Shadow Banking and Systemic Bailout Exposure*

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February 27, 2018

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Abstract

We study the impact of systemic bailout expectations on bank credit growth patterns. Using daily put options data of U.S. bank holding companies, we measure each bank holding company's exposure to the systemic bailout factor, which is the sensitivity of each bank's out-of-the-money put option price to the variations of sector-wide put option basket-index spreads. We show that low market expectations of the banking sector systemic bailouts played a significant role in the weak bank credit recovery after the subprime crisis. Bank holding companies with higher pre-crisis exposure to the systemic bailout factor experienced larger post-crisis deviations from the pre-crisis bank credit growth trend. Perhaps surprisingly, such pattern is persistent even for banks that are less affected by the post-crisis financial regulations and less exposed to borrowers from the deteriorating sectors. Furthermore, we drill down to the commercial bank subsidiary level data while controlling for parent bank holding company fixed effects. This analysis reveals that commercial bank subsidiaries within the same bank holding company present same credit growth patterns even though they have different exposure to financial regulations and deteriorating sectors. To rationalize the empirical findings, we propose a model with both commercial banks and shadow banks. The securitization market, which connects the two types of banks, determines how market expectations of systemic bailouts to shadow banks affect the credit origination capacity of the whole banking system.

*I am deeply indebted to Aaron Tornell and Roger Farmer for their invaluable guidance and unwavering supports. I am thankful to Andy Atkeson, Saki Bigio, Francois Geerolf, Gary Hansen, Zhipeng Liao, Paulo Medas, Lee Ohanian, Tigran Poghosyan, Pierre-Olivier Weill, and participants at UCLA Macroeconomics Proseminar, UCLA International Proseminar, IFABS Asia Meeting for insightful discussions. All remaining errors are mine. **Keywords:** Shadow banking; Systemic bailouts; Systemic risk; Securitization market; Risk retention; Catastrophe bonds; Financial regulations; Long-run credit growth; Local projection. **JEL Classification Numbers:** G01, G18, G21, G23, G28

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1 Introduction

The modern banking system in the United States is an aggregate of commercial banks and shadow banks. Unlike the regulated and explicitly guaranteed commercial banking sector, the shadow banking sector is subject to less regulations and exposed to the risk of lacking enough government guarantees[1]. In this complex system, commercial banks are closely linked to shadow banks via the securitization market, where some of the mortgages on commercial banks' balance sheets are sold to shadow banks[2]. Since the bailout guarantees to shadow banks are implicit and systemic, creditors' expectations of sector-wide systemic bailouts have an impact on shadow banks' borrowing constraint. Such impact may indirectly affect the lending capacity of commercial banks through the securitization market.

In this paper, we investigate if the decline in market expectations of the banking sector systemic bailouts played a significant role in the slow bank credit recovery after the subprime crisis. More specifically, we use micro-level data to empirically examine the relation between market expectations of systemic bailouts and bank credit growth patterns. Our main hypothesis argues that bank holding companies with higher exposure to the systemic bailout factor experienced greater credit loss from the pre-crisis trend during recovery periods. In addition, we test if the main hypothesis is driven by post-crisis financial regulations or weak credit demand from borrowers. The empirical findings that we have obtained are rationalized by a structural model that features many characteristics of the modern banking system.

Our empirical analysis is based on a new measurement of each bank holding company's exposure to the systemic bailout factor. We define such factor as market expectations of systemic bailouts to the shadow banking sector[3]. To measure how likely the market believes bailout guarantees will be granted in case of a systemic default, we follow Kelly, Lustig, and Van Nieuwerburgh (2016) and compute the difference in costs of Out-of-The-Money (OTM) put options for the banking sector

[1] We define commercial banks as depository institutions that have access to the federal deposit insurance or can borrow from the Federal Reserve at the Discount Window. The commercial banks are unregulated nonbank financial institutions that also provide financial intermediations but are exposed to implicit government guarantees. Examples of shadow banks are security broker-dealers, insurance companies, money market funds, etc.

[2] Poszar et al. (2010) outlines a very detailed framework of the shadow banking system in the United States where securitization activities link all the components.

[3] One should note that a greater amount of systemic bailout guarantees amid the U.S. subprime crisis are towards the shadow banking sector or the shadow banking subsidiaries of bank holding companies. For instance, the Trouble Asset Relief Program (TARP) provided by the Treasury targets bank holding companies that suffered from losses due to asset-backed securities. The Term Asset-Backed Securities Loan Facility (TALF) launched by the Fed purchased asset-backed securities directly from the market for providing liquidity to the distressed shadow banking sector.

index KBE[4] and its corresponding basket. Since put options act as "crash insurance" for the underlying assets, the price difference between put options that insure the banking sector index and the counterparts that insure a basket of individual banks calibrates the systemic bailout effect that is priced in the former but not in the latter. Thus, such basket-index spread is larger when the market believes systemic bailouts to the whole sector is more likely than individual bailouts. Each bank's exposure to the systemic bailout factor is hereby computed as the sensitivity of their own put option prices to the variations of the aggregate level put option basket-index spreads around announcement dates related with systemic bailouts.

