7.298)	(0.742)	(0.744)	(0.747)
Safe×Level4	-2.997	-3.000	-3.144	-1.518	-1.518	-1.528
	(8.835)	(8.859)	(8.864)	(1.155)	(1.155)	(1.155)
Safe×Level5	-10.61	-10.64	-10.74	-1.378	-1.376	-1.376
	(10.33)	(10.32)	(10.34)	(1.107)	(1.109)	(1.113)
Fragile×Level2	-39.63***	-39.57***	-39.41***	-4.276***	-4.278***	-4.285***
	(10.73)	(10.75)	(10.81)	(1.489)	(1.490)	(1.494)
Fragile×Level3	-22.37***	-22.42***	-22.72***	-1.833**	-1.831**	-1.837**
	(8.273)	(8.255)	(8.293)	(0.776)	(0.777)	(0.776)
Fragile ×Level4	-15.96*	-15.95*	-16.08*	-2.317*	-2.317*	-2.327*
	(9.313)	(9.332)	(9.343)	(1.227)	(1.227)	(1.228)
Fragile ×Level5	-32.88***	-32.93***	-33.11***	-3.048***	-3.046***	-3.060***
	(10.77)	(10.76)	(10.80)	(1.112)	(1.114)	(1.119)
lsize	4.473	4.277	0.00532	0.865**	0.872**	0.544
	(4.437)	(4.346)	(4.760)	(0.369)	(0.370)	(0.458)
GIIPS×Post		3.401			-0.122	
		(2.222)			(0.194)	
Constant	-63.81	-61.39	-9.033	-11.36**	-11.45**	-7.463
	(53.72)	(52.53)	(57.62)	(4.500)	(4.503)	(5.581)
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
CountryFE×Post	No	No	Yes	No	No	Yes
Observations	1,662	1,662	1,662	1,662	1,662	1,662
R-squared	0.173	0.174	0.179	0.158	0.158	0.159

$S_{1,i,t} - S_{0,i,t}$ is the different amount of sovereign between those of higher yields and those of lower yields at one credit rating of bank i at time t. In column (1)-(3) and (4)-(6), the difference of sovereigns is scaled down by the total sovereign amount of bank i and total asset of bank i respectively. Level i, where i=1,2,3,4,5,6, indicates the credit ratings of sovereigns: AAA, AA, A, BBB, B, C. GIIPS is equal to 1 if bank i locates in one of the following countries: Greece, Ireland, Italy, Portugal, Spain. Post is the dummy variable of the 2011 test. Clustered standard errors are in the parenthesis.

Table 25: Robustness test: Dependent variable

VARIABLES	(1) $\frac{S_{1,i,t}-S_{0,i,t}}{TS_{i,t}}$	(2) $\frac{S_{1,i,t}-S_{0,i,t}}{TS_{i,t}}$	(3) $\frac{S_{1,i,t}-S_{0,i,t}}{TS_{i,t}}$	(4) $\frac{S_{1,i,t}-S_{0,i,t}}{AT_{i,t}}$	(5) $\frac{S_{1,i,t}-S_{0,i,t}}{AT_{i,t}}$	(6) $\frac{S_{1,i,t}-S_{0,i,t}}{AT_{i,t}}$
Post×Safe	-4.783*	-5.240*	-5.707*	-1.862***	-1.912***	-1.781*
	(2.795)	(2.713)	(3.391)	(0.691)	(0.663)	(0.930)
Post×Fragile	-10.97***	-10.49***	-12.33***	-1.939**	-1.887**	-2.165**
	(3.228)	(3.398)	(4.157)	(0.729)	(0.767)	(1.003)
Post	6.366**	7.003**	9.083***	1.574**	1.643**	2.387**
	(2.620)	(2.677)	(3.379)	(0.663)	(0.661)	(0.928)
Level2	10.89	10.90	10.89	1.520*	1.521*	1.520*
	(7.147)	(7.150)	(7.193)	(0.883)	(0.883)	(0.887)
Level3	13.22*	13.20*	13.20*	2.191*	2.189*	2.164*
	(7.324)	(7.337)	(7.341)	(1.151)	(1.152)	(1.142)
Level4	39.24***	39.27***	39.24***	6.878***	6.881***	6.900***
	(4.652)	(4.650)	(4.693)	(1.157)	(1.155)	(1.161)
Level5	17.36**	17.36**	17.38**	2.037**	2.037**	2.050**
	(8.214)	(8.210)	(8.317)	(0.801)	(0.801)	(0.816)
Safe×Level2	-4.905	-4.896	-4.639	0.0288	0.0297	0.0558
	(8.218)	(8.226)	(8.269)	(1.216)	(1.217)	(1.225)
Safe×Level2	-2.691	-2.670	-2.610	-0.447	-0.445	-0.413
	(8.382)	(8.394)	(8.398)	(1.383)	(1.384)	(1.380)
Safe×Level3	-33.73***	-33.75***	-33.54***	-5.771***	-5.774***	-5.772***
	(6.129)	(6.139)	(6.176)	(1.366)	(1.364)	(1.372)
Safe×Level4	-7.524	-7.521	-7.397	-0.463	-0.463	-0.470
	(8.989)	(8.986)	(9.087)	(0.987)	(0.987)	(1.001)
Safe×Level5	-7.524	-7.521	-7.397	-0.463	-0.463	-0.470
	(8.989)	(8.986)	(9.087)	(0.987)	(0.987)	(1.001)
Fragile×Level2	-9.729	-9.732	-9.726	-1.352	-1.352	-1.352
	(7.331)	(7.334)	(7.379)	(0.898)	(0.898)	(0.902)
Fragile×Level3	-20.78**	-20.76**	-20.97**	-3.043**	-3.042**	-3.043**
	(9.586)	(9.597)	(9.648)	(1.369)	(1.370)	(1.366)
Fragile×Level4	-51.16***	-51.19***	-51.23***	-9.033***	-9.036***	-9.061***
	(14.78)	(14.78)	(14.91)	(2.577)	(2.577)	(2.595)
Fragile×Level5	-26.94**	-26.94**	-26.93**	-2.946***	-2.946***	-2.953***
	(10.20)	(10.20)	(10.31)	(0.921)	(0.920)	(0.936)
lsize	0.0952	0.128	0.512	6.712***	6.716***	6.881***
	(0.488)	(0.512)	(0.325)	(0.575)	(0.579)	(0.407)
GIIPS×Post		-1.115			-0.121	
		(1.499)			(0.355)	
Constant	-9.341	-9.734	-14.51***	-82.80***	-82.84***	-84.86***
	(5.882)	(6.111)	(4.138)	(7.291)	(7.336)	(5.266)
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
CountryFE×Post	No	No	Yes	No	No	Yes
Observations	1,200	1,200	1,200	1,200	1,200	1,200
R-squared	0.179	0.179	0.184	0.203	0.203	0.207

$S_{1,i,t} - S_{0,i,t}$ is the different amount of sovereign between those of higher yields and those of lower yields at one credit rating of bank i at time t. In column (1)-(3) and (4)-(6), the difference of sovereigns is scaled down by the total sovereign amount of bank i and total asset of bank i respectively. Level i, where i=1,2,3,4,5,6, indicates the credit ratings of sovereigns: AAA, AA, A, BBB, B, C. GIIPS is equal to 1 if bank i locates in one of the following countries: Greece, Ireland, Italy, Portugal, Spain. Post is the dummy variable of the 2014 test. Clustered standard errors are in the parenthesis.

