7-2017

Bank risk in a decade of low interest rates

Yen-Ling Chang
Dakota State University

Daniel A. Talley
Dakota State University

J Econ Finan (2017) 41:505–528
DOI 10.1007/s12197-016-9367-5

Bank risk in a decade of low interest rates

Yen-Ling Chang[1] · **Daniel A. Talley**[1]

Published online: 18 August 2016

Abstract A low interest rate regime remains in place in the U.S. after the Financial Crisis of 2008. Banks nevertheless need to find ways to boost the economic value to shareholders. This research examine whether it is possible for banks to stay the course and pursue profitable yet riskier assets or investments regardless of the fact that regulators have put restrictions on banks' asset portfolio formation and capital ratio. This study hypothesizes that banks still engage in highly risky yet profitable investments or services to offset low interest income even after the 2008 Financial Crisis. A panel VAR model and a dynamic GMM model incorporating two structural breaks are employed to examine bank data obtained from the FFIEC from 2003 thru 2014. This study suggests that banks, especially larger banks, still have strong incentives to undertake riskier projects with higher expected returns in order to increase their performance. This has implications for policy makers examining risks inherent to the banking system.

Keywords 2008 financial crisis · Bank profitability · Interest rates · Off-balance-sheet activities · Panel VAR · GMM · Multiple structural breaks

JEL Classification G21 · E44

1 Introduction and literature review

During a lengthy period (i.e. 2008–2014) of low interest rates, the primary venue for banks to generate revenues, the traditional loan business becomes less profitable. Therefore, banks as any other corporation have to find alternatives to maintain acceptable level of returns in order to satisfy their clients and stakeholders.

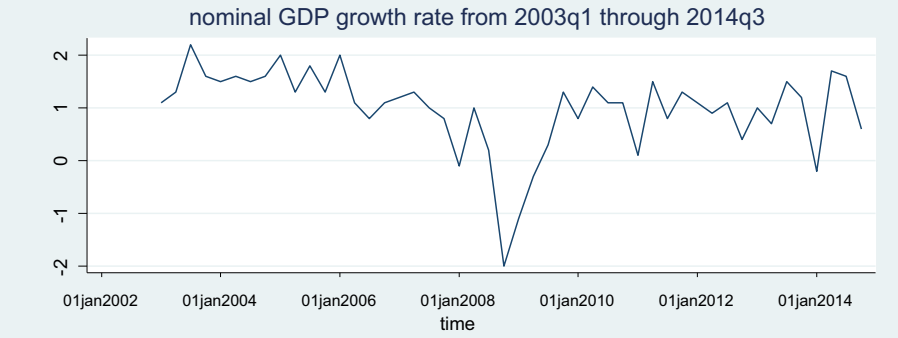
✉ Yen-Ling Chang
yenling.chang@dsu.edu

[1] Department of College of Business and Information Systems, Dakota State University, Madison, SD, USA

Since a low interest rate regime remains in place in the U.S. after the Financial Crisis of 2008 and banks nevertheless need to find ways to boost the economic value of the shareholders, would it be possible for banks to stay the same course and pursue risky assets or investments regardless of the fact that regulators imposed restrictions on banks asset portfolio formation during and after the Financial Crisis? The data in Fig. 1 suggest this possibility. Therefore, we hypothesize that banks still engage in both highly risky yet profitable investments and services even after the Financial Crisis of 2008 while the interest rate remains low. We suspect that banks still have strong incentives to undertake profitable yet riskier activities and investments in order to improve their performance (Fahlenbrach et al. 2012). Duchin and Sosyura (2014) analyze TARP banks and non-TARP banks and show that TARP banks shifted credit originations to higher risk yet profitable loans after they received financial aid from the government. This research examines publicly available bank data to see if banks seek higher yield by providing fee-based services such as loan commitments, credit substitutes, and other services such as trusts.

Stiroh (2006a, b) use publicly traded U.S. bank-holding company data to examine the determinants of risk and analyze how they have evolved. Using the standard

(A) Pattern of GDP growth from 2003q1 through 2014q3



(B) Pattern of 10-year Treasury bond interest rate from 2003q1 through 2014q3

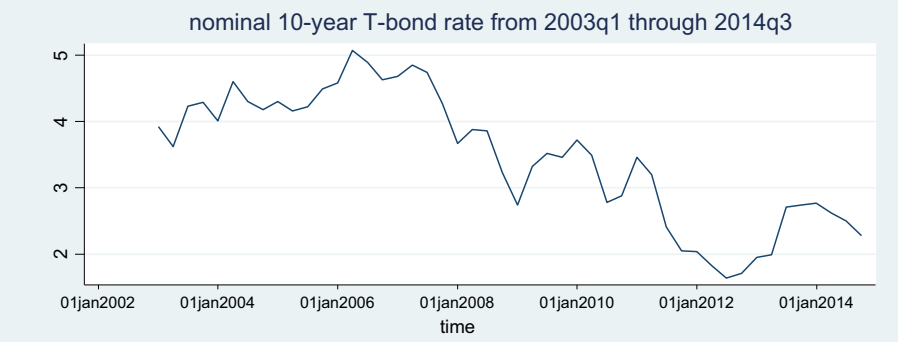
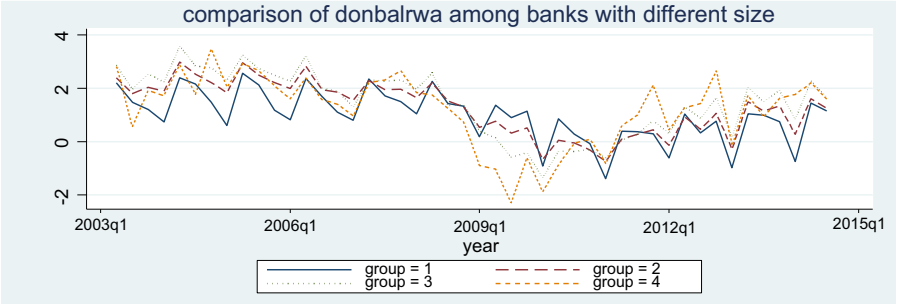
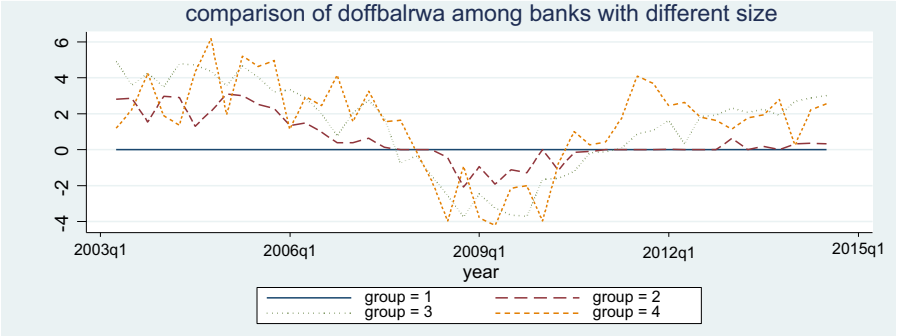


Fig. 1 Pattern of macroeconomic and bank level variables from 200q1 through 2014q3. A. Pattern of GDP growth from 2003q1 through 2014q3 B. Pattern of 10-year Treasury bond interest rate from 2003q1 through 2014q3 C. Pattern of on-balance-sheet activities for different sizes from 2003q1 through 2014q3 D. Pattern of off-balance-sheet activities for different sizes of banks from 2003q1 through 2014q3 E. Pattern of return on assets for different sizes of banks from 2003q1 through 2014q3

(C) Pattern of on-balance-sheet activities for different sizes from 2003q1 through 2014q3



(D) Pattern of off-balance-sheet activities for different sizes of banks from 2003q1 through 2014q3



(E) Pattern of return on assets for different sizes of banks from 2003q1 through 2014q3

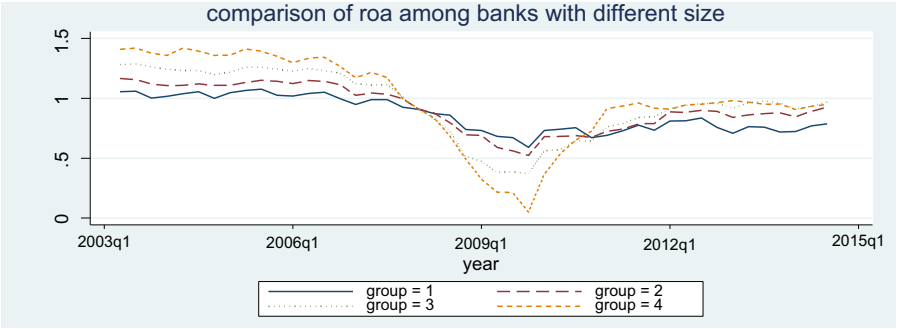


Fig. 1 (continued)

deviation of equity return as the proxy for risk, the results show that balance sheet activities, such as commercial and industrial loans and consumer lending, as well as income statement items, such as other noninterest income, drive the cross-sectional differences in bank holding company risks. Sources of risk have changed since banks shifted their business model from deposit-driven activities to fee-based activities after 2001. The results also indicate that income statement activities (items) become more important than balance sheet items as determinants of risk. In particular, the non-interest income and expense items generated by fee-

based activities, i.e. off-balance-sheet activities, have drawn more attention by the banking community in the last decade.