To empirically test if the decline in market expectations of systemic bailouts is an important reason for the weak post-crisis credit recovery, we outline one main hypothesis as well as two alternative hypotheses. First, shadow bank creditors' expectations of systemic bailouts are closely related to borrowing constraints of shadow banks and the liquidity in the securitization market. In turn, such effect would transmit to the lending capacity of commercial banks via the securitization market. In this sense, the market itself disciplines the risk-taking of shadow banks. Bank holding companies that were more exposed to the systemic bailout factor during the crisis onset would be more adversely affected during recovery periods, especially when the market expects no more systemic bailouts. We name this explanation as the *systemic bailout expectations* hypothesis.

Second, bank holding companies that were more exposed to the systemic bailout factor could be the ones that are more likely to be regulated by the post-crisis financial regulations. Higher likelihood of being guaranteed by the federal government incentivizes more risk-taking in the securitization market and more holdings of toxic asset-backed securities. However, the post-crisis financial regulations such as the Dodd-Frank Wall Street Reform and Consumer Protection Act requires higher risk retention when securitizing balance sheet assets and higher capital buffer when holding risky structured financial assets. These new regulations would substantially prevent banks from extending new credit during recovery periods. Therefore, the effect in the main hypothesis might have been endogenously driven by financial regulations other than the market itself. In other words, there could be an alternative hypothesis for slow credit growth after the crisis, which is the *financial regulations* hypothesis.

Third, weak demand for bank credit from the real sector may have been responsible for the slow post-crisis credit recovery. During the crisis run-up, banks might have lowered lending standards

[4]Kelly, Lustig, and Van Nieuwerburgh (2016) use financial sector index XLF. Instead, we apply their approach to KBE, the banking sector index, to only concentrate on systemic bailout expectations within the banking sector.

when issuing credit. However, the credit demand by distressed borrowers or borrowers from a distressed sector could be persistently weak during recovery periods. To make it worse, it could be costly for banks to extend credit to new borrowers with higher credit demand. Hence, the channel associated with factors from the credit demand side is classified as the *credit demand* hypothesis.

The empirical tests with bank holding company level data and the local projections approach *a la* Jordà (2005) favor the main hypothesis (*systemic bailout expectations* hypothesis). First, the group of bank holding companies with higher exposure to the systemic bailout factor experienced significantly larger post-crisis credit loss from the pre-crisis growth trend. In fact, our tests further reveal that the credit growth path of low exposure banks reverts to the pre-crisis trend 5 years after the crisis onset. However, such reversion to the pre-crisis trend does not appear for the high exposure banks. Second, the significant credit loss from the pre-crisis trend still exists for banks that are supposed to be less adversely affected by the post-crisis financial regulations (i.e. lower exposure to the securitization market and lower holdings of structured financial products) but more exposed to the systemic bailout factor. This finding is inconsistent with the *financial regulations* hypothesis, which claims that financial regulations are the main reason for the slow credit recovery. Third, linking each bank to its borrowers composition through loan level data *DealScan*, we find the main hypothesis is still valid for banks with less pre-crisis lending to non-tradable sectors such as constructions and financial services [5]. In this regard, the *credit demand* hypothesis could not be a leading explanation for slow post-crisis credit recovery as well.

Furthermore, we drill down to the commercial bank subsidiary level data via the U.S. Call Report and merge it with the parent bank holding company balance sheets. The commercial bank level data allows us to compare credit growth patterns across different commercial bank subsidiaries within the same bank holding company (i.e. same exposure to the systemic bailout factor). The analysis reveals that there is no significant difference in credit growth patterns within the same bank holding company, even though commercial bank subsidiaries may be affected differently by financial regulations and deteriorating credit demand. This result provide another evidence for the *systemic bailout expectations* hypothesis. In addition, we explore whether the impact on parent bank holding company credit growth is through less credit originations by each commercial bank subsidiary (intensive margin) or less commercial bank subsidiaries survival during the crisis aftermath

[5] The non-tradable sectors experienced more significant boom and bust cycles around financial crises (Ranciere and Tornell, 2016). Borrowers from non-tradable sectors are considered in this paper as the ones that have weaker credit demand during the aftermath of crises.

(extensive margin). Our merged data favors the former, which shows that lenders have become more cautious after the subprime crisis when facing very low market expectations of systemic bailouts.

We rationalize the empirical findings with a structural model of the modern banking system. In the model, traditional commercial banks are subject to the capital requirement so that they securitize and move on-balance-sheet mortgages to off-balance-sheet (or shadow bankers). Shadow banks purchase mortgages from the securitization market by issuing a menu of safe (non-defaultable) and risky (defaultable or put-option-like) bonds[6]. In contrast to commercial banks, shadow banks can trade mortgages among themselves such that they can diversify idiosyncratic risks and expose themselves to systemic risk. For shadow banks that issue safe bonds, mortgage diversification guarantees a safe return to repay creditors even in the worse realization of their portfolio. However, for shadow banks that issue risky bonds, mortgage diversification allows all of them to be exposed to enough systemic risk such that systemic bailouts could be granted in a bad state. With this model set-up, creditors' expectations of systemic bailouts are important because they determine shadow banks' borrowing constraint when issuing risky bonds.