Table 26: European banks Regulatory Arbitrage in 2011 test

VARIABLES	(1) $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$	(2) $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$	(3) $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$	(4) $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$	(5) $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$
Post×RA×Safe	-0.514*	-0.193	-0.215	-0.223	-0.219
	(-1.89)	(-0.92)	(-1.34)	(-1.38)	(-1.36)
Post×RA×Fragile	-0.542**	-0.514**	-0.281*	-0.289*	-0.287*
	(-2.57)	(-2.19)	(-1.69)	(-1.73)	(-1.72)
Safe×RA	0.196	-0.122	0.051	0.056	0.053
	(0.90)	(-0.57)	(0.33)	(0.36)	(0.34)
Fragile×RA	0.049	0.024	0.092	0.093	0.092
	(0.43)	(0.10)	(0.55)	(0.56)	(0.55)
Post×RA	0.828***	0.617***	0.680***	0.098	0.297
	(3.78)	(3.05)	(4.49)	(0.71)	(1.58)
Post×Safe	0.161	-0.018	-0.009	-0.005	-0.007
	(1.34)	(-0.18)	(-0.11)	(-0.06)	(-0.08)
Post×Fragile	0.174	0.197*	0.092	0.097	0.096
	(1.33)	(1.82)	(1.03)	(1.07)	(1.07)
RA	-0.619***	-0.411**	-0.605***	-0.018	-0.192
	(-3.91)	(-2.06)	(-4.24)	(-0.12)	(-1.15)
Post	-0.640***	-0.480***	-0.492***	0.101	-.0126
	(-4.56)	(-5.68)	(-7.12)	(0.96)	(-0.12)
lsize	-0.039	-0.080	-0.121	-0.114	-0.116
	(-1.04)	(-0.75)	(-1.09)	(-1.03)	(-1.04)
Local_c*Post			-0.631	-0.886	-0.764
			(-0.50)	(-0.71)	(-0.68)
local_c			6.127***	6.291***	6.168***
			(4.69)	(4.87)	(5.27)
Constant	1.275**	1.747	2.094	1.330	1.457
	(2.45)	(1.35)	(1.55)	(0.98)	(1.08)
Bank FE	No	Yes	Yes	Yes	Yes
sovereign FE	No	No	No	Yes	Yes
sovereign FE×Post	No	No	No	No	Yes
Observation	8049	8049	8049	8049	8049
R^2	.011	.040	.251	.490	.491

The dependent variable $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$ is the sovereign j held by bank i scaled down by total assets during 2010 and 2012; Post=1 if after the 2011 stress test,otherwise Post=0. RA=1, if the sovereign bonds' spread yield is higher than the median within one risk-weighting category. The benchmark is marginal bank whose capital ratio is between 5 %-6%. Fragile bank's capital ratio is lower than 5 %. Safe banks' capital ratio is higher than 6%. Local_c=1 if bank i holds its own country's sovereign bond. T-values are in parentheses. (*** p<0.01, ** p<0.05, and p<0.1)

Table 27: European banks Regulatory Arbitrage in 2014 test

VARIABLES	(1) $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$	(2) $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$	(3) $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$	(4) $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$	(5) $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$
Post*RA*Safe	-0.717**	-0.542**	-0.393*	-0.396*	-0.398*
	(-2.61)	(-2.08)	(-1.76)	(-1.77)	(-1.77)
Post*RA*Fragile	-0.756**	-0.602**	-0.423*	-0.425*	-0.428*
	(-2.57)	(-2.21)	(-1.89)	(-1.89)	(-1.90)
Safe*RA	-0.528*	-0.703**	-0.457**	-0.461**	-0.460**
	(-1.97)	(-2.32)	(-2.44)	(-2.45)	(-2.44)
Fragile*RA	-0.634**	-0.788**	-0.436**	-0.442**	-0.441**
	(-2.35)	(-2.47)	(-2.35)	(-2.36)	(-2.35)
Post*RA	0.723**	0.571**	0.398*	0.398*	0.317
	(2.67)	(2.20)	(1.81)	(1.80)	(1.47)
Post*Safe	0.174***	0.093	0.051	0.052	0.053
	(2.89)	(1.16)	(0.79)	(0.80)	(0.81)
Post*Fragile	0.261***	0.175*	0.123	0.124	0.125
	(3.04)	(1.87)	(1.59)	(1.60)	(1.60)
RA	0.502*	0.654**	0.355*	0.315	0.353
	(1.89)	(2.21)	(1.96)	(1.56)	(1.67)
Post2014	-0.167***	-0.108	-0.065	-0.064	.0480091
	(-3.04)	(-1.37)	(-0.98)	(-0.96)	(0.75)
lsize	-0.004	-0.012	-0.013	-0.013	-0.013
	(-0.38)	(-0.25)	(-0.26)	(-0.26)	(-0.26)
Local_c*Post			0.467	0.460	0.417
			(0.91)	(0.93)	(0.87)
local_c			7.013***	6.905***	6.917***
			(8.97)	(9.43)	(9.35)
Constant	0.299**	0.410	0.276	0.210	0.198
	(2.42)	(0.69)	(0.46)	(0.35)	(0.33)
Bank FE	No	Yes	Yes	Yes	Yes
sovereign FE	No	No	No	Yes	Yes
sovereign FE*Post	No	No	No	No	Yes
Observation	7732	7732	7732	7732	7732
R^2	.010	.018	.557	.586	.587

The dependent variable $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$ is the sovereign j held by bank i scaled down by total assets during 2013 and 2015; Post=1 if after the 2014 stress test,otherwise Post=0. RA=1, if the sovereign bonds' spread yield is higher than the median within one risk-weighting category. The benchmark is marginal bank whose capital ratio is between 5 %-6%. Fragile bank's capital ratio is lower than 5 %. Safe banks' capital ratio is higher than 6%. Local_c=1 if bank i holds its own country's sovereign bond.T-values are in parentheses. (*** p<0.01, ** p<0.05, and p<0.1)

Table 28: Robustness test: restricted sample to low $\triangle$ on CET 1 ratio

VARIABLES	Safe $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$	Marginal $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$	All $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$	All $\frac{Sovereign_{i,j,t}}{AT_{i,t}}$
Post×RA	0.426***	0.872**		
	(0.0502)	(0.319)		
Post	-0.438***	-0.540***	-0.423***	0.268
	(0.0684)	(0.0519)	(0.0621)	(0.174)
RA	-0.527***	-0.871**	-0.528***	0.0532
	(0.0617)	(0.316)	(0.0634)	(0.0762)
Post×RA×Marginal			0.409*	0.412*
			(0.228)	(0.229)
Post×Group			-0.146	-0.148
			(0.122)	(0.122)
RA×Marginal			-0.322	-0.324
			(0.222)	(0.222)
Post×RA			0.432***	
			(0.0507)	
Local_c	6.321***	9.407**	7.133***	7.222***
	(1.727)	(3.350)	(1.445)	(1.349)
Local_c×Post2010	-1.262	-2.301	-2.071	-2.255*
	(1.675)	(3.466)	(1.420)	(1.317)
lsize	-0.0894	-0.471	0.0483	0.0488
	(0.108)	(0.297)	(0.182)	(0.183)
Constant	1.721	6.068	0.0106	-0.790
	(1.341)	(3.470)	(2.242)	(2.228)
Bank FE	YES	YES	YES	YES
sovereign FE*Post	YES	YES	NO	YES
Observations	7,113	1,010	7,601	7,601
R-squared	0.246	0.446	0.245	0.478

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The dependent variable is $\frac{Sovereign_{i,j,t}}{TA_{i,t}}$; Column (1) presents the regression on safe banks; Column (2) presents the regression on marginal banks; Column(3) and (4) present the regression of these two groups; RA=1 if the sovereign bonds' spread yield is higher than the median within the same category; Marginal banks' core capital ratio is between 5 %-6%; local_c=1 if bank i holds its own country's sovereign bond;