Several papers have discussed the impact of off-balance-sheet activities on bank performance and different kinds of risks, including systemic risk, total risk, and market risk. An early study by Allen and Jagtiani (2000) finds that the benefit of diversification by expanding bank business into nontraditional business might not be large enough to offset the increase in systemic risk and market risk. Stiroh and Rumble (2006) use U.S. financial holding companies to examine whether engaging in more off-balance-sheet activities helps bank diversify risk. Their results indicate that the benefit of diversification has been diminished and offset by more risk exposure to unstable noninterest earnings generated by those fee-based activities. Calmés and Théoret (2010) use an ARCH-M model to examine Canadian bank data and confirm that noninterest income generated by off-balance-sheet activities no longer impacts bank returns positively. It turns out the surge in off-balance-sheet activities eventually increases bank risk. DeYoung and Torna (2013) analyze the relationship between bank failure and noninterest income activities. They further decompose noninterest income businesses into nontraditional stakeholder activities, fee for services activities, and traditional banking activities such as depositor services and fiduciary services. Their analysis suggests the likelihood of bank failure is much higher for already financially distressed banks engage in stakeholder activities such as underwriting, investment banking, venture capital and other investments that may require banks to hold risky assets.

On the other hand, Ziadeh-Mikati (2012) uses U.S. commercial bank data to examine the impact of off-balance-sheet activities on bank failure and risk exposure. Their study specifically separates off-balance-sheet activities into three different categories including credit substitutes, credit derivatives and derivative contracts. The results show that banks engaging in more credit substitutes have a lower degree of volatility on return on assets (ROA), higher quality of assets, and lower credit risks.[1] A recent study by Papanikolaou and Wolff (2014) documents the impact of off-balance-sheet activities as part of the risk-weighted capital ratio on overall banking risk. According to their finding, off-balance-sheet leverage is negatively linked to the soundness of the banking system as a whole before and after the Financial Crisis of 2008.

Although early literature documents inconclusive results on whether off-balance sheet activities (fee-based activities) increase or reduce bank risk, recent studies show a positive relationship between off-balance-sheet activities and bank risk. Furthermore, most studies conduct a unidirectional test, that is, they assume off-balance sheet activity is an exogenous factor to be included in the regression model. This treatment of off-balance sheet activity ignores the fact that sometimes banks use off-balance sheet activities (or services-based activities) to enhance or improve bank profitability when focusing on loan originations or other on-balance-sheet activities that do not adequately increase bank profit. That is, the motivation to increase off-balance-sheet activities could be partly due to falling revenues on interest-bearing assets over a period during which interest rates first fall and later are stable but at a very low level.

[1] The paper uses the ratio of non-performing loans, the ratio of loan loss reserves and loan loss provision to measure banks' credit risk.

We take a different approach to allow a contemporaneous relationship between off-balance sheet activities, which are the primary sources of non-interest income, and interest rates while accounting for other relevant bank variables. We argue that the primary consideration for a bank to engage in more off-balance-sheet activities depends on economic conditions that affect the ability of a bank to generate revenues. During an economic boom, a bank is more than willing to make loans to individuals and businesses in anticipation of low default risks and higher payoffs. However, during a slow economy, firms reduce investment at the same time that banks require stricter credit standards (Ivashina and Scharfstein 2010). Banks also find themselves scaling down the amount of new loans. Furthermore, it might be more costly for banks to make loans, for example if the cost of taking deposits is not recovered when interest rates are being held low by the monetary authority.

The most closely related prior study is Delis and Kouretas (2011). They conclude that lower interest rates are associated with increasing risk-taking behavior using European bank data. Their paper also suggests that the impact of lower interest rate on holdings of riskier assets was diminished for banks with higher equity capital and amplified for banks with higher off-balance-sheet items. One possible reason is that banks have to develop business other than traditional banking activities in order to generate extra revenues to satisfy their shareholders. Under this scenario, banks naturally engage in more services-based activities such as providing standby credits, letters of credit, loan commitments and financial derivative contracts that are not for hedging purposes.

Our main research interest centers on the investigation of the relationship between off-balance sheet activities and interest rates and the impulse response relationship among all dependent variables. Our paper differs in two important ways from Delis and Kouretas (2011). First of all, we use risk-weighted off-balance-sheet items and risk-weighted on-balance-sheet items as proxies for bank risk-taking behavior.[2] Secondly, our model addresses endogeneity by using Panel VAR in addition to the Dynamic GMM model for panel data used in their paper.

Delis and Kouretas (2011) address the issue of the dynamic nature of bank risk-taking and how the potential endogeneity of some of the control variables may affect the results by using a dynamic GMM model for panel data (Arellano and Bond (1991); Arellano and Bover (1995); Blundell and Bond (1998)). Following a similar methodology in the first part of the paper, the results of our model are remarkably similar results to theirs. Specifically, we find that both bank size and 10-year bond rates have a significant and negative relationship with bank risk behavior while economic growth frequently shows a positive relationship with bank risk behavior.

[2] The risk-weighted off-balance-sheet assets including financial derivatives and other off-balance-sheet assets are calculated based on 0 %, 20 %, 50 % and 100 % conversion factors regulated by the two-step approach of the regulatory capital rule. For instance, unused commitments with an original maturity of one year or less are in the 0 % credit conversion factor group; a commercial letter of credit is in the 20 % credit conversion factor group; unused portions of commitments, including home equity lines of credit, with an original maturity exceeding one year or that are unconditionally cancellable are in the 50 % credit conversion factor group; guarantees or financial guarantee-type standby letters of credit, recourse obligations and direct credit substitutes, and forward agreements with a certain drawdown are in the 100 % credit conversion factor group. A financial institution must determine the credit equivalent amount of its off-balance sheet financial derivative contracts that are not subject to qualifying bilateral netting contracts.

However, a dynamic GMM model for panel data does not fully consider endogeneity of some of the control variables such as off-balance-sheet items, on-balance-sheet items, interest rates, and economic growth. Our paper addresses this issue by employing a Panel Vector Autoregression (Panel VAR) model. This model allows us to take advantage of the rich information embedded in the cross-sectional and time-series data while examining the interaction among the included endogenous variables.

Ivashina and Scharfstein (2010) investigate bank lending behavior and suggests that a possible reason that the rise in commercial and industrial loans during the Financial Crisis of 2008 (documented by Chari et al. 2008) is partly due to an increase in the drawdown of revolving credit facilities. Therefore, an increase in on-balance-sheet items in this period may be caused by a decrease in off-balance-sheet items in the previous quarter. That is, risk has transferred from off-balance-sheet activities to on-balance-sheet activities and accordingly affects bank profitability. Hence, we find it proper to separate bank risk-taking behavior into on-balance-sheet risk taking and off-balance-sheet risk taking and examine how they simultaneously interact with lower interest rates during different economic conditions.

Using a dynamic model for panel data, our empirical results strongly suggest that banks, on average, engage in more off-balance-sheet activities during a period of falling interest rates when controlling for economic conditions and other bank level variables. The results obtained by the Panel VAR model are similar in that off-balance-sheet activities negatively respond to a change in lagged 10-year T-bond rate between 2008q2 and 2010q4, suggesting banks increase their off-balance-sheet activities in response to falling interest rates. The negative impact is persistent for more than 12 quarters. We further break down all banks into four different groups by total assets and examine how each group responses to falling interest rates. On one hand, larger banks from Groups 2, 3 and 4 respond negatively to falling interest rates subsequently and remain in negative territory for more than 12 quarters. On the other hand, the smallest banks that form Group 1 have almost no response to falling interest rates contemporaneously and subsequently. The different response suggests that larger banks are able to act more quickly in response to a less hospitable business environment than smaller banks. Yet larger banks also have higher risks since 2008 when businesses have faced considerable economic uncertainty.

The remainder of the paper is organized as follows. Section 2 introduces the econometric model. We discuss the rationale behind the model specification and possible limitations of the model associated with the nature of the banking data. Section 3 presents empirical results and provides a discussion of insights from the results. Section 4 discusses some relevant policy implications and concludes the paper.

2 Data and model specification

2.1 Data

Bank level data is retrieved from the Federal Financial Institutions Examination Council (FFIEC). We obtained Uniform Bank Performance reports (UBPR) dated from

2003q1 through 2014q3 for all American banks from the FFIEC website. This report contains annual and quarterly financial and accounting information for domestic banks. The GDP growth rate and the 10-year T-bond rate are obtained from the FRED database of the Federal Reserve Bank at St. Louis. We apply several filters to the bank data. First of all, we exclude trust banks that do not have traditional bank businesses such as loans and deposits. Banks with negative net interest income and negative total shareholders' equity are also deleted from the sample. Banks with return on equity above 100 % are deleted as we find an extremely high return on equity is caused by near-zero total shareholder's equity. Then we manually identify data points that are extreme that are likely due to acquisition and/or merger. Lastly, we exclude banks with less than 3 years of financial data. With all of these filters in place, the resulting data set has 279,884 total observations from 7509 banks. All banks are grouped into one of the four size classes based on total assets of $10 million or less, between $10 million and $1 billion, between $1 billion and $10 billion, and above 10 billion, and are denoted Group 1–4 respectively.