The equilibrium growth path follows the boom-bust cycle model *a la* Schneider and Tornell (2004) and Ranciere and Tornell (2016), where creditors simultaneously fund the same type of shadow bank bonds and their expectations of systemic bailouts to shadow banks may endogenously determine the total bank credit growth rate. Intuitively, higher expectations of systemic bailouts relax shadow banks' borrowing constraint when issuing risky bonds. With more liquidity in the securitization market, mortgages are securitized and transferred with higher market value and it could in turn relax commercial banks' borrowing constraints. Eventually, the lending capacity of the banking sector is increased. The second implication of the model is on the comparison between different types of risky bonds. Since the put-option-like securities feature higher leverage, the growth enhancing effect due to higher market expectations of systemic bailouts is larger if the shadow banking sector issues put-option-like securities. Finally, the last implication is focused on the case where shadow bank creditors expect low likelihood of systemic bailouts. With a decline in systemic bailout expectations, the banking system that is funded by risky shadow bank bonds would be more disciplined by the market and experience larger credit loss.

[6]Safe shadow bank bonds may be debt securities such as commercial paper (CP) or asset-backed commercial paper (ABCP) in money market funds that rarely break the buck. Risky bonds refer to private-label (subprime) mortgage-backed securities (MBS) that inherit certain default risk, and put-option-like securities such as credit default swaps (CDS) and synthetic collateralized debt obligations (CDO) that insures against default risks. Pozsar et al. (2010) elaborate on the detail of securities issued by shadow banks.

Related Literature. This paper is closely related to three strands of literature. First, since the onset of the recent subprime crisis, both empirical and theoretical studies have been focused on the role of the unregulated nonbank financial institutions (i.e. shadow banks) as an alternative of traditional commercial banks. For instance, empirical papers such as Gorton and Metrick (2012), Covitz, Liang, and Suarez (2009), Shin (2009), and Kacperczyk and Schnabl (2010, 2013) investigate patterns and effects of the run on the whole shadow banking system. In this paper, we rationalize the bust of the shadow banking system as the result of systemic risk exposure. When shadow banks diversify enough portion of their mortgage portfolio, a banking crisis is no longer triggered by idiosyncratic risks but by the systemic risk (i.e. systemic banking crisis). In this regard, we are in line with the model of shadow banking in Gennaioli et al. (2013), in which banks diversify their mortgage portfolio in order to improve financial stability from an ex-ante perspective. However, we extend their model in two aspects. First, our model also study the link between commercial banks and shadow banks. Second, more importantly, portfolio diversification might not improve financial stability if shadow banks issue risky bonds but could increase the likelihood of systemic bailouts in the bad states. This paper is also related to theoretical papers such as Plantin (2015), Huang (2016), and Begenau and Landvoigt (2017). All these three papers model shadow banking as an outside option for traditional commercial banks to pursue regulatory arbitrage. They suggest that financial stability and welfare are inverse U-shape functions of financial regulations on commercial banks. Although our paper also considers regulatory arbitrage as the main purpose of shadow banking and securitization activities, the commercial banking sector and the shadow banking sector are related through the input-output link (i.e. securitization market) instead of working as substitutes.

Second, a vast literature has studied the moral hazard problem arose in the securitization market. For instance, Purnanandam (2011) provides empirical evidence that the mortgage originators during the subprime crisis run-up periods provided poor quality control when screening securitized mortgages. Gorton and Pennacchi (1995), Pennacchi (1988), and Parlour and Plantin (2008) provide theoretical framework for both the moral hazard problem and the risk retention solution in securitization. Ashcraft and Schuermann (2008) list seven key information frictions emerge in the securitization process. In this paper, we take into account two main moral hazard problems facing commercial bankers and shadow bankers: 1) Commercial banks (i.e. mortgage originators) may not monitor the quality of securitized mortgages and thus risk retention in the securitization process

guarantees the monitoring incentive; 2) shadow banks (i.e. mortgage servicers) may divert the borrowed funds after liquidation and therefore creditors may fund shadow bank bonds up to the amount such that diversion would not be chosen by shadow bankers. Importantly, these two moral hazard problems are somewhat related in the model since the shadow bank borrowing constraint (formed by non-diversion constraint) affect the market value of securitized mortgages, which in turn determines the risk retention constraint.