Table 29: Robustness test: Two tests together

VARIABLES	(1) $\frac{Sovereign_{i,j,t}}{TA_{i,t}}$	(2) $\frac{Sovereign_{i,j,t}}{TA_{i,t}}$	(3) $\frac{Sovereign_{i,j,t}}{TA_{i,t}}$	(4) $\frac{Sovereign_{i,j,t}}{TA_{i,t}}$	(5) $\frac{Sovereign_{i,j,t}}{TA_{i,t}}$
PostTest1*RA*Safe	-0.345*	-0.108	-0.039	-0.292*	-0.282*
	(-1.67)	(-0.60)	(-0.26)	(-1.82)	(-1.77)
PostTest1*RA*Fraigle	-0.350*	-0.442**	-0.098	-0.352**	-0.342**
	(-1.85)	(-2.13)	(-0.63)	(-2.24)	(-2.19)
PostTest2*RA*Safe	-1.518***	-1.106***	-0.943**	-0.984**	-0.984**
	(-3.41)	(-2.68)	(-2.56)	(-2.64)	(-2.63)
PostTest2*RA*Fragile	-1.479***	-1.397***	-1.015***	-1.054***	-1.054***
	(-3.24)	(-3.21)	(-2.71)	(-2.80)	(-2.79)
PostTest1*Safe	-0.042	-0.166*	-0.234**	0.059	0.047
	(-0.58)	(-1.79)	(-2.53)	(0.61)	(0.49)
PostTest1*Fragile	-0.060	0.062	-0.123	0.170*	0.159
	(-0.44)	(0.59)	(-1.29)	(1.77)	(1.66)
PostTest2*Safe	0.309**	0.115	0.087	0.084	0.085
	(2.12)	(0.69)	(0.55)	(0.65)	(0.65)
PostTest2*Fragile	0.325	0.347*	0.229	0.227	0.230
	(1.60)	(1.94)	(1.37)	(1.63)	(1.63)
Safe*RA	0.143	-0.190	-0.042	0.088	0.084
	(0.60)	(-0.84)	(-0.25)	(0.55)	(0.53)
Fragile*RA	-0.042	-0.044	-0.002	0.126	0.121
	(-0.16)	(-0.17)	(-0.01)	(0.76)	(0.73)
PostTest1*RA	0.632***	0.530***	0.506***	0.179	0.207
	(4.22)	(3.12)	(3.60)	(1.54)	(1.48)
PostTest2*RA	1.896***	1.619***	1.412***	0.876**	0.924**
	(4.47)	(3.97)	(3.88)	(2.44)	(2.54)
Local_c*PostTest1			-0.118	0.099	0.149
			(-0.09)	(0.08)	(0.13)
RA	-0.540**	-0.343	-0.511***	-0.086	-0.121
	(-2.65)	(-1.61)	(-3.36)	(-0.57)	(-0.69)
PostTest	-0.405***	-0.326***	-0.286***	0.008	0.000
	(-4.41)	(-4.10)	(-3.84)	(0.11)	(.)
lsize	-0.033	-0.099	-0.148**	-0.135*	-0.128*
	(-1.15)	(-1.51)	(-2.04)	(-1.96)	(-1.86)
local_c			6.250***	6.155***	6.145***
			(9.21)	(9.56)	(9.62)
Constant	1.084**	1.970**	2.400***	1.608*	1.545*
	(2.36)	(2.46)	(2.71)	(1.91)	(1.86)
Bank FE	No	Yes	No	Yes	Yes
sovereign FE	No	No	No	Yes	Yes
sovereign FE*Post	No	No	No	No	Yes
Observation	11620	11620	11620	11620	11620
R^2	.01137219	.03551944	.30945425	.50423379	.50494939

Marginal banks are benchmark. The dependent variable is $\frac{Sovereign_{i,j,t}}{TA_{i,t}}$; RA=1 if the sovereign bonds' spread yield is higher than the median within the same credit rating; Marginal=1 if banks' core capital ratio is between 5 %-6%; Fragile=1 if bank's core capital ratio is lower than 5 %; local_c=1 if bank i holds its own country's sovereign bond;

Table 30: Robustness test: Two tests together

VARIABLES	(1) $\frac{Sovereign_{i,j,t}}{TotalSovereign_{i,t}}$	(2) $\frac{Sovereign_{i,j,t}}{TotalSovereign_{i,t}}$	(3) $\frac{Sovereign_{i,j,t}}{TotalSovereign_{i,t}}$	(4) $\frac{Sovereign_{i,j,t}}{TotalSovereign_{i,t}}$	(5) $\frac{Sovereign_{i,j,t}}{TotalSovereign_{i,t}}$
PostTest1*RA*Safe	-2.988**	-2.393*	-0.665	-1.770***	-1.791***
	(-2.11)	(-1.80)	(-1.12)	(-2.99)	(-3.05)
PostTest1*RA*Fraigle	-5.486***	-5.506***	-1.624**	-2.752***	-2.771***
	(-4.36)	(-3.90)	(-2.56)	(-4.35)	(-4.38)
PostTest2*RA*Safe	-5.215***	-4.441***	-1.955***	-2.146***	-2.154***
	(-4.26)	(-4.14)	(-3.15)	(-3.46)	(-3.47)
PostTest2*RA*Fragile	-6.365***	-6.197***	-2.083***	-2.290***	-2.296***
	(-4.39)	(-4.40)	(-2.84)	(-3.13)	(-3.13)
PostTest1*Safe	1.369***	1.001***	-0.282	0.989***	1.010***
	(3.63)	(3.67)	(-1.22)	(5.50)	(5.58)
PostTest1*Fragile	2.018***	2.180***	0.006	1.286***	1.305***
	(5.04)	(5.48)	(0.02)	(5.79)	(5.71)
PostTest2*Safe	1.730***	1.228***	0.573*	0.561***	0.563***
	(3.62)	(3.12)	(1.82)	(2.84)	(2.83)
PostTest2*Fragile	1.923***	1.873***	0.578	0.576**	0.577**
	(3.98)	(3.46)	(1.58)	(2.15)	(2.15)
Safe*RA	-0.937	-1.620	-1.130**	-0.576	-0.563
	(-1.13)	(-1.56)	(-2.56)	(-1.34)	(-1.32)
Fragile*RA	-0.639	-0.715	-0.732	-0.180	-0.170
	(-0.51)	(-0.60)	(-1.46)	(-0.37)	(-0.35)
PostTest1*RA	4.152***	3.786***	2.390***	0.932*	-0.073
	(3.44)	(3.03)	(4.83)	(1.88)	(-0.11)
PostTest2*RA	7.518***	6.993***	3.965***	1.556***	-0.454
	(6.88)	(6.94)	(7.04)	(2.74)	(-0.48)
Local_c*PostTest1			-32.039***	-30.987***	-30.794***
			(-10.93)	(-10.99)	(-10.90)
RA	-1.607*	-1.174	-1.759***	-0.030	1.353*
	(-1.79)	(-1.20)	(-4.41)	(-0.03)	(1.80)
PostTest	-1.565***	-1.480***	-1.329***	-0.008	0.000
	(-8.21)	(-7.81)	(-8.73)	(-0.07)	(.)
lsize	0.053***	0.662**	0.219	0.249	0.247
	(2.74)	(2.58)	(1.23)	(1.30)	(1.30)
local_c			61.256***	60.294***	60.266***
			(14.39)	(14.20)	(14.18)
Constant	2.900***	-4.093	0.474	-3.215	-4.098*
	(3.70)	(-1.33)	(0.22)	(-1.41)	(-1.77)
Bank FE	No	Yes	Yes	Yes	Yes
sovereign FE	No	No	No	Yes	Yes
sovereign FE*Post	No	No	No	No	Yes
Observation	11620	11620	11620	11620	11620
R^2	.00780041	.00891315	.65267617	.76725228	.76791725

Marginal banks are benchmark. The dependent variable is $\frac{Sovereign_{i,j,t}}{TotalSovereign_{i,t}}$; RA=1 if the sovereign bonds' spread yield is higher than the median within the same category; Marginal=1 if banks' core capital ratio is between 5 %-6%; Fragile=1 if bank's core capital ratio is lower than 5 %; local_c=1 if bank i holds its own country's sovereign bond.