Table 1 provides a descriptive summary for major variables in the Panel VAR model. Panel A of Table 1 presents bank-level variables that are differenced into log-transformed values. For instance, the average growth rate on net interest income is 4.22 % with a high standard deviation of 80.60 %. One point worth noting is that off-balance-sheet activities outgrew on-balance-sheet activities over the past decade. Delis and Kouretas (2011) also concluded that banks held riskier assets before the onset of the Financial Crisis of 2008. One should pay attention to the within and between variations of the data. Apparently variation is higher over time than across banks suggesting the time effect might have strong explanatory power when compared to differences across banks. Panel B of Table 1 presents a descriptive summary for two macroeconomic variables, the nominal GDP growth rate and the 10-year T-bond rate, in three different sub-periods.

Figure 1 presents the trend on the GDP growth rate, the 10-year T-bond rate, the growth rate of on-balance-sheet activities and the growth rate of off-balance-sheet activities. As shown in Panel A, the U.S. economy experienced negative growth from 2008q3 thru 2009q2. Meanwhile, Panel B of Fig. 1 shows that the 10-year T-bond rate started to fall as the Federal Reserve Bank used several monetary measures to bring down long-term rates. The 10-year T-bond reached its lowest level in 2012q2 and slowly climbed afterward. A statistical summary of the two macroeconomic variables is presented in Panel B of Table 1. Two possible major structural breaks are observed in the 10-year T-bond rate series. One can conclude that, while the economy has experienced a notable contraction and two expansions during this period with the GDP growth rate exhibiting a V-shaped pattern, the 10-year T-bond rate has an overall downward trend as the average T-bond rate declines from 4.389 % to 2.374 % over the same period.

Panels C and D of Fig. 1 show the patterns of the growth rate on both risk-weighted on-balance-sheet and risk-weighted off-balance-sheet activities by total asset size groups. All banks had a similar growth pattern before 2008. However, the largest banks (Group 4) saw significant declines in on-balance-sheet-activities right after 2008q1, and clearly indicate that largest banks suffered greatly at the beginning of the Financial Crisis of 2008. This group also had a quick increase in on-balance-sheet activities after 2010. In

Table 1 Summary statistics for main level variables in GMM and Panel VAR model

Panel A: Bank level variables

Variable		Mean (%)	Standard deviation	Minimum	Maximum	Observations
tenetintinc	Overall	4.22	80.60	-672.56	585.92	*N* = 279,884
	Between		3.85	-18.64	55.74	*n* = 7509
	Within		80.54	-667.33	591.15	T-bar = 37.27
nonintinc	Overall	4.34	87.03	-681.97	640.52	N = 279,884
	Between		5.53	-26.68	56.25	n = 7509
	Within		86.90	-672.92	625.19	T-bar = 37.27
onbalrwa	Overall	1.88	7.15	-383.27	317.07	N = 279,884
	Between		2.56	-11.87	24.37	n = 7509
	Within		6.80	-371.09	299.18	T-bar = 37.27
offbalrwa	Overall	2.92	52.75	-974.21	871.73	N = 279,884
	Between		6.53	-39.79	49.16	n = 7509
	Within		52.44	-958.59	862.79	T-bar = 37.27

Panel B: Macroeconomic variables

Variable	Mean (%)	Standard deviation	Minimum	Maximum	Observations
Pre-2008					
gdpgr	1.345	0.512	-0.1	2.2	20
tb10y	4.389	0.379	3.62	5.07	20
Crisis Period					
gdpgr	0.345	1.088	-2	1.4	11
tb10y	3.535	0.409	2.74	3.88	11
Post-2011					
gdpgr	0.98	0.551	-0.2	1.7	15
tb10y	2.374	0.545	1.64	3.46	15

tenetintinc is net interest income; nonintinc is non-interest income; onbalrwa is risk-weighted on balance sheet activities; offbalrwa is risk-weighted off balance sheet activities; the Mean statistic is in percentage;gdpgr is nominal GDP growth rate; tb10y is 10-year T-bond rate

Panel D, we observe a similar pattern for the growth of off-balance-sheet activities. Likewise, Groups 3 and 4 were hit hard by the financial crisis and their off-balance-sheet activities continued to decline for a much longer period of time but thereafter gradually climbed. This is consistent with the idea that larger banks are willing to take steps to engage in riskier fee-based businesses as the risk-weighted off-balance-sheet assets increase higher than the level during the period of financial crisis. It is clear that smaller banks did not invest many of their resources in off-balance-sheet activities in the past decade as a flat trend centered around zero is observed in the final panel.

It is interesting to note that the larger banks resumed expanding their off-balance-sheet businesses after 2010 and maintained modest growth of on-balance-sheet activities when the 10-year T-bond rate continued to fall after 2010 as shown in Panel B of Fig. 1. This preliminary result is consistent with our hypothesis that banks, especially larger banks, are likely to invest in riskier assets when the traditional banking business

is less able to generate satisfactory returns to stakeholders and shareholders. Table 2 shows the contemporaneous correlation among the macro-level and bank-level variables in different time periods.[3] During both the period of the Great Recession and the weak recovery, the GDP growth rate is positively related to both the 10-year T-bond rate and all bank-level variables included in the table for the entire sample period as shown in Panel A. The 10-year T-bond rate is positively related to all bank-level variables. Off-balance-sheet activities are negatively associated with non-interest income and net interest income. The association between the 10-year T-bond rate and off-balance-sheet activities is significantly negative for the period of 2003q1 through 2008q1. Although the association remains negative, it is not significant for the next two subsequent periods. Interestingly, bank-level variables are all negatively associated with the 10-year T-bond rate in the post-crisis period (i.e. 2011q1-2014q3). One thing worth noting is that off-balance-sheet activities are negatively related to income statement items such as non-interest income and net interest income for the last two sub-periods as shown in the table and this relationship is significant for the post-crisis period.

2.2 Model specification

The main focus of our research lies in the relationship between low interest rates and bank risk-taking behavior while controlling for other bank-level factors. Therefore, we start with an analysis of risk-weighted on- and off-balance-sheet items.

Banks reveal their level of aggressiveness by making profitable loans or investing in riskier portfolio assets and by taking on more contingent liabilities that are recorded as risk-adjusted on-balance-sheet and risk-adjusted off-balance-sheets items, respectively. In general, banks have more rate-sensitive assets than rate-sensitive liabilities, which will result in positive GAP.[4] When interest rates decline significantly for a long period of time, banks with positive GAP are likely to see lower net interest income, which might be one trigger for banks to engage in more fee-based activities. Therefore, we include both the growth rate of net interest income and the growth rate of non-interest income in our model as endogenous variables.

In this section, we address concerns about the presence of unit roots in the variables by conducting a Fisher-type unit root test for panel data that calculates augmented Dickey-Fuller and Phillips-Perron statistics. Results in Panel A of Table 3 for the null hypothesis that a unit root is present in all panel data is rejected, except for the 10-year T-Bond rate. This result is not surprising as Panel B of Fig. 1 may indicate multiple structural breaks for the 10-year T-bond rate during the sample period. Therefore, we conduct a unit root test with multiple structural breaks developed by Clemente et al. (1998) for the 10-year T-bond rate.[5] Panel B of Table 3 indicates that the existence of a unit root in the 10-year T-bond rate series is rejected at the 10 % significant level and

[3] One anonymous reviewer noted that the correlation between interest income and non-interest income is higher than 0.9, as shown in Table 2. We acknowledge the issue and explore the relationship between contemporaneous value of one variables against a one-period lag of the other variable. The result which is not presented in Table 2 suggests a weaker correlation, close to −.35. Therefore, collinearity issue is unlikely to be significant.

[4] The difference between rate-sensitive assets and rate-sensitive liabilities.

[5] We also perform a Zivot-Andrews (1992) unit root test and the result only suggests one structural break at 2006q1, which does not fit the pattern of 10-year T-Bond rate shown in Panel B of Figure 1.