Finally, this paper also contributes to the literature of systemic bailout guarantees. Theoretical papers such as Acharya and Yorulmazer (2008), Acharya et al. (2011), and Bianchi (2016) design the optimal or the socially efficient bailout schemes. However, this paper is close to Schneider and Tornell (2005), Rancière et al. (2008), Farhi and Tirole (2012), and Rancière and Tornell (2016). They consider systemic bailouts as a credit market imperfection which encourages risk-taking activities. Similarly, systemic bailouts in our paper encourage risk-taking by incentivizing systemic risk exposure such that the shadow banking sector collapses systemically. In addition, empirical papers use various methods to measure market expectations of systemic bailouts. For instance, Acharya et al. (2015) analyze the risk-sensitivity of credit spreads of financial institutions and argue that firms with larger size and more contribution to systemic risk are associated with higher market expectations of implicit bailouts. Schweikhard and Tsesmelidakis (2012) compare equity-implied credit spreads to actual credit default swap (CDS) quotes and ascribe the difference between the two to bailout expectations. However, these approaches would substantially reduce our sample size to decades of bank holding companies. Thus, we follow Kelly et al. (2016) which use the OTM put option basket-index spread to gauge market expectations of systemic bailouts. Since each bank holding company might be affected differently by systemic bailouts, as an extension of Kelly et al. (2016), we measure bank level exposure to systemic bailouts by computing responsiveness of their put option prices to the variations of put option basket-index spread. Such novel bank level data could be used for future empirical research on banking sector systemic bailouts.

Roadmap. The rest of the paper is structured as follows. Section 2 showcases the motivating evidence of the U.S. banking system. Section 3 describes the data and empirical strategy. Section 4 shows the main empirical findings. Section 6 presents a model of the modern banking system, after which Section 7 lays out an analysis of multiple equilibria credit growth paths as well as its implications. Section 8 concludes.

2 Motivating Evidence

2.1 Fact 1: Heterogeneous Liability Compositions

Banks' liability compositions are highly heterogeneous across sectors: traditional commercial banks are mostly funded by deposits with explicit FDIC guarantees, while shadow banks are mostly funded by risky short-term debt securities with implicit federal guarantees. Although banks' liability compositions are highly homogeneous within sectors and highly constant over time (Hanson et al. 2015), commercial banks and shadow banks rely on very different funding structures.

	2000 Q1	**2005 Q1**	**2010 Q1**	**2015 Q1**
Depository institutions				
Net interbank liabilities	1.74%	2.70%	3.76%	2.12%
Checkable deposits	10.52%	7.62%	7.03%	11.73%
Time and savings deposits	53.59%	55.63%	57.11%	60.29%
Federal funds and repos	8.86%	6.90%	4.75%	1.58%
Debt securities	1.48%	1.40%	4.71%	1.68%
Loans	6.69%	6.26%	4.14%	3.01%
Taxes payables	0.24%	0.37%	-0.61%	-0.19%
Other liabilities	16.89%	19.27%	19.11%	19.78%
Total Liabilities	*100%*	*100%*	*100%*	*100%*
Security brokers and dealers				
Security repos	61.08%	66.57%	61.05%	50.73%
Corporate bonds	2.05%	2.02%	2.78%	3.55%
Loans	25.04%	20.31%	22.05%	31.87%
Trade and tax payables	2.04%	1.17%	2.00%	0.79%
Other liabilities	9.79%	9.93%	12.12%	13.06%
Total Liabilities	*100%*	*100%*	*100%*	*100%*

Table. US commercial banks and shadow banks liability compositions. This table illustrates the liability compositions of U.S. depository institutions (commercial banks) and security brokers and dealers (shadow banks) as of 2000Q1, 2005Q1, 2010Q1, and 2015Q1 using the "Financial Accounts of the United States" (Flow of Funds).

As an illustration, the table above shows the liability compositions of U.S. depository institutions (commercial banks) and security brokers and dealers (shadow banks) from the "Financial Accounts

of the United States." Checkable deposits and time and savings deposits historically take up 60% of depository institutions' liabilities. In a sharp contrast, security repos[7], which are not guaranteed by the federal government but are collateralized by risky securities, take up 60% of security brokers and dealers' liabilities.

2.2 Fact 2: Loss of Market Access for Risky Shadow Bank Securities

The riskiest shadow bank securities that were used as the underlying collateral in the repo market before the crisis has lost market access since the crisis onset. One example of the risky shadow bank bonds is the subprime residential mortgage-backed securities (RMBS). The left panel of Fig. 1 displays issuance and outstanding of the subprime RMBS in the last two decades. As a comparison, the right panel of Fig. 1 shows the same figures for agency (FHLMC, FNMA, and GNMA) mortgage-backed securities and other guarantees, which are considered as safer shadow bank securities. The market appetite for riskier shadow bank securities has been weak since the crisis. Issuance of the subprime RMBS declined from more than 1 trillion dollars in 2006 to less than 100 billion dollars after 2008. By contrast, the safer shadow bank securities still managed to maintain market access.