Table 31: Time dependent RA

VARIABLES	(1) $\frac{Sovereign_{i,j,t}}{TotalAsset_{i,t}}$	(2) $\frac{Sovereign_{i,j,t}}{TA_{i,t}}$	(3) $\frac{Sovereign_{i,j,t}}{TA_{i,t}}$	(4) $\frac{Sovereign_{i,j,t}}{TA_{i,t}}$	(5) $\frac{Sovereign_{i,j,t}}{TA_{i,t}}$
PostTest1*RA*Safe	-0.391*	-0.125	-0.084	-0.313*	-0.282*
	(-1.88)	(-0.70)	(-0.53)	(-1.91)	(-1.68)
PostTest1*RA*Fraigle	-0.075	-0.153	-0.115	-0.341**	-0.308*
	(-0.36)	(-0.69)	(-0.73)	(-2.15)	(-1.87)
PostTest2*RA*Safe	-1.370***	-0.904***	-0.844***	-0.873***	-0.874***
	(-3.53)	(-2.70)	(-2.89)	(-2.99)	(-2.99)
PostTest2*RA*Fragile	-1.130***	-1.014***	-0.707**	-0.736**	-0.735**
	(-2.95)	(-2.89)	(-2.38)	(-2.49)	(-2.48)
PostTest1*Safe	0.039	-0.144	-0.224**	0.034	-0.003
	(0.40)	(-1.50)	(-2.23)	(0.31)	(-0.03)
PostTest1*Fragile	-0.151	-0.121	-0.193	0.063	0.026
	(-1.00)	(-0.81)	(-1.48)	(0.45)	(0.17)
PostTest2*Safe	0.517**	0.198	0.171	0.175	0.177
	(2.07)	(1.06)	(0.96)	(1.07)	(1.08)
PostTest2*Fragile	0.369*	0.106	-0.026	-0.023	-0.020
	(1.69)	(0.47)	(-0.11)	(-0.11)	(-0.09)
Safe*RA	0.222	-0.154	-0.013	0.097	0.084
	(0.92)	(-0.67)	(-0.08)	(0.60)	(0.52)
Fragile*RA	0.041	0.015	0.025	0.133	0.117
	(0.15)	(0.06)	(0.14)	(0.80)	(0.70)
PostTest1*RA	0.612***	0.497***	0.501***	0.188	0.196
	(4.02)	(2.95)	(3.47)	(1.53)	(1.42)
PostTest2*RA	1.575***	1.253***	1.145***	0.573**	0.562**
	(4.72)	(4.06)	(4.25)	(2.10)	(2.22)
Local_c*PostTest1			-0.499	-0.266	-0.144
			(-0.41)	(-0.22)	(-0.13)
RA	-0.600***	-0.368*	-0.524***	-0.036	-0.044
	(-2.83)	(-1.69)	(-3.39)	(-0.29)	(-0.29)
PostTest	-0.415***	-0.320***	-0.281***	0.026	0.000
	(-4.21)	(-3.99)	(-3.61)	(0.33)	(.)
lsize	-0.080	-1.115***	-1.125***	-1.128***	-1.124***
	(-1.51)	(-4.40)	(-4.57)	(-4.55)	(-4.52)
local_c			6.482***	6.349***	6.330***
			(9.60)	(9.90)	(9.95)
Constant	1.657**	14.340***	14.311***	13.742***	13.682***
	(2.37)	(4.65)	(4.78)	(4.59)	(4.42)
Bank FE	No	Yes	No	Yes	Yes
sovereign FE	No	No	No	Yes	Yes
sovereign FE*Post	No	No	No	No	Yes
Observation	12725	12725	12725	12725	12725
R^2	.01005513	.04638922	.27972295	.42767863	.42944719

Marginal banks are benchmark. The dependent variable is $\frac{Sovereign_{i,j,t}}{TotalAsset_{i,t}}$; Post=1 if after the 2011 stress test; RA=1 if the sovereign bonds' spread yield is higher than the median within the same category; Marginal=1 if banks' core capital ratio is between 5 %-6%; Fragile=1 if bank's core capital ratio is lower than 5 %; local_c=1 if bank i holds its own country's sovereign bond;

Table 32: Time dependent RA

VARIABLES	(1) $\frac{Sovereign_{i,j,t}}{TS_{i,t}}$	(2) $\frac{Sovereign_{i,j,t}}{TS_{i,t}}$	(3) $\frac{Sovereign_{i,j,t}}{TS_{i,t}}$	(4) $\frac{Sovereign_{i,j,t}}{TS_{i,t}}$	(5) $\frac{Sovereign_{i,j,t}}{TS_{i,t}}$
PostTest1*RA*Safe	-2.327*	-1.723	-0.362	-1.544***	-1.731***
	(-1.90)	(-1.53)	(-0.69)	(-3.14)	(-3.49)
PostTest1*RA*Fraigle	-0.721	-0.702	0.024	-1.129	-1.307*
	(-0.42)	(-0.39)	(0.04)	(-1.64)	(-1.89)
PostTest2*RA*Safe	-3.625***	-2.832***	-1.433**	-1.583**	-1.610**
	(-3.58)	(-3.06)	(-2.13)	(-2.46)	(-2.49)
PostTest2*RA*Fragile	-4.601***	-4.394***	-1.253*	-1.420**	-1.442**
	(-3.69)	(-3.61)	(-1.75)	(-2.06)	(-2.09)
PostTest1*Safe	1.404***	1.033***	-0.303	1.041***	1.250***
	(3.50)	(3.54)	(-1.21)	(5.58)	(5.46)
PostTest1*Fragile	0.247	0.355	-0.630**	0.704**	0.912***
	(0.34)	(0.49)	(-2.03)	(2.47)	(2.89)
PostTest2*Safe	1.768***	1.274***	0.659*	0.681***	0.686***
	(3.31)	(3.22)	(1.78)	(2.78)	(2.76)
PostTest2*Fragile	1.989***	1.826***	0.480	0.513*	0.519*
	(3.67)	(3.46)	(1.20)	(1.80)	(1.81)
Safe*RA	-0.840	-1.539	-1.089**	-0.527	-0.433
	(-1.02)	(-1.45)	(-2.44)	(-1.23)	(-1.03)
Fragile*RA	-0.379	-0.491	-0.677	-0.118	-0.030
	(-0.31)	(-0.41)	(-1.35)	(-0.24)	(-0.06)
PostTest1*RA	3.493***	3.116***	2.111***	0.657	0.688
	(3.44)	(3.05)	(5.03)	(1.52)	(1.40)
PostTest2*RA	5.594***	5.042***	3.112***	0.860	1.267*
	(6.25)	(6.05)	(5.42)	(1.45)	(1.77)
Local_c*PostTest1			-32.568***	-31.454***	-31.124***
			(-12.65)	(-12.65)	(-12.45)
RA	-1.688*	-1.230	-1.752***	0.865*	1.092**
	(-1.88)	(-1.22)	(-4.30)	(1.92)	(2.12)
PostTest	-1.504***	-1.407***	-1.255***	-0.009	0.000
	(-6.93)	(-7.85)	(-7.34)	(-0.07)	(.)
lsize	0.050***	0.133	0.039	0.047	0.052
	(2.71)	(1.28)	(0.94)	(1.00)	(1.04)
local_c			61.648***	60.632***	60.580***
			(16.14)	(15.80)	(15.76)
Constant	3.089***	2.319*	2.654***	-0.833	-1.469*
	(3.96)	(1.84)	(5.30)	(-0.92)	(-1.74)
Bank FE	No	Yes	No	Yes	Yes
sovereign FE	No	No	No	Yes	Yes
sovereign FE*Post	No	No	No	No	Yes
Observation	12725	12725	12725	12725	12725
R^2	.00522086	.0062086	.66203939	.77382936	.77468029

Marginal banks are benchmark. The dependent variable is $\frac{Sovereign_{i,j,t}}{TS_{i,t}}$; Post=1 if after the 2011 stress test; RA=1 if the sovereign bonds' spread yield is higher than the median within the same category. local_c=1 if bank i holds its own country's sovereign bond.