Table 2 Correlation coefficient among variables included in the GMM and Panel VAR model

2003q1-2014q3	gdpgr	tb10y	tenetintinc	nonintinc	onbalrwa	offbalrwa
gdpgr	1					
tb10y	0.261*	1				
tenetintinc	0.167*	0.040*	1			
nonintinc	0.155*	0.031*	0.940*	1		
onbalrwa	0.040*	0.113*	0.116*	0.112*	1	
offbalrwa	0.027*	0.026*	-0.008*	-0.005*	0.087*	1
Pre-2008	gdpgr	tb10y	tenetintinc	nonintinc	onbalrwa	offbalrwa
gdpgr	1					
tb10y	0.057*	1				
tenetintinc	0.032*	0.231*	1			
nonintinc	0.014*	0.221*	0.965*	1		
onbalrwa	-0.007*	0.015*	0.105*	0.102*	1	
offbalrwa	0.021*	-0.008*	0.004	0.006*	0.098*	1
Crisis Period	gdpgr	tb10y	tenetintinc	nonintinc	onbalrwa	offbalrwa
gdpgr	1					
tb10y	0.257*	1				
tenetintinc	0.262*	0.244*	1			
nonintinc	0.238*	0.206*	0.913*	1		
onbalrwa	-0.048*	0.064*	0.125*	0.123*	1	
offbalrwa	0.002	-0.002	-0.004	-0.000	0.076*	1
Post-2011	Gdpgr	tb10y	tenetintinc	nonintinc	onbalrwa	offbalrwa
gdpgr	1					
tb10y	-0.050*	1				
tenetintinc	0.545*	-0.174*	1			
nonintinc	0.518*	-0.179*	0.922*	1		
onbalrwa	0.059*	-0.031*	0.145*	0.136*	1	
offbalrwa	-0.014*	-0.002	-0.024*	-0.020*	0.058*	1

gdpgr is quarterly growth rate in GDP; tb10y is 10-year T-bond rate; tenetintinc is net interest income in log-difference form; nonintinc is non interest income in log-difference form; onbalrwa is risk-weighted on balance sheet activities in log-difference form; offbalrwa is risk-weighted off balance sheet activities in log-difference form (*indicates 5 % significance level)

that 2008q1 and 2010q4 are the two significant breaks on the 10-year T-bond rate. With this result in mind, we create two dummy variables to account for the effect of structural breaks in the interest rate data.

We employ the Arellano and Bond (1991) linear dynamic panel data model based on Generalized Method of Moment (GMM) estimation to analyze bank risk-taking behavior in response to a lower interest rate.[6] There are some benefits to use this model. First of all, this model allows us to consider relevant endogenous variables along with

[6] Arellano and Bover (1995) also discussed dynamic panel data models concerning the use of predetermined instrumental variables.

Table 3 Unit root tests

Panel A: Fisher unit root test for panel data

Variables		Augmented Dickey-Fuller	Phillips-Perron Test
tenetintinc	Level	325,000***	250,000***
	Difference	358,000***	448,000***
nonintinc	Level	250,000***	211,000***
	Difference	340,000***	437,000***
gdpgr	Level	-2.766*	
	Difference		
onbalrwa	Level	19,600***	28,000***
	Difference	112,000***	214,000***
offbalrwa	Level	28,600***	36,800***
	Difference	165,000***	310,000***
tb10y	Level	-1.003	
	Difference	-3.136*	

Panel B: Unit root test with structural breaks for 10-year T-Bond rate

$T = 37$		optimal breakpoints: 2008q1 , 2010q4		
AR(1)	du1	du2	(rho-1)	constant
Coefficients:	-1.0139	-0.9840	0.3300	4.3667
t-statistics:	-6.168***	-5.688***	-5.49*	

tenetintinc is net interest income; nonintinc is non-interest income; onbalrwa is risk-weighted on balance sheet activities; offbalrwa is risk-weighted off balance sheet activities; gdpgr is quarterly growth rate in GDP; tb10y is 10-year T-bond rate. Values in the table inciate Chi-square statistic. *,** and *** indicate significant at 10 %, 5 % and 1 % significance level, respectively

predetermined variables together. Second, we are able to alleviate the serial correlation caused by endogenous variables other than dependent variable by using those endogenous variables and their own lags as instrumental variables in the model. This model also allows us to control for the time effect. Lastly, we include two macro-level factors, the U.S. GDP growth rate and the interest rate on 10-year U.S. Treasury Bonds, to reflect the impact of the general economic conditions on bank management and performance. We also include banks' log-transformed total asset and return on assets as control variables for bank-level characteristics (Athanasoglou et al. (2008); Demirgüç-Kunt et al. (2008); Laeven and Levine (2009)).

Dynamic panel data is presented by Equation (2.1).

$$\begin{aligned}(2.1)\ \text{offbalrw}a_{i,t} &= \sum_{i=1}^{N}\sum_{p=1}^{P}\beta_{1,p}\text{offbalrw}a_{i,t-p} + \sum_{i=1}^{N}\sum_{p=0}^{P}\beta_{2,p}\text{onbalrw}a_{i,t-p} + \sum_{i=1}^{N}\sum_{p=0}^{P}\beta_{3,p}net\text{intinc}_{i,t-p} \\ &+\sum_{i=1}^{N}\sum_{p=0}^{P}\beta_{4,p}\text{nonintinc}_{i,t-p} + \sum_{p=0}^{P}\beta_{5,p}tb10y_{t-p} + \sum_{p=0}^{P}\beta_{6,p}tb10y_{t-p}\text{*post2008} + \sum_{p=0}^{P}\beta_{7,p}tb10y_{t-p}\text{*post2011} \\ &+\sum_{p=0}^{P}\beta_{8,p}\text{gdpgr}_{t-p} + \sum_{p=0}^{P}\beta_{9,p}\text{gdpgr}_{t-p}\text{*post2008} + \sum_{p=0}^{P}\beta_{10,p}\text{gdpgr}_{t-p}\text{*post2011} + \beta_{11}size_{i,t} + \beta_{12}roa_{i,t} + \beta_{13}\text{post2008} \\ &+\beta_{14}\text{post2011} + \varepsilon_{i,t}.\end{aligned}$$

where offbalrwa is risk-weighted off-balance-sheet activities; onbalrwa is risk-weighted on-balance-sheet activities; netintinc is net interest income; nonintinc is non-interest income; tb10y is the 10-year T-bond rate; post2008 takes a value of 1 if time is 2008q2 to 2010q4, otherwise 0; post2011 takes a value of 1 if time is 2011q1 or after, otherwise 0; gdpgr is the GDP growth rate; size is the log-transformed total assets; roa is return on assets; i = 1, 2,...., N representing number of banks; p is the number of lags used for endogenous and exogenous variables, P is the maximum number of lags; and $\varepsilon_{i,t}$ is the error term.

We then run the Arellano-Bond two-step GMM estimation as shown in Equation (2.1).[7] In this dynamic model, all variables are log-transformed data except for return on assets, the dummy variable and its interaction terms with the two macro-level variables. Next, we use a Panel VAR methodology developed by Holtz-Eakin et al. (1985); Holtz-Eakin et al. 1988 and referred to HENR hereafter). The major advantage of this model is to pool cross-sectional and time series information across banks. The HENR model allows for less strict assumptions when testing hypotheses. Without requiring all dependent variables to be time stationary as a considerable amount of firm-level data are pooled together, it is still possible to use standard asymptotic distribution theory to formulate valid tests for non-stationary behavior (HENR pp3, 1988). We adopt the version of HENR model programmed by Love and Zicchino (2006) using STATA. In our model we include two macro-level variables and four bank-level variables.

In constructing the Panel VAR, the order of each endogenous variable in the model is crucial to the results when testing hypotheses. Our baseline model must put the least-endogenous variables first in the sequence of variables. We consider a model with the following order for each variable: GDP growth rate, 10-year T-Bond rate, net interest income growth rate, non-interest income growth rate, growth rate of on-balance-sheet activities, and growth rate of off-balance-sheet activities. Since our goal is to examine the response of bank risk behavior based on different asset types, we place risk-weighted on-balance-sheet and off-balance-sheet assets in the last two equations of the Panel VAR model. It is worth noting that the results do not change materially when we change the order of the variables in the Panel VAR model.

The Panel VAR model is presented in Equation (2.2).

$$(2.2) \qquad Y_t = A_t + \sum_{p=1}^{P} BY_{t-p} + \varepsilon_t$$

where A is a vector representing firm heterogeneity; Y is a vector of endogenous variables including GDP growth rate, 10-year T-bond rate, growth rate of net interest income, growth of non-interest income, growth rate of on-balance-sheet activities and growth rate of off-balance-sheet activities; Y_{t-p} is a vector of p-th lagged endogenous variables; P is the maximum number of lags used in the model, and $\varepsilon$is a vector of error terms. By fitting the data to Equation (2.2), impulse response functions (IRFs) are used to analyze the response of one variable to the shock of another variable in the model.

[7] We performed two-step GMM estimations. Two-step GMM estimation fails to reject the null hypothesis of zero serial correlation up to the fifth order, therefore up to 5 periods of lags of the dependent variable are included in the GMM model.

We then generate 95 % confidence interval boundaries associated with each impulse response function to examine the impact of a positive, one standard deviation shock of one variable to measure the dynamic response of each other variable in the system.