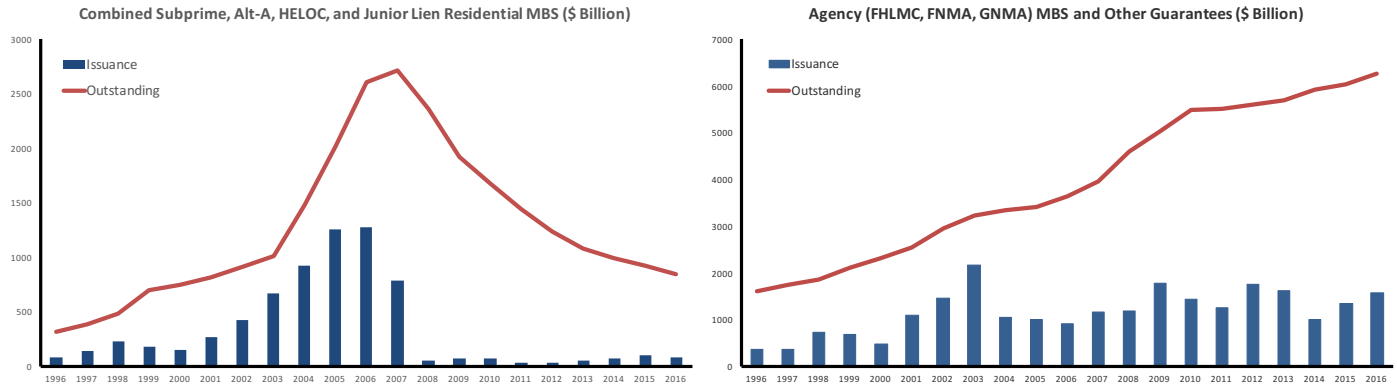

Fig.1. Issuance and Outstanding of US subprime residential mortgage-backed securities and agency mortgage-backed securities. This figure displays the market access of the riskiest shadow bank bonds (subprime RMBS) and the safest shadow bank bonds (agency MBS) since 1996 based on the aggregate data published by the Securities Industry and Financial Markets Association (SIFMA).

[7] A repo (repurchase agreement) is a short-term contract that swaps liquidity and collateral between two parties in the market. It is the most common source of funds for the shadow banking sector (Pozsar, 2010)

2.3 Fact 3: Low Post-Crisis Market Expectations of Systemic Bailouts

The market expectations of systemic bailouts to the banking sector is high during the crisis run-up, but winds down after a series of government rescue programs. There are various approaches in empirical literature measuring market expectations of systemic bailouts. We employ the approach in Kelly et al. (2016) which uses the difference in costs between out-of-money put options for individual banks and puts on the financial sector index (i.e. basket-index option price spreads) to gauge market expectations of systemic bailouts to the financial sector. More specifically, this approach is based on the "too-systemic-to-fail" argument that systemic bailouts are expected to be more likely when puts on the financial sector index (e.g. XLF) are relatively cheaper than the corresponding share-weighted basket of put options. I use this approach, among other things [8], because of the following reasons. First, instead of measuring each individual bank's likelihood of receiving bailouts, this approach draws attention to market expectations on systemic bailouts to the whole sector. Second, since investors purchase out-of-the-money put options to insure their positions in the event of a price crash, the basket-index option price spreads can accurately reflect investors' expectations[9]. Finally, although banks' credit default swap spreads can be used to measure expectations on systemic bailouts, there are only around 20 bank holding companies that have issued credit default swaps before the recent financial crises according to Markit database. However, the sample of put options covers 384 bank holding companies with a complete daily price dataset.

Since Kelly et al. (2016) compute the basket-index spreads with the financial sector index XLF, I repeat their approach with a focus on the banking sector index, KBE. Thus, the banking sector's basket-index spread is defined as the per dollar costs of basket and index insurance (implied price over strike price):

$$Put\ Spread = \frac{P^{basket} - P^{index}}{K^{index}}$$

where P^{index} is the put option price of KBE, P^{basket} is the corresponding basket price weighted by the share in KBE, and K^{index} is the share-weighted strike price of the index. Since the stock and share in KBE varies a lot over time, I document the holdings at the end of each quarter based on

[8] Acharya et al. (2015) analyze the risk-sensitivity of credit spreads of financial institutions and argue that firms with larger size and more contribution to systemic risk are associated with higher market expectations on implicit bailouts. Schweikhard and Tsesmelidakis (2012) compare equity-implied credit spreads to actual credit default swap (CDS) quotes and ascribe the difference between the two to bailout expectations. However, such approach restricts the sample of the financial sector to decades of companies.

[9] Expectations of bailouts can be jointly determined by various factors such as size, systemic risk contributions, asset-backed security holdings, etc.

the Center for Research in Security Prices (CRSP) database. Table D.1 reports the top 20 holdings in KBE at 12/31/2007 and 12/31/2009. I follow Kelly et al. (2016) and focus primarily on options with 365 days to maturity and delta of 25[10].

[INSERT TABLE D.1 HERE]

Fig. 2 shows that the OTM put option basket-index spread was consistently higher during the run-up to the subprime crisis and reached the peak on March 3, 2009, when Treasury and Federal Reserve eventually launched the Term Asset-Backed Securities Loan Facility (TALF)[11]. However, the basket-index spread drops significantly and remains at a low level afterwards, which reveals that the market expects no more systemic bailouts after TALF.