Table 33: Robustness test: Time Trend

VARIABLES	(1) $\frac{Sovereign_{i,j,t}}{TA_{i,t}}$	(2) $\frac{Sovereign_{i,j,t}}{TotalSovereign_{i,t}}$
TimeTrend*RA	0.019	-0.087
	(0.53)	(-0.29)
TimeTrend*Safe	-0.015	-0.021
	(-1.05)	(-1.64)
TimeTrend*Fragile	-0.004	0.011
	(-0.23)	(0.24)
Safe*RA	-0.109	-1.684***
	(-1.07)	(-2.68)
Fragile*RA	-0.099	-1.868***
	(-0.88)	(-3.33)
RA	-0.030	0.679
	(-0.24)	(0.93)
time_trend	0.012	-0.070
	(0.46)	(-0.97)
lsize	-0.120	0.394
	(-1.09)	(0.72)
Constant	1.516	-3.968
	(1.12)	(-0.60)
Bank FE	Yes	Yes
sovereign FE	Yes	Yes
sovereign FE*Post	Yes	Yes
Observation	8049	8049
R^2	.48981736	.76687121

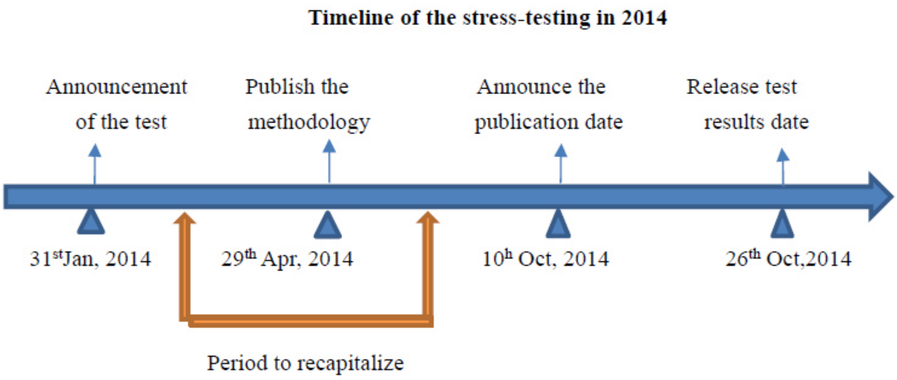
Marginal banks are benchmark. The dependent variable of (1) is $\frac{Sovereign_{i,j,t}}{TA_{i,t}}$; the one of (2) is $\frac{Sovereign_{i,j,t}}{TotalSovereign_{i,t}}$; RA=1 if the sovereign bonds' spread yield is higher than the median within the same category; Marginal=1 if banks' core capital ratio is between 5 %-6%; Fragile=1 if bank's core capital ratio is lower than 5 %; local_c=1 if bank i holds its own country's sovereign bond;

Table 34: Robustness test: Time Trend

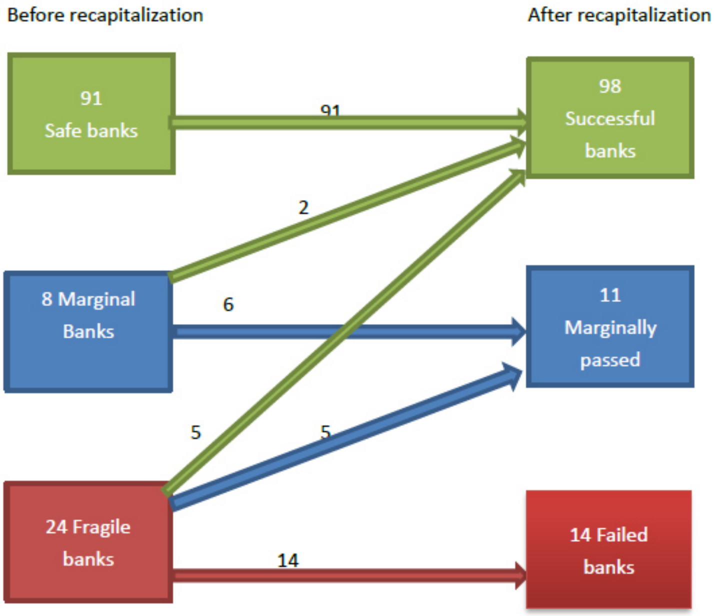
VARIABLES	(1) $\frac{Sovereign_{i,j,t}}{TotalSovereign_{i,t}}$	(2) $\frac{Sovereign_{i,j,t}}{TotalSovereign_{i,t}}$	(3) $\frac{Sovereign_{i,j,t}}{TotalSovereign_{i,t}}$
Post*RA*Safe	-3.380***	-1.035*	-1.035*
	(-3.20)	(-2.00)	(-2.00)
Post*RA*Fragile	-3.912***	-1.280**	-1.280**
	(-3.36)	(-2.10)	(-2.10)
Safe*RA	-2.668*	-2.003**	-2.003**
	(-1.84)	(-2.57)	(-2.57)
Fragile*RA	-2.988*	-1.564*	-1.564*
	(-1.87)	(-1.92)	(-1.92)
Post*RA	3.458***	0.732	0.732
	(3.36)	(1.26)	(1.26)
Post*Safe	1.739***	0.300*	0.303*
	(4.26)	(1.90)	(1.91)
Post*Fragile	2.051***	0.379**	0.381**
	(3.85)	(2.02)	(2.03)
RA	2.348	0.637	0.637
	(1.64)	(0.49)	(0.49)
lsize	0.055*	0.004***	0.003
	(1.93)	(3.21)	(1.13)
Local_c*Post		-1.844	-1.844
		(-0.98)	(-0.98)
local_c		58.939***	58.939***
		(12.36)	(12.36)
time_trend			-0.008**
			(-2.51)
Constant	1.584***	0.318**	0.379**
	(3.77)	(2.16)	(2.33)
Bank FE	No	Yes	Yes
sovereign FE	Yes	Yes	Yes
sovereign FE*Post	No	Yes	Yes
Observation	7689	7689	7689
R^2	.00420989	.7111051	.71110523

Marginal banks are benchmark. The dependent variable is $\frac{Sovereign_{i,j,t}}{TotalSovereign_{i,t}}$; Post=1 if after the 2011 stress test; RA=1 if the sovereign bonds' spread yield is higher than the median within the same category; Marginal=1 if banks' core capital ratio is between 5 %-6%; Fragile=1 if bank's core capital ratio is lower than 5 %; local_c=1 if bank i holds its own country's sovereign bond.