3 Discussion of empirical results

3.1 Arellano-bond dynamic GMM

In this section, we present the results of Equation (2.1) using Arellano-Bond dynamic GMM estimation. Three model specifications are selected and presented in Table 4. All bank-level variables are log-transformed in both models. The dependent variable is the growth rate of off-balance-sheet activities. Different from the first model, the second model includes interaction terms for two time dummy variables with the GDP growth rate and the 10-year T-bond rate, respectively. The third model is similar to Model 2 except that the variables contained in the interaction terms are demeaned.[8] We specify that all bank-level variables, the GDP growth rate and the 10-year T-bond rate are endogenous and interact with each other contemporaneously or subsequently. Three (five) lags of bank-level variables are included in the first (second and third) model(s) as the AR test associated with this model shows insignificant serial correlation after the fifth lag of the residuals. Up to 12 (24) lags of all bank-level variables and the two macroeconomic variables serve as instrumental variables for the implementation of two-step estimation. The Hansen J-statistic's p values for all three models are each greater than 0.1, indicating these models have no significant over-identification problem.[9]

All three models suggest that current off-balance-sheet activities are significantly and negatively affected by its own innovation contemporaneously and in the most recent three quarters. They also indicate that off-balance-sheet activities are significantly and negatively associated with current on-balance-sheet activities. The impact of previous changes in on-balance-sheet activities on current off-balance-sheet activities is positive and slightly significant. Model 1 shows that lags of net interest income are negatively but not significantly associated with off balance-sheet activities. However, the negative association between the two variables becomes stronger and significant after considering interaction terms and the demean effects as shown in Models 2 and 3. Surprisingly, off-balance-sheet activities appear to have a weak relationship with non-interest income contemporaneously and subsequently as shown in Model 1. After considering structural breaks and demean effects, Models 2 and 3 show that past non-interest income is positively associated with current off-balance-sheet items.

[8] We adopted an anonymous reviewer's suggestion to use the difference between individual observations from its overall average for the variables contained in the interaction terms. This allows us to isolate the impact of dummy variable (Crisis Period and Post-2011) on the key variables of 10 year Treasury rate and GDP growth rate. We thank the anonymous reviewer for this suggestion.

[9] We tried different model specifications by alternatively dropping either interest income or non-interest income as one reviewer expressed concern about a high correlation between the two variables. However, the p value of the Hansen J-statistics for these alternative models suggest dropping either variable is not appropriate. The results from these alternative model specifications are not included herein but are available upon request.

Table 4 Generalized method of moments dynamic panel model

Dep. Var: D.loffbalrwa	Model 1	Model 2	Model 3
loffbalrwa			
LD.	-0.278(−1.96)**	-0.345(−4.85)***	-0.401(−5.48)***
L2D.	-0.452(−4.11)***	-0.213(−3.59)***	-0.239(−4.07)***
L3D.	-0.162(−1.57)	-0.130(−2.2)**	-0.124(−2.06)**
L4D.	0.495(6.56)***	0.436(9.44)***	0.449(10.29)***
L5D.	0.041(4.28)***	0.044(6.74)***	0.046(7.21)***
lonbalrwa			
D1.	-1.598(−5.09)***	-1.044(−1.85)*	-1.204(−2.07)**
LD.	0.301(1.01)	0.502(1.12)	0.234(0.51)
L2D.	-0.071(−0.17)	0.942(2.78)***	0.967(2.77)***
L3D.	0.250(4.12)***	0.672(1.78)*	0.694(1.79)*
L4D.		-0.512(−1.17)	-0.102(−0.23)
L5D.		-0.011(−0.17)	0.034(0.48)
ltenetintinc			
D1.	0.035(0.3)	0.057(0.33)	0.176(0.97)
LD.	0.023(0.29)	-0.152(−1.36)	-0.143(−1.27)
L2D.	-0.086(−1.18)	-0.190(−1.64)*	-0.245(−2.09)**
L3D.	-0.027(−0.56)	0.028(0.27)	0.006(0.05)
L4D.		-0.215(−1.41)	-0.328(−2.08)**
L5D.		-0.067(−1.52)	-0.102(−2.39)**
lnonintinc			
D1.	-0.046(−0.41)	0.029(0.3)	0.033(0.35)
LD.	-0.042(−0.64)	0.139(1.6)	0.159(1.73)*
L2D.	0.067(1.14)	0.117(1.32)	0.163(1.76)*
L3D.	0.005(0.42)	-0.095(−1.84)*	-0.082(−1.58)
L4D.		0.065(0.95)	0.045(0.68)
L5D.		0.005(0.57)	0.004(0.44)
tb10y	-0.006(−0.59)	0.062(1.87)*	0.081(2.46)**
tb10y*post2008		-0.118(−1.51)	-0.311(−3.01)***
tb10y*post2011		-0.060(−1.53)	-0.080(−2.04)**
L1.tb10y	-0.032(−3.93)***	-0.045(−1.55)	-0.058(−1.99)**
L1.tb10y*post2008		0.010(0.13)	-0.010(−0.23)
L1.tb10y*post2011		0.064(1.83)*	0.073(2.09)**
L2.tb10y	-0.024(−2.08)**	0.017(0.75)	0.021(0.92)
L2.tb10y*post2008		-0.062(−0.46)	-0.143(−1.91)*
L2.tb10y*post2011		-0.030(−1.08)	-0.033(−1.16)
L3.tb10y	-0.045(−4.12)***	0.004(0.16)	0.0003(0.01)
L3.tb10y*post2008		-0.035(−0.1)	0.278(2.55)**
L3.tb10y*post2011		0.041(1.71)*	0.038(1.6)
L4tb10y	-0.006(−0.91)	0.030(0.84)	0.038(1.08)

Table 4 (continued)

Dep. Var: D.loffbalrwa	Model 1	Model 2	Model 3
L4.tb10y*post2008		-0.075(−0.25)	0.200(1.88)*
L4.tb10y*post2011		-0.030(−0.82)	-0.031(−0.87)
gdpgr	0.018(3.42)***	0.009(1.15)	0.006(0.75)
gdpgr*post2008		0.013(0.14)	-0.026(−1.15)
gdpgr*post2011		-0.009(−0.79)	-0.007(−0.58)
L1.gdpgr	0.023(3.2)***	0.033(1.93)*	0.029(1.67)*
L1.gdpgr*post2008		-0.021(−0.78)	0.039(1.59)
L1.gdpgr*post2011		-0.028(−1.29)	-0.029(−1.27)
L2.gdpr	0.004(0.62)	0.069(1.85)*	0.076(2.06)**
L2.gdpgr*post2008		-0.045(−1.09)	-0.015(−0.72)
L2.gdpgr*post2011		-0.074(−1.94)*	-0.086(−2.25)**
L3.gdpgr	0.020(2.36)**	0.059(1.78)*	0.066(2)**
L3.gdpgr*post2008		-0.047(−0.74)	-0.062(−2.28)**
L3.gdpgr*post2011		-0.051(−1.48)	-0.063(−1.83)*
L4.gdpgr	0.014(3.08)***	0.049(2.49)**	0.057(2.93)***
L4.gdpgr*post2008		-0.019(−0.11)	-0.130(−2.19)**
L4.gdpgr*post2011		-0.033(−1.64)*	-0.044(−2.19)**
ltotalassets	-0.219(−3.22)***	-0.148(−2.36)**	-0.135(−2.08)**
roa	-0.0256(−1.23)	-0.006(−0.37)	-0.008(−0.45)
post2008	-0.115(−3.52)***	-0.09(−0.89)	-0.362(−2.62)***
post2011	-0.076(−2.11)**	-0.017(−0.69)	-0.023(−0.95)
p value for Hansen J statistics	0.365	0.485	0.168
autocorrelation	AR(6)	AR(6)	AR(6)
Wald statistic	659.64	723.61	744.95

The dependent variable, loffbalrwa, is risk-weighted off-balace-sheet activities. Risk-weighted on-balance-sheet activities (lonbalrwa), net interest income (tenetintinc) and non-interest income (nonintinc) are other endogenous variables in the right-hand side of the model; gdpgr is the growth rate in GDP; tb10y is 10-year T-bond rate. (All the variables mentioned above are transformed by logarithm); ltotalassets is log of total assets. Roa is return on assets. post2008 is a dummy variable, the value takes one if date is between 2008q2 and 2010q4. post2011 is a dummy variable, the value take on eif date is 2011q1 or after. (*,*** and *** indicate significant in 10 %, 5 % and 1 % significance level). Model 1 is the baseline mode without any interaction terms. Model 2 uses T-bond rate and GDP growth rate in the interaction terms. Model 3 uses demeaned T-bond rate and GDP growth rate in the interaction terms. *P* value indicates the result of Hansen's J-statistic test for over-identification. Autocorrelation test indicates no serial correlation prior to the 6th lag of endogenous variables in the models. Wald statistic denotes the goodness of fit of the regressions

Taken as a whole, these results indicate that higher on-balance-sheet activities and higher income statement items in the past quarters trigger banks to engage in more off-balance-sheet business, whereas higher off-balance-sheet activities in the previous quarters put a brake on bank acquisition of off-balance-sheet assets. These results show that banks try to strike a balance between revenue creation and risk control. All three models indicate that a lower current return on assets has no impact on off-balance-sheet activities as is presented in Table 4. Surprisingly, the negative and significant

coefficient for the size effect as measured by total assets indicates that the rate at which larger banks grow their off-balance-sheet activities is not as high as those smaller banks over the period from 2003 to 14.