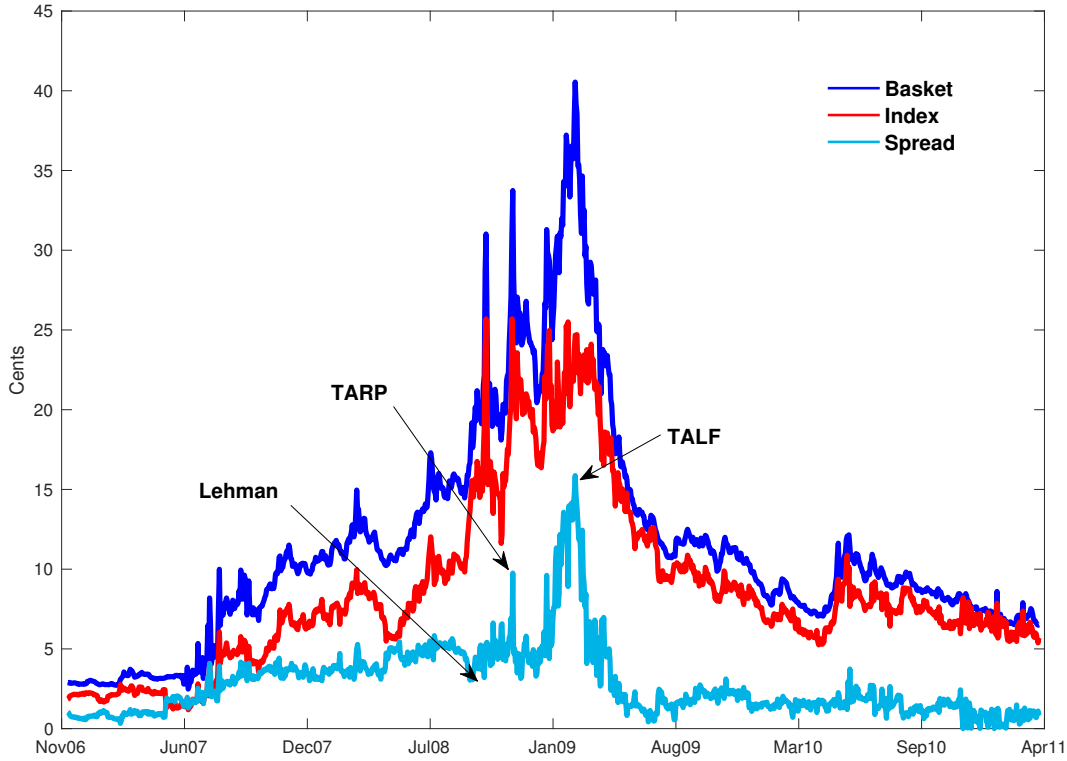

Fig. 2. Market expectations of systemic bailouts based on put options basket-index spread. This figure plots the series of OTM put option costs on KBE index, basket, and basket-index spread over the period between November 2006 and April 2011. Following Kelly et al. (2016), delta is 25 and time to maturity is 365 days.

[10]Please refer Kelly et al. (2016) Section I "Measuring the Basket-Index Spread" for the detail of computing put spread.

[11]The purpose of TALF, according to the Fed, is to "increase credit availability and support economic activity by facilitating renewed issuance of consumer and small business asset-backed securities at more normal interest rate spreads." In other words, such program was launched to support the market value of risky shadow bank bonds.

2.4 Taking Stock

Based on these facts manifested from both aggregate and micro-level data, our synthesis is that the shadow banking sector has experienced the loss of market access for newly issued risky securities accompanied by weak market expectations of systemic bailouts by the government. Shadow banks' business model heavily relies on short-term debts (e.g. repos) that are collateralized by risky securities such as subprime mortgage-backed securities. However, when market expectations of systemic bailouts are low, the underlying collateral might not be as attractive as it was before the crisis. Moreover, government regulations on the issuance of asset-backed securities would amplify the disruptive effect on securitization activities and credit intermediations through the shadow banking sector. In the rest of this paper, we take these facts into account and address the question of how market expectations of systemic bailouts affect risky shadow bank bonds issuance and determine the commercial bank credit origination capacity via the securitization market.

3 Data and Empirical Strategy

3.1 Data Construction

Our main data is merged from four sources: (1) *Options Volatility Surface*, which is provided by Option Metrics, (2) *FR Y-9C Consolidated Report of Condition and Income* of bank holding companies from the Federal Reserve Bank of Chicago, (3) Call Report (*FFIEC 031 and FFIEC 041 Consolidated Reports)* of commercial banks, which is also available from the Federal Reserve Board of Chicago, and (4) the commercial and industrial (C&I) loan level data that comes from the Thomson Reuters DealScan database. The four data sources are merged at a commercial bank level according to the structure presented in Fig. 3.

Options Volatility Surface file provides daily standardized implied volatilities for put and call options that have been interpolated over a grid of time to maturity and option delta. Both FR Y-9C and FFIEC 031/041 are bank level consolidated reports with the distinction that the former could be a sum of different commercial bank subsidiaries and shadow bank (non-bank) subsidiaries. Since we focus on the impact of systemic bailout expectations on commercial bank credit originations, we aggregate commercial bank loans (obtained from Call Report) at a bank holding company level for testing our main hypothesis. Finally, we exploit the syndicated commercial and industrial loan level data for computing each bank holding company's exposure to the deteriorating sectors. The

loan-level data include the identities of the borrowers and lenders of each syndicated loan as well as the share of each participating bank holding company, so we can match each bank holding company with their syndicated loan borrowers[12]. We explore the database and obtained 384 bank holding companies that have out-of-the-money (OTM) put options traded in the market during the second half of 2008 and have full financial statements data from consolidated reports around the subprime crisis. Our sample covers periods over 2005Q1-2015Q4 and 384 bank holding companies. Table D.2 reports the summary statistics.