B Appendix 2



Test result before and after recapitalization in 2014



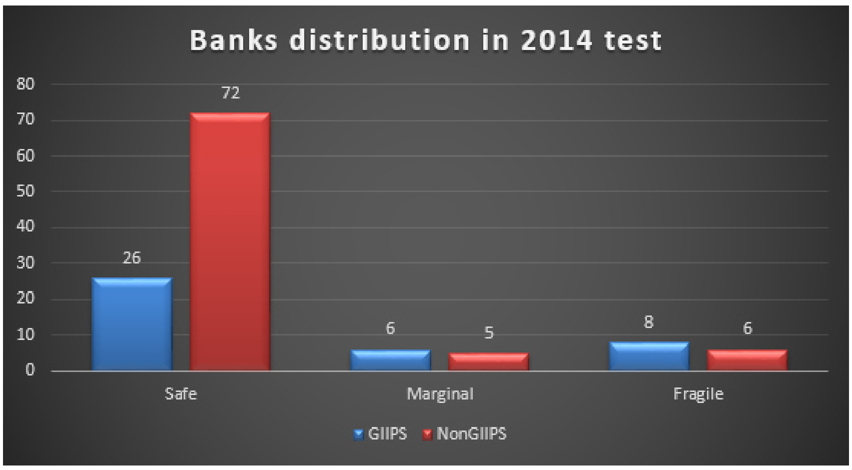


Figure 6: **The evolution net income over total assets**

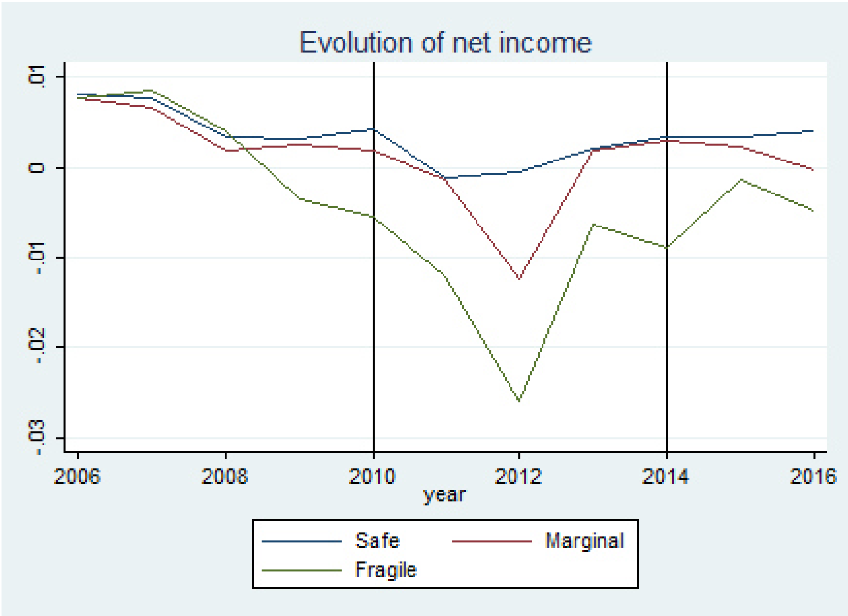


Table 35: Summary of credit ratings before or after the tests

Ratings	**Before 2011 test**	**After 2011 test**
AAA	AT, DE, DK, FI, FR	AT, DE, DK, FI, FR
	LI, LU, NL, NO, SE, UK	LI, LU, NL, NO, SE, UK
AA	BE, ES, SI	BE, ES, SI, IT
A	CY, CZ, EE, IT, MT, PL, SK, PT	CY, CZ, EE, MT, PL, SK
BBB	BG, HU, GR, IE, IS, LT	BG, HU, LV, RO, LT
B	GR, RO	IE, IS, PT
C		GR
	Before 2014 test	**After 2014 test**
AAA	DE, DK, FI, LI, LU, NO, NL, SE	AT, DE, DK, FI, LI, LU, NO,NL, SE
AA	AT, BE, EE, FR, UK	BE, EE, FR, UK,
A	CZ, MT, PL, SK	CZ, MT, PL, SK, IE, LV,
BBB	BG, ES, IS, IT, LT, LV, SI	BG, ES, IS, IT, LT, RO
B	CY, HU, IE, PT, RO	CY, HU IE, PT
C	GR	GR