We then turn to the relationship between off-balance-sheet activities and the macro-level variables. Model 1 does not include interaction terms, while Models 2 and 3 separates the entire sample into (pre-crisis) stable and high interest rate, (crisis) declining interest rate, and (post-crisis) stable and low interest rate time periods. In the models, we use 2008q1 and 2010q4 as two break points. This results from a Clemente et al. (1998) test for structural breaks. Model 1 presents an insignificant and negative contemporary relationship between the 10-year T-bond rate and off-balance-sheet activities while the first three lags of the T-bond rate are negatively related to off-balance-sheet activities and this negative association fades away after the third lag. This finding supports the hypothesis that banks grow off-balance-sheet activities in periods when interest rates are relatively lower.

Models 2 considers interaction terms between non-demeaned macro-level factors and the two dummy variables. The association between off-balance-sheet activities and the rest of the bank-level variables do not change materially even after time-dummies and their interaction terms with macroeconomic variables are added to the model.[10] As for the relationship between off-balance-sheet activities and the 10-year T-bond rate, the empirical results show that off-balance-sheet activities respond positively and contemporaneously to a falling interest rate before 2008. After 2008q2, off-balance-sheet activities decrease but not significantly along with a declining interest rate. When using demeaned macro-variable in the interaction terms, Model 3 shows a much stronger and significant association between off-balance-sheet item and the interest rate, suggesting that banks aggressively engage in off-balance-sheet activities during and beyond the period of financial crisis.

We then ask whether banks are likely to respond to interest rate changes subsequently. To answer this question, we examine the relationship between current off-balance-sheet activities and lagged T-bond rate for the three periods. Model 2 shows current off-balance-sheet items is not significantly impacted by lagged T-bond rate for all periods except the first and third lags during post-2011 era. Model 3 reinforces the results of Model 2 with even stronger significance for the impact of the lagged T-bond rate on current off-balance-sheet items during all three periods. In summary, Model 3 presents a "negative and then positive" dynamic relationship between current off-balance-sheet activities and lagged T-bond rate for the periods of the financial crisis and post-2011 except this "negative and then positive" pattern continues much longer for the financial crisis period.

As the findings of GMM models suggests a significant impact of a one period lag change in the interest rate on the contemporaneous movement of the off-balance-sheet variable, it is now appropriate to examine how an interest rate shock affects bank risk-

[10] We also included an interaction term of lagged off-balance-sheet item and time dummy variables, as one reviewer's suggestion based on Balli and Sorensen (2013) that we should consider the impact of regulatory change during the financial crisis period on some off-balance-sheet activities. The results of these additions are not materially different from those presented in Table 4.

taking behavior over time. In the next section, we focus on the impact of a one standard deviation shock to the 10-year T-bond rate on the bank-level variables included in the GMM model above.

3.2 Panel VAR model

In this section, we present the empirical results of equation (2.2) built on the framework developed by Love and Zicchino (2006). The main interest of our framework is to examine how a shock to the interest rate affects bank-level variables. Our Panel VAR model allows all variables in the system to interact with each other. We start out with our baseline VAR model by placing the variables in the following order: GDP growth rate, 10-year T-bond rate, net interest income, non-interest income, on-balance-sheet activities, and off-balance-sheet activities.[11] This ordering is in line with the principle of constructing a VAR model by the degree of endogeneity of each variable, in order of least to most.

We run Equation (2.2) for the entire time period as well as for the three sub-periods separated by the time points of 2008q1 and 2010q4.[12] Most of the coefficients are significant. We pay particular attention to the association between off-balance-sheet activities and the 10-year T-bond rate. The overall results are consistent with Equation (2.1) in many ways. First, off-balance-sheet activities positively associate with lagged GDP growth rate for all periods, indicating that strong economic growth triggers banks to take on more risky assets regardless of the time period analyzed. Second, off-balance-sheet activities are positively related to lagged on-balance-sheet activities for all periods. Off-balance-sheet activities are not strongly related to lagged non-interest income and lagged net interest income throughout the whole time period.

Since the main interest of this Panel VAR model is to analyze how the shock to the interest rate transmits throughout the whole system and how it affects off-balance-sheet activities, we analyze the impulse response functions up to fifth period among six variables. Figure 2 presents the graphs of impulse response functions for the response of on-balance-sheet activities to the shock of the 10-year T-bond rate as well as for off-balance-sheet activities.

Panel A.1 of Fig. 2 shows that a shock to the 10-year T-bond rate has a contemporaneous and negative effect to off-balance-sheet activities prior to 2008q1, however, the impact turns and remains positive for over 24 periods. Next, Panel A.2 of Fig. 2 shows a positive but not significant response to the shock occurred in the contemporaneous period and turns negative in the following period and then dies out for the rest of the periods, indicating that an interest rate shock was likely to have temporary and negative impact on off-balance-sheet activities during the Crisis Period. Panel A.3 displays a similar pattern as Panel A.2 except that there is positive and significant effect in the initial period and the impact turns negative in Period 2 then changes to positive value and stays in the positive territory over 24 periods. Panel A.4 presents a positive response of off-balance-sheet activities to the interest rate shock for the entire sample

[11] We change the order of the variables included in the system and find the results do not change materially. Results are available upon request.

[12] Due to space limitations, we do not include the results of the 6-variable Panel VAR model and impulse response functions. Regression results are available upon request.

Fig. 2 Impulse response functions for the 6-variable Panel VAR model. Panel VAR model using Love's structural VAR model. This model contains six variables. The first two variables are macroeconomic variables including GDP growth rate and 10-year T-bond rate. The last four are bank-level variables including net interest income, non-interest income, on-balance-sheet items and off-balance-sheet items. We run the model for the entire sample and then break down the time period into three sub-periods according to Clemente et al. (1998) unit root test with two structural breaks. The first break point is 2008q1 and the second one is 2010q4. We then focus on the response of off-balance-sheet activities and on-balance-sheet activities to the shock of 10-year T-bond rate. The confidence bands of the impulse response functions are formed at 95 % confidence level. (The results do not change fundamentally when we change the order of variables in the model). Panel A: Response of off-balance-sheet activities to the shock of 10-year T-bond rate during different time period. Panel B: Response of on-balance-sheet activities to the shock of 10-year T-bond rate during different time period. Panel C: Response of off-balance-sheet activities to the shock of 10-year T-bond rate prior to 2008q1 for different group size. Panel D: Response of off-balance-sheet activities to the shock of 10-year T-bond rate between 2008q2 and 2010q4 in different group size. Panel E: Response of off-balance-sheet activities to the shock of 10-year T-bond rate after 2011q4 in different group size.

period that is similar to that of Panels A.2 and A.3, suggesting the impact from Crisis Period and Post-2011 is dominant over the entire period.

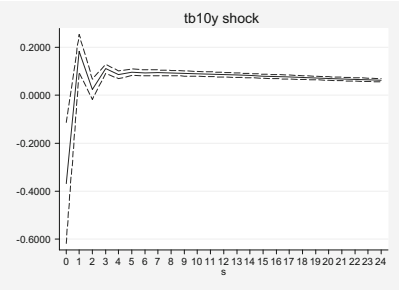
We also examine whether bank size matters with respect to a change in bank risk. In general, we find that patterns for Groups 1 and 2 are similar in that their off-balance-sheet activities respond positively to an interest rate shock, whereas the response for Groups 3 and 4 are negative but not significant throughout the entire time period.

Because of these inconsistent results,[13] we break down the groups based on bank size and time horizon. Panel C of Fig. 2 displays impulse response functions of all groups for the time period prior to 2008q2. Group 1 as shown in Panel C.1 had a negative response of off-balance-sheet activities to a one standard deviation interest rate shock, however, the impact quickly turns positive in the second period and remains positive afterwards. Although Group 2 shown in Panel C.2 did not have a significant response to the interest rate shock in the first place, the response becomes positive and long-lasting. Off-balance-sheet activities of Group 3, shown in Panel C.3, responds negatively to the interest rate shock contemporaneously but the impact approaches zero afterwards. Panel C.4 indicates that the interest rate shock did not affect mega-banks' off-balance-sheet activities before the Financial Crisis of 2008.

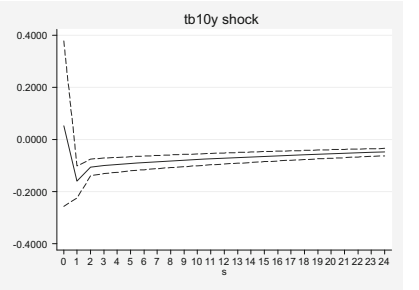
Panel D presents the impulse response functions of off-balance-sheet activities to an interest rate shock for all groups between 2008q2 and 2010q4. This time period was the darkest period of recent financial industry history as numerous financial scandals started to unfold and several Too-Big-To-Fail financial institutions desperately required government bailouts. At the same time, developed countries experienced one of the worst recessions since WWII. The list of bank bankruptcies continued to grow and news reports of bank earnings falling short of expectations were constant. Return on Assets as shown in Panel E of Fig. 1 also shows banks of all size experienced negative returns during this period. The Federal Reserve Bank's FOMC, taking into account of all measures, decided to use unusual financial facilities to bring down both long-term and short-term interest rates to a very low level. With this history in mind, we find that Panel D of Fig. 2 describes a very interesting picture for banks of different size during

[13] Those results are not presented here but are available upon request.