[INSERT TABLE D.2 HERE]

In the subsections that follow, we describe the measurement of the main bank holding company level indices: exposure to the systemic bailout factor (put option beta), exposure to the securitization market, and exposure to weak borrowers.

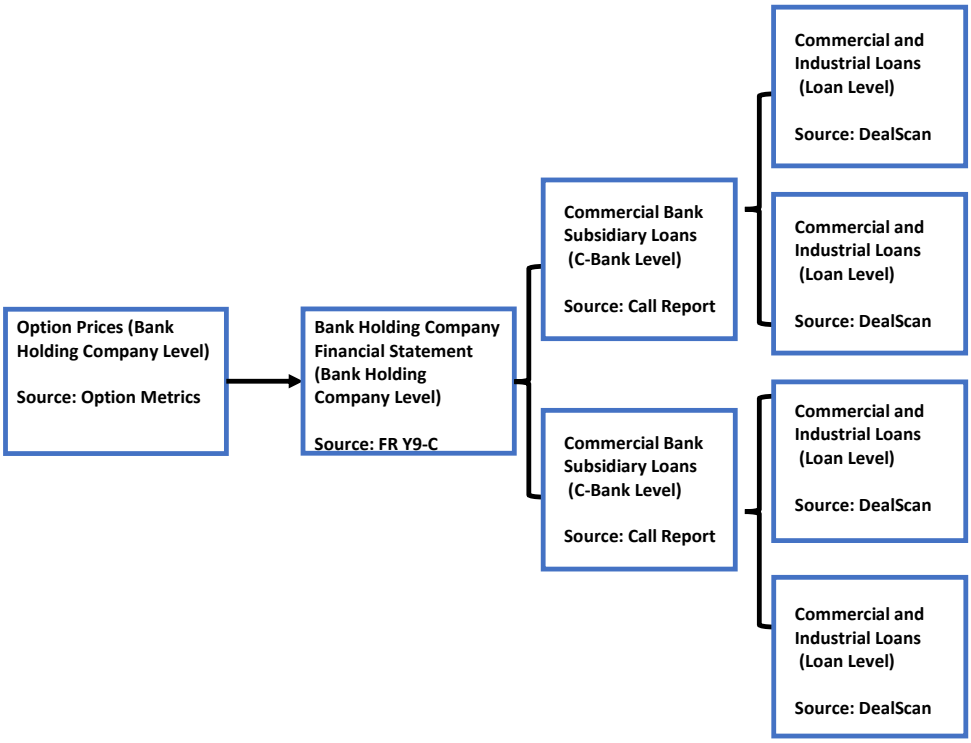

Fig. 3. Structure of data. This figure presents the structure of data that are obtained from the following four sources: (1) Option Volatility Surface (bank holding company level standardized option prices), (2) FR Y-9C Consolidated Reports of U.S. bank holding companies, (3) FFIEC 031 and FFIEC 041 Consolidated Reports of commercial

[12]Unfortunately, such loan level data only allows us to match borrowers to bank holding companies instead of commercial bank subsidiaries. As will be described later, since the Wharton Research Data Services (WRDS) provides the *DealScan-Compustat Linking Table,* we also use Compustat to find the NAICS sector code of each borrower.

banks, and (4) DealScan syndicated commercial and industrial loans.

Exposure to Systemic Bailouts (Put Option Beta) For the purpose of empirical tests, we measure investors' reaction to holding each individual bank holding company's put options when their expectations of systemic bailouts to shadow bank change. Thus, we exploit daily put option price data in the sample of 384 bank holding companies that exist in the second half of 2008 when a series of systemic bailout programs were announced. I define each bank holding company's exposure to the systemic bailout factor as the responsiveness of the put option cost to variations in the basket-index spreads in 8 event windows. The event windows are constructed based on public announcements that are closely related with shadow bank bailouts during 2008 Q3-Q4.

First, we identify 4 public announcements/events during the last two quarters of 2008 that have increased the likelihood of systemic bailouts to the shadow banking sector: (1) July 13, 2008: Paulson requests government funds to take over Fannie Mae and Freddie Mac, (2) October 3, 2008: The Trouble Asset Relief Program (TARP) passes the U.S. House of Representatives, (3) October 6, 2008: The Term Auction Facility is increased to $900 billion, and (4) November 25, 2008: The Term Asset-Backed Securities Loan Facility (TALF) is announced. We also identify 4 public announcements/events during the same episode that have reduced the probability of systemic bailouts to the shadow banking sector: (1) September 15, 2008: Lehman Brothers files for bankruptcy, (2) September 29, 2008: The TARP does not pass the house, (3) November 7, 2008: President Bush warns against too much government intervention in the financial sector, and (4) November 13, 2008: Paulson's plan to use TARP funds to buy troubled assets from banks is not passed. Fig. 3 presents the event studies of put option costs (implied price over strike price) over 21-day time windows around positive announcements and negative announcements. The cost of put options significantly decreases after positive announcements but significantly increases after negative announcements.