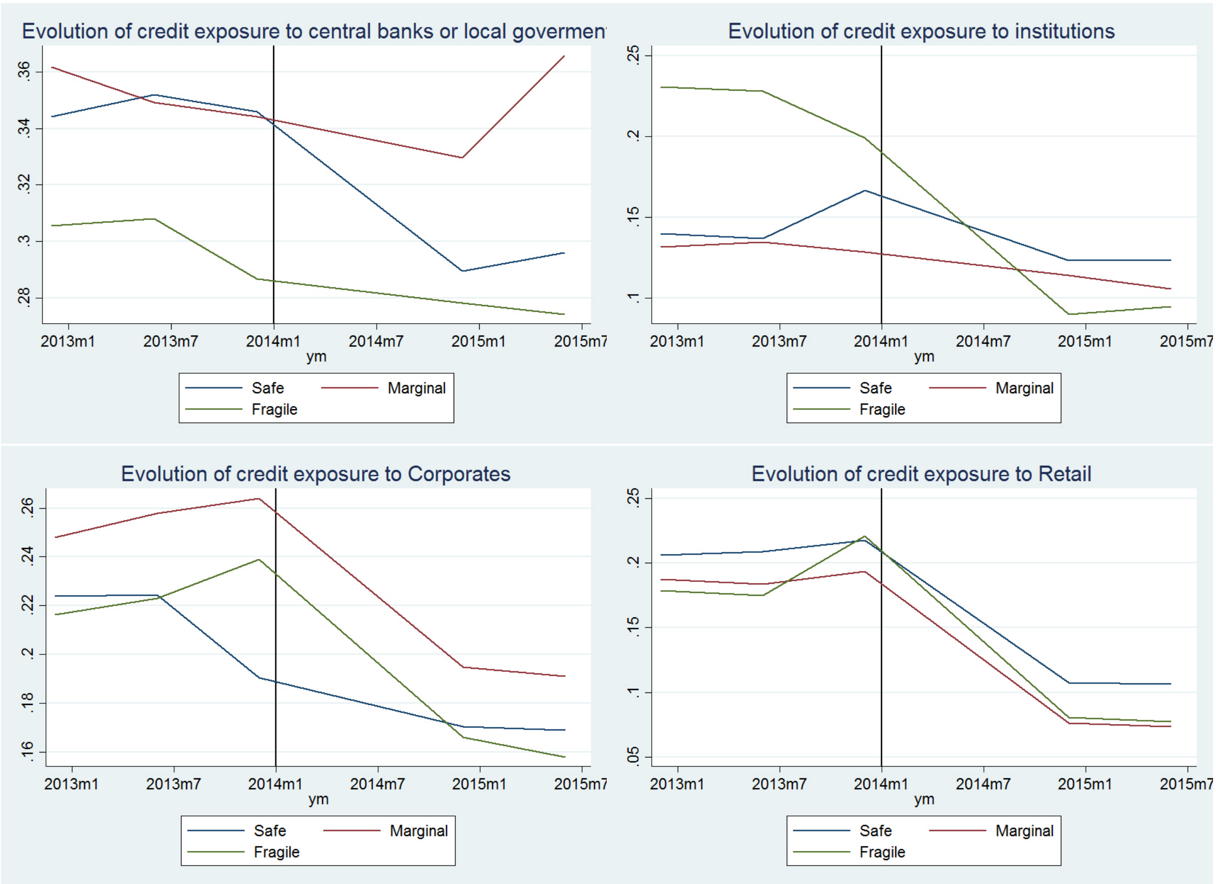


Figure 7: The evolution of different credit risk exposures

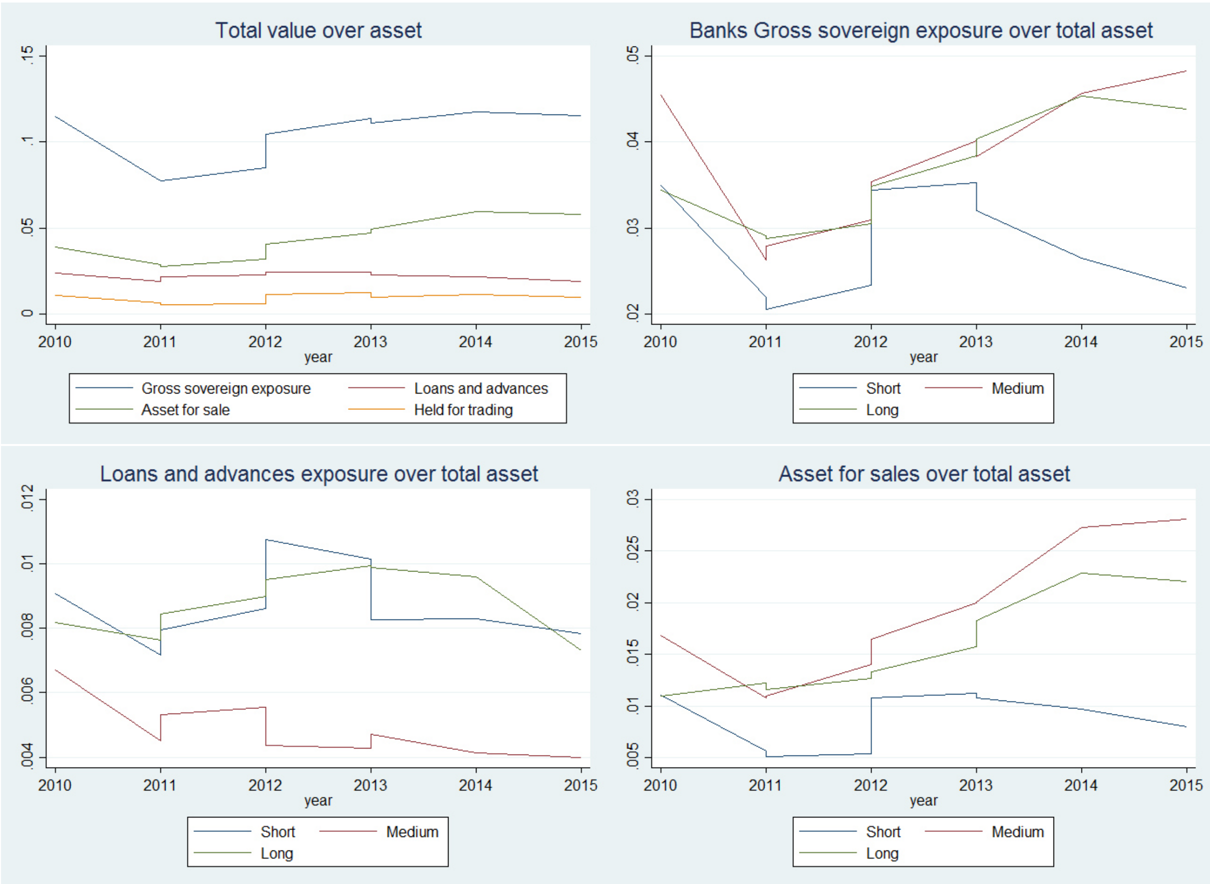


Figure 8: **Total sovereign over total assets**

Note:Sovereign debt amount is scaled down by total asset. In the graph, shows the value-weighted average across banks. Short includes the sovereign debt with a maturity less than 3 years; medium is the sovereign debt lasting less than 10 years; long represent all the sovereign amount with a maturity larger than 10 years.

Figure 9: Different maturity of sovereign in groups
Note: Short term: maturity$\leq$ 1 Year; Medium term: maturity$<$10 Year; Long term: maturity $\geq$ 10 year.

GIIPS sovereign in groups

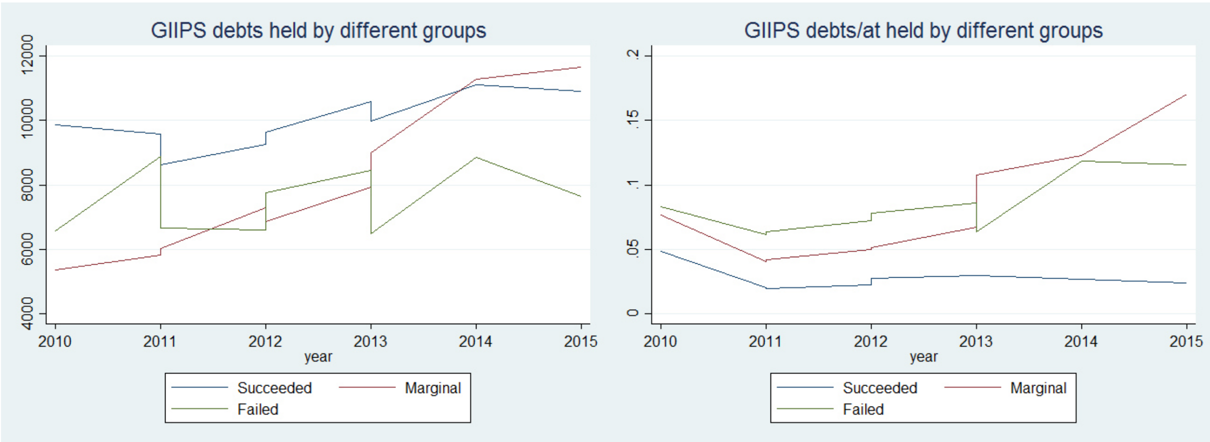


Figure 10: GIIPS sovereign in groups
Note: The left graph shows the amount of GIIPS sovereign; the right graph includes the percentage of GIIPS over total asset.

Figure 11: **Summary of GIIPS sovereigns across groups**

Before the test			**After the test**					
Dec, 2010			Sep, 2011			Deb-2011		
Safe banks			Safe banks			Safe banks		
GIIPS	9845.43	4.83%	GIIPS	9569.72	2.06%	GIIPS	8610.97	1.94%
NonGIIPS	36656.94	7.32%	NonGIIPS	24689.83	5.51%	NonGIIPS	22863	5.60%
Marginal banks			Marginal banks			Marginal banks		
GIIPS	5362.626	4.65%	GIIPS	5815.355	4.80%	GIIPS	6025.115	4.82%
NonGIIPS	3662.294	2.79%	NonGIIPS	7413.098	4.10%	NonGIIPS	7489.761	4.90%
Fragile banks			Fragile banks			Fragile Banks		
GIIPS	6581.044	5.38%	GIIPS	8873.416	7.12%	GIIPS	6663.422	7.84%
NonGIIPS	3914.486	1.05%	NonGIIPS	5693.063	0.59%	NonGIIPS	6762.248	1.23%

C Appendix3

C.1 Sovereign risk treated in the 2011 stress test

On the Methodological Note - Additional guidance of 2011 stress test (Page 5-6); EBA define a consistent approach to deal with the sovereign risk. Since simplicity is a desired element of any approach, a common PD and LGD should be identified as a starting point. They use the public credit ratings of sovereign bonds offered by Credit Agencies. Notch downgrades can then be applied in the stress taking into account the situation as of 1 June 2011. The following notch downgrades, which depend on the starting rating levels, are to be applied to the exposures vis--vis sovereign and institution exposures: (1) AAA / Aaa no downgrading; (2) AA / Aa2 to A- / A3: two notch downgrades; and

(3) BBB+ / Baa1 or below: four notch downgrades with a floor at CCC. For simplicity this approach could focus purely on determining appropriate provisions (EL) for both IRB and TSA banks. No changes would be made to RWA from the existing submission.