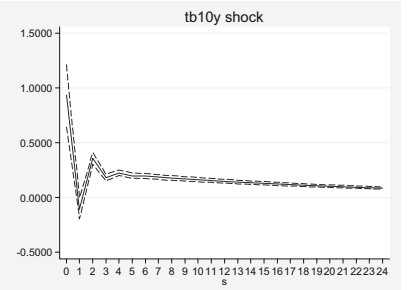
(A.1) Pre-2008: 2003q1-2008q1



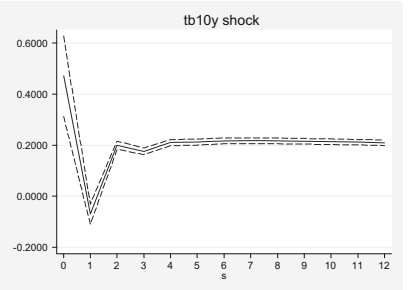
(A.2) Crisis Period: 2008q2-2010q4



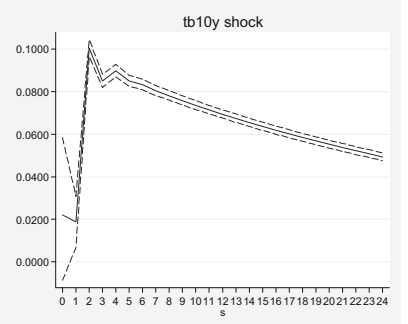
(A.3) Post-2011: 2011q1-2014q3



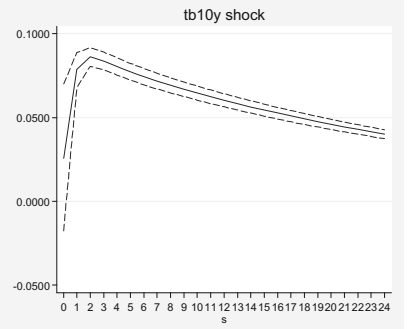
(A.4) Entire time period



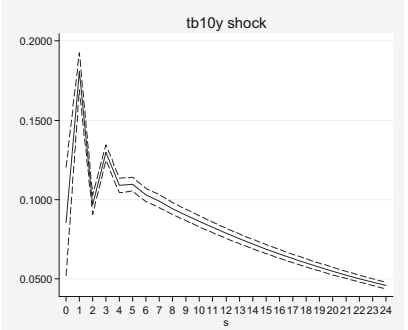
(B.1) Pre-2008: 2003q1-2008q1



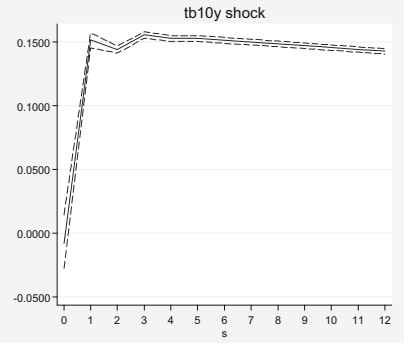
(B.2) Crisis Period: 2008q2-2010q4



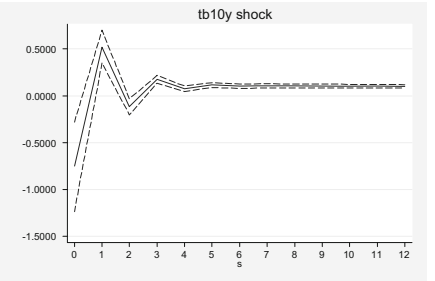
(B.3) Post-2011: 2011q1-2014q3



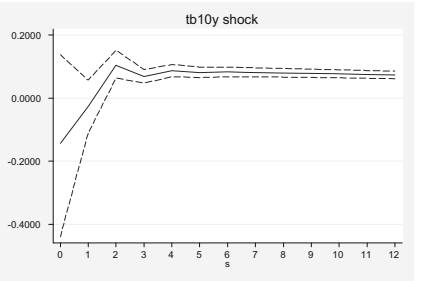
(B.4) Entire sample period



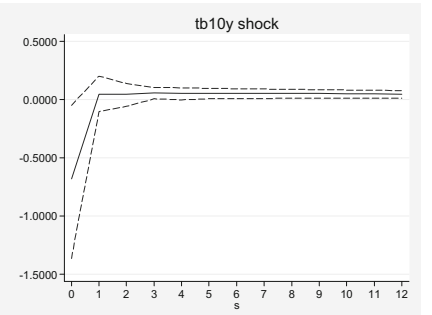
(C.1) Group 1: less than $100 million



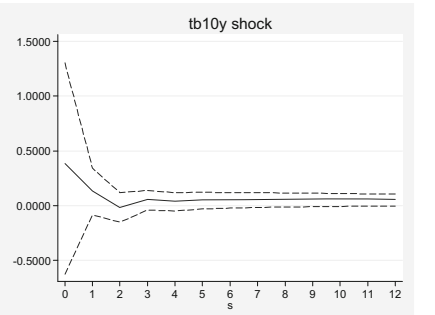
(C.2) Group 2: between $100 million and $1 billion



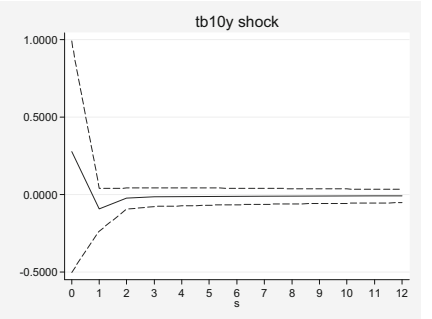
(C.3) Group 3: between $1 billion and $10 billion



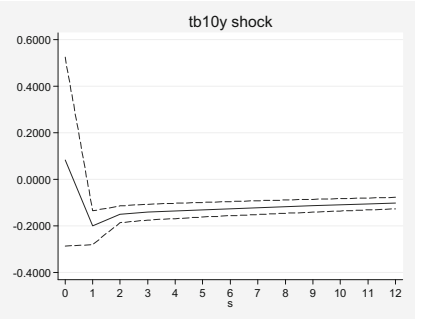
(C.4) Group 4: above $10 billion



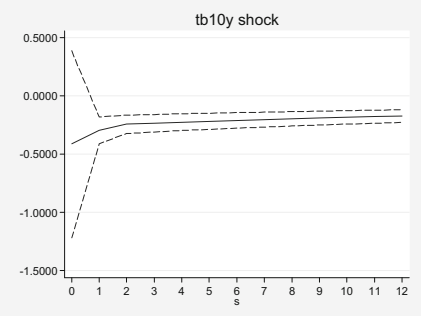
(D.1) Group 1: less than $100 million



(D.2) Group 2: between $100 million and $1 billion



(D.3) Group 3: between $1 billion and $10 billion



(D.4) Group 4: above $10 billion

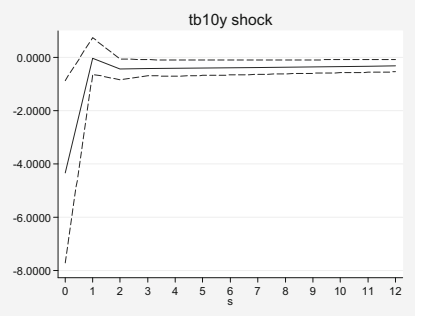
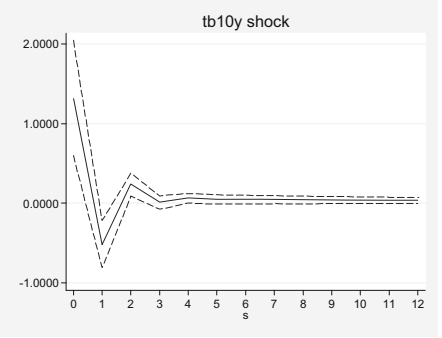
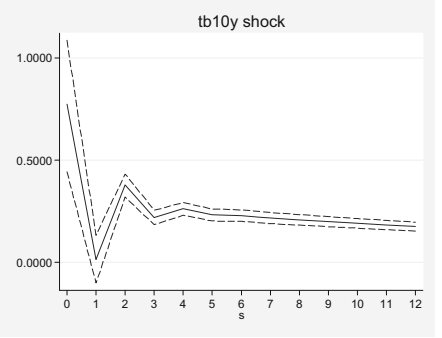


Fig. 2 (continued)