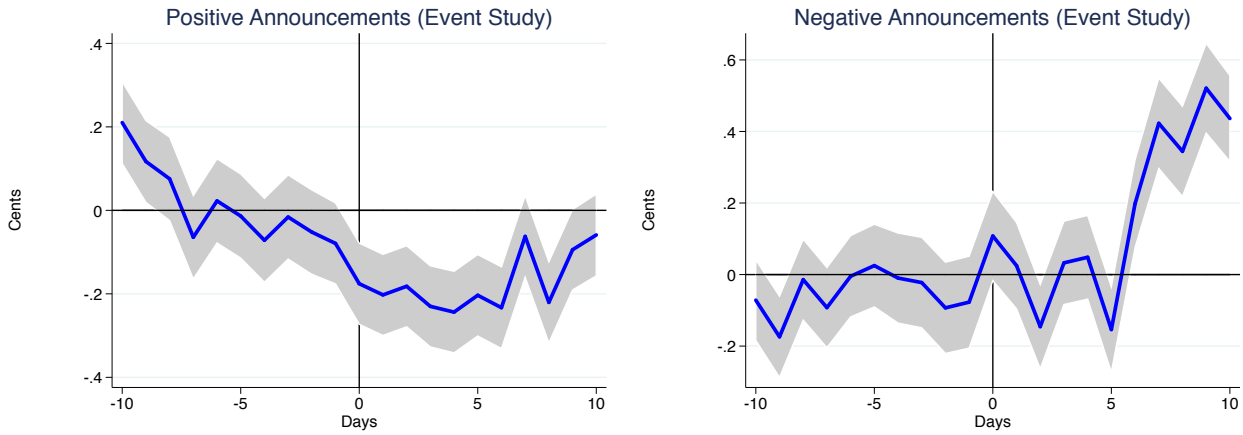

Fig. 4. Event studies. Put option costs (cents) over 21-day time windows around positive announcements (left) and negative announcements (right).

Second, each bank holding company's exposure to systemic bailouts is defined as the sum of put option price responsivenesses to the variations in the banking sector put option basket-index spread (market expectations of systemic bailouts) around 8 announcement dates. The following is the formula to compute our main bank level index:

$$Exposure\ to\ Bailouts_i = \sum_{j=1}^{8} \beta_{i,j,Bailout} \tag{1}$$

where $\beta_{i,j,Bailout}$ is a bank holding company's "put option beta" that captures the exposure to the systemic bailout factor around announcement date j. Given the announcement date T_j, such put option beta is extracted from the following regression over the event window $t \in \{T_j - 10, T_j + 10\}$

$$\Delta \left(\frac{P}{K} \right)_{i,j,t} = \beta_{i,j,Bailout} \Delta Spread_{j,t} + \beta_{i,j,Risk} Leverage_{i,j,t} + \epsilon_{i,j,t} \tag{2}$$

where the left hand side variable $\Delta (P/K)_{i,j,t}$ indicates the daily change in the out of the money of bank i's put option, and $\Delta Spread_{j,t}$ is the daily change in the banking sector basket-index spread that has been calibrated above. Since the changes in bank market leverage ratio would alter the riskiness of underlying equity of put options, we also control for the market leverage ratio $Leverage_{i,j,t}$, which is the log ratio of book value of assets to market value of equity.

Exposure to the Securitization Market: Following Loutskina (2011) and Huang (2017), we define a bank holding company's exposure to the securitization market as the likelihood that it can

securitize the loans on its balance sheet. The construction of such measure involves three steps. The first step is to calculate the whole banking sector's potential to securitize loans of a category for the quarter according to the aggregate data from "Financial Accounts of the United States" published by the Federal Reserve Board. The five categories of loans that we take into account are i) home mortgages, ii) multi-family residential mortgages, iii) commercial mortgages, iv) consumer credit, and v) farm mortgages. Appendix C.1 explains the detail on how we locate the aggregate data in "Financial Accounts of the United States". The second step is to aggregate commercial bank subsidiary level stock of loans according to parent bank holding companies. Since a bank holding company may control multiple commercial bank subsidiaries[13], we extract the loan amount data from the commercial bank level Call Report published by the Federal Financial Institutions Examination Council (FFIEC) and aggregate the total amount of each category for the parent bank holding companies. We explain the detail of Call Reports data in Appendix C.2. Finally, we derive the exposure to the securitization market by computing the weighted average of each bank holding company's loan amount based on the economy-wide securitization ratio for each loan category. We use the following formula to compute bank holding company i's exposure to the securitization market at time t:

$$\begin{aligned} Exposure\ to\ Securitization_{i,t} = & \sum_{m=1}^{5} \left[\left(\frac{Economy\ Wide\ Securitized\ Loans_{m,t}}{Economy\ Wide\ Total\ Loans_{m,t}} \right) \right. \\ & \left. \times \left(\frac{Type\ m\ Loans_{i,t}}{Total\ Loans_{i,t}} \right) \right] \end{aligned} \tag{3}$$

where the first ratio in (3) is obtained from "Financial