C.2 Different types of risk trested in the 2014 stress test

(A) Credit risk

Scope: All assets in the banking book which are exposed to credit risk excluding counterparty credit risk, on and off-balance sheet positions, IRB and STA portfolios. Methodology also applied to IRC.

Methodology: Stressed point-in-time PD and point-in-time LGD for provisioning. Potential rating migration and stressed IRB regulatory parameters for RWA.

RWA impact: Stressed RWA in IRB and STA, including RWA for defaulted assets and IRB excess or shortfall. RWA floored at 2013 levels.

(B) Market risk

Scope: All financial assets and liabilities assessed at fair value (positions in HfT, AfS and designated at fair value through profit and loss portfolios), including counterparty

credit risk. Hedge accounting portfolios. Securitizations held at fair value.
Methodology: Simplified approach: bankspecific reduction in NTI based on historical variation. Comprehensive approach: revaluation of positions based on market risk parameters. CVA haircuts for OTC derivatives. Default of largest counterparty (excl. CCP, market infrastructure, sovereign).
RWA impact: RWA increase for VaR, SVaR and CRM capital charges due to predefined assumptions (constant RWA for banks using simplified approach; VaR replaced by SVaR for banks using comprehensive approach, fixed scaling for CRM). IRC and CVA increase due to worsened risk parameters.
(C) Sovereign risk
Scope: (direct debt exposures as well as indirect exposures to central and local governments). Assessed at fair value (HFT, AFS, fair value through profit and loss) and amortized cost positions.
Methodology: All fair value positions: application of market risk methodology for impact of changes in market prices. Regulatory banking book positions: application of credit risk methodology for impairment estimates based on rating migration defined by ESRB/ECB.
RWA impact: RWA increase due to worsened risk parameters in IRB and STA.
(D)Securitization risk
Scope: Securitization and securitization positions assessed at fair value (HfT, AfS, designated at fair value through profit and loss) and amortized cost positions. ABCP (incl. ABCP liquidity lines) excluded but subject to either the regular RWA treatment or market risk methodology. Methodology: Increase of RWA depending on risk profile of the positions (three risk buckets). Impairment estimates for positions not held for trading. Application of market risk methodology for fair value positions. RWA impact: RWA increase for all securitization positions based on predefined risk buckets.

C.3 Economic Hypothesis

C.3.1 Model of Glasserman and Kang (2014)

Regulators' objective is to stabilize the market by minimizing the risk in the bank's portfolio y while allowing the bank an adequate rate of return at time t=1:

$$\begin{aligned} \min_{y} \quad & y^T \Sigma y \\ \text{s.t.} \quad & \mu^T y \geq l \end{aligned}$$

for some $l > 0$. It's equivalent[38] to solve the following maximization under regulation constraints at t=1:

$$\begin{aligned} \max_{y} \quad & \mu^T y \\ \text{s.t.} \quad & \sqrt{y^T \Sigma y} \leq \eta \end{aligned}$$

Solving the objective function under regulation constraints, from the regulators' point of view the optimal banks' portfolio should be:

$$\Rightarrow y_1^* = \frac{\eta}{\sqrt{\mu^T \Sigma^{-1} \mu}} \Sigma^{-1} \mu$$

The optimal portfolios under regulations can be implemented by imposing a required capital ratio on banks. Banks' assets are assigned to different risk-weights w according to different categories of the asset[39]. At t=1 their objective function under regulation constraints becomes:

$$\begin{aligned} (BC)\max_{x} \quad & \mu^T x - \frac{\gamma}{2} x^T \Sigma x \\ s.t. \quad & x^T w \leq K \end{aligned}$$

$$\Rightarrow x_1^* = \frac{1}{\gamma} \Sigma^{-1} \mu - \frac{(w^T \Sigma^{-1} \mu - \gamma K)^+}{w^T \Sigma^{-1} w} \frac{1}{\gamma} \Sigma^{-1} w$$

[38] Under the assumption that the return of x is normally distributed. Regulators' minimization of banks probability of default can be transformed into the minimization problem of risk level.

[39] More details can be found in the Basel III

C.3.2 My extension of the model

The objective function for all types of banks at t=1 becomes:

$$\max_x \quad \pi(\mu^T x - \frac{\gamma}{2} x^T \Sigma x) + (1-\pi)P$$
$$\begin{cases} \pi = 1 & if \quad x^T w \leq K \\ \pi \in [0,1) & if \quad x^T w > K \end{cases}$$

If $x_1 = \frac{K}{w}$ on the binding constraint, I have $V_1 = \mu^T x_1 - \frac{1}{\gamma} x^T \Sigma x = \mu^T (\frac{K}{w}) - \frac{1}{\gamma} (\frac{K}{w})^T \Sigma (\frac{K}{w})$;

If $x_1 = x_0^*$, the expected value becomes $V_2 = \pi(\mu^T x_0^* - \frac{1}{\gamma} x_0^{*T} \Sigma x_0^*) + (1-\pi)P$.

At the optimal, there are two possible cases: Case (1) $V_1 > V_2$ and Case (2)$V_1 > V_2$

C.3.3 Regulatory Arbitrage

Suppose that the risk weight w is linear to the risk of the asset σ: $w = c\sigma$, where $\sigma = (diag(\Sigma))^{\frac{1}{2}}$[40] and c is a constant. From the previous optimal solution, we have:

$x_1^* = \frac{1}{\gamma} \Sigma^{-1} \mu - \frac{(w^T \Sigma^{-1} \mu - \gamma K)^+}{w^T \Sigma^{-1} w} \frac{1}{\gamma} \Sigma^{-1} w$

Replace $w = c\sigma$, then we have:

$x_1^* = \frac{1}{\gamma} \Sigma^{-1} \mu - \frac{(w^T \Sigma^{-1} \mu - \gamma K)^+}{w^T \Sigma^{-1} w} \frac{1}{\gamma} \Sigma^{-1} w$

$x_1^* = \frac{1}{\gamma} \Sigma^{-1} \mu - \frac{(c\sigma^T \Sigma^{-1} \mu - \gamma K)^+}{c\sigma^T \Sigma^{-1} c\sigma} \frac{1}{\gamma} \Sigma^{-1} c\sigma$

$x_1^* = \frac{1}{\gamma} \Sigma^{-1} (\mu - \frac{(c\sigma^T \Sigma^{-1} \mu - \gamma K)^+}{c\sigma^T \Sigma^{-1} c\sigma} \sigma)$

$x_1^* = \frac{1}{\gamma} \Sigma^{-1} (\mu - \frac{(c\sigma^T \Sigma^{-1} \mu - \gamma K)^+}{cM^{-1}} \sigma)$

$\Rightarrow x_1^* = \frac{1}{\gamma} \Sigma^{-1} (\mu - \rho\sigma)$

Where $(c\sigma^T \Sigma^{-1} \mu - \gamma K)^+$ is a scalar function of K and denote ρ as the function of K and c. If the constraints are binding, x_1^* is not linear to $x_0^* = \frac{1}{\gamma} \Sigma^{-1} \mu$ any more, i.e., the regulations imposed on banks change the optimal investment scheme of constrained banks. In the real economy, the risk weight $w = c\bar{\sigma}$ is linear to the standard deviations of the asset categories $\bar{\sigma}$, that is to say, it is not a continuous variable. Banks can always chose $x_1^{'} (\neq x_1^*)$ to take more risk.

[40] $\Sigma = \sigma M \sigma^T$, M is the correlation matrix of assets