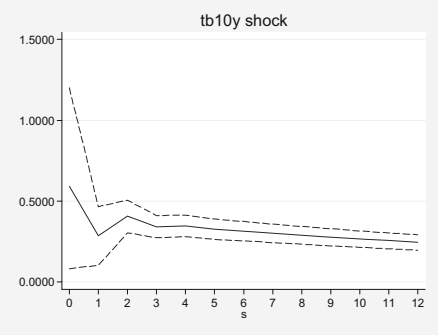
(E.1) Group 1: less than $100 million



(E.2) Group 2: between $100 million and $1 billion



(E.3) Group 3: between $1 billion and $10 billion



(E.4) Group 4: above $10 billion

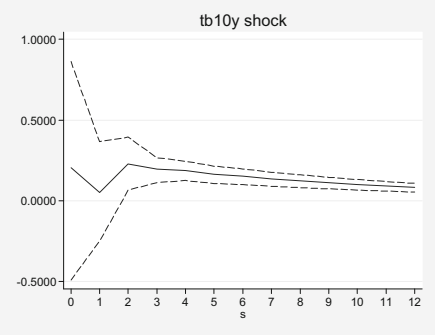


Fig. 2 (continued)

this period of time. Panels D.1 and D.2 suggest that Groups 1 and 2 had similar positive but insignificant responses to a falling interest rate contemporaneously but the impact of the shock has different results in the two groups after the initial period. Banks in Group 2 increased their risky off-balance-sheet assets in the subsequent periods in response to a declining interest rate. Banks in Group 3 show a negative but insignificant response to the lower interest rate in the initial period, however the response is similar to that of Group 2 as shown in Panel D.3. Panel D.4 shows that the response of the largest banks in Group 4 is negative contemporaneously but then stays close to zero after the initial period. In summary, the larger banks, excluding Group 1, respond negatively to a falling interest rate and the negative response remained persistent and significant after the first period.

Finally, we present the impulse response functions for off-balance-sheet activities to a one standard deviation interest rate shock for all groups for the period after 2010q4 in Panel E. We find that the patterns of responses are very similar to those of the pre-2008 period in the subsequent periods except that the impact stays above zero in the later periods. The impact is positive and long-lasting except for smallest banks. In conclusion, the Panel VAR model suggests that the impact of an interest rate shock on off-

balance-sheet activities is positive prior to 2008 and post 2011 but negative for the period between 2008 and 2011.

We next turn our attention to the impact of interest rate shock on-balance-sheet activities. Panel B displays a positive impulse response functions for on-balance-sheet activities to a one standard deviation interest rate shock throughout the entire period and all three sub-periods. Comparing Panel B with Panel A, we find that the response of on-balance-sheet activities to an interest rate shock is notably different from that of off-balance-sheet activities over the same time horizon, indicating that a change in interest rates has different policy implications for both on-balance-sheet and off-balance-sheet transactions. When the interest rate level is relatively higher, banks tend to pursue more on-balance-sheet activities and couple that with gradual growth in off-balance-sheet business. On the other hand when the interest rate falls continuously leading to an era of low interest rates and slow economic growth, banks slowly realize that on-balance-sheet activities become less profitable and take on more off-balance-sheet business that generates fee-based revenues.

4 Conclusions

This paper investigates whether bank risk-taking behavior changes during a period of falling interest rates and weak economic conditions. Using both on-balance-sheet activities and off-balance-sheet activities as measures for bank risk, we hypothesize that banks are likely to engage in more risky off-balance-sheet activities, i.e. fee-based business, when on-balance-sheet assets, i.e. interest-bearing accounts, become less profitable due to lower interest rates. We employed a dynamic GMM model for panel data and a Panel VAR model to test these hypotheses.

The results of a dynamic GMM model for panel data indicate that off-balance-sheet activities after 2008q1 are negatively related to contemporaneous and one-lag interest rates while controlling for the GDP growth rate, other bank level variables, two dummy variables and interaction terms of dummy variables with the 10-year T-bond rate and GDP growth rate, respectively. These results support our hypothesis that banks might increase the amount of higher risk assets in the subsequent quarter in anticipation of higher expected return associated with them during the low interest rate era. Although different dependent variables are used as a proxy for risk taking behavior in Delis and Kouretas (2011), their results indicate that lower interest rates (short term/bank lending rates) lead to higher ratio of risky assets relative to total bank asset holdings. Our empirical results also suggest the same conclusion using a more extended time period that includes a time of financial crisis in the history of banking and its aftermath.

To examine how an interest rate shock affects bank risk, we conduct a parsimonious Panel VAR analysis including the GDP growth rate, the 10-year T-bond rate, and four bank-level variables. Our empirical results indicate that an interest rate shock to the Panel VAR system causes off-balance-sheet activities of larger banks to decrease contemporaneously and then increase subsequently for the period of 2008 through 2010. However, no such pattern is observed for smaller banks during the same period. This is an interesting finding and future research should explore factors that determine risk-taking behavior for banks of different size during such exceptionally difficult economic conditions.

Our research sheds light on banking regulations regarding bank risk management during a time of financial turmoil. The possibility that larger banks tend to invest in riskier off-balance sheet assets to boost earnings should alarm lawmakers as Too-Big-To-Fail banks could undermine economic welfare if they are not able to remain financially and managerially sound. Therefore, an implication for policy makers is the need to impose a more restrictive capital ratio on larger bank. On the other hand, smaller banks do not engage in more off-balance-sheet activities during a period of stable low interest rates. Therefore imposing a higher capital ratio standard on smaller banks might have a detrimental effect on profitability and sustainability without corresponding benefits in reducing bank risk.

References

Allen L, Jagtiani J (2000) The risk effects of combining banking, securities and insurance activities. J Econ Bus 52:485–497

Arellano M, Bond S (1991) Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. Rev Econ Stud 58:277–297

Arellano M, Bover O (1995) Another look at the instrumental-variable estimation of error-components models. J Econ 68:29–52

Athanasoglou PP, Brissimis SN, Delis MD (2008) Bank-specific, industry-specific and macroeconomic determinants of bank profitability. J Int Financ Mark Inst Money 18(2):121–136

Balli HO, Sorensen BE (2013) Interaction effects in econometrics. Empir Econ 45(1):583–503

Blundell R, Bond S (1998) Initial conditions and moment restrictions in dynamic panel data models. J Econ 87(1):115–143

Calmés C, Théoret R (2010) The impact of off-balance-sheet activities on banks returns: an application to the ARCH-M to Canadian data. J Bank Financ 34(7):1719–1728

Chari V. V., Christiano, L., and Kehoe, P. J. (2008) Facts and myths about the financial crisis of 2008. Federal Reserve Bank Minneapolis Working Paper.

Clemente J, Montañés A, Reyes M (1998) Testing for a unit root variables with a double change in the mean. Econ Lett 59(2):175–182

Delis MD, Kouretas GP (2011) Interest rates and bank risk taking. J Bank Financ 35(4):840–855

Demirgüç-Kunt A, Detragiache E, Tressel T (2008) Banking on the principles: compliance with Basel core principles and banks soundness. J Financ Intermed 17(4):511–542

DeYoung R, Torna G (2013) Nontraditional banking activities and bank failures during the financial crisis. J Financ Intermed 22(3):397–421

Duchin R, Sosyura D (2014) Safer ratios, riskier portfolios: Banks' response to government aid. J Financ Econ 113(1):1–28

Fahlenbrach R, Prilmeier R, Stulz RM (2012) This time is still the same: using bank performance in 1998 to explain bank performance during the recent financial crisis. J Financ 67(6):2139–2195

Holtz-Eakin D, Newey W, Rosen HS (1989) Implementing causality tests with panel data, with an example from local public finance. NBER Technical Working Paper No. 48.

Holtz-Eakin D, Newey W, Rosen HS (1988) Estimating vector autoregressions with panel data. Econometrica 56(6):1371–1395

Ivashina V, Scharfstein D (2010) Bank lending during the financial crisis of 2008. J Financ Econ 97(3):319–338

Laeven L, Levine R (2009) Bank governance, regulation and risk taking. J Financ Econ 93(2):259–275

Love I, Zicchino L (2006) Financial development and dynamic investment behavior: evidence from panel VAR. the quarterly review of economic and. Finance 46(2):190–210

Papanikolaou N, Wolff CCP (2014) The role of on-and off-balance-sheet leverage of banks in the late 2000s crisis. J Financ Stab 14:3–22

Stiroh KJ (2006a) New evidence on the determinants of bank risk. J Financ Serv Res 30:237–263

Stiroh KJ (2006b) A portfolio view of banking with interest and non-interest activities. J Money Credit Bank 38(5):1351–1361

Stiroh KJ, Rumble A (2006) The dark side of diversification: the case of U.S. financial holding companies. J Bank Financ 30:2130–2161

Ziadeh-Mikati, N. (2012) Bank risk exposure, bank failure and off-balance-sheet Activities: An Empirical Analysis For U.S. Commercial Banks. SSRN Working Paper, Downloaded March 13, 2013.

Zivot E, Andrews DWK (1992) Further evidence on the great crash, the oil price shock and the unit root hypothesis. J Bus Econ Stat 10(3):251–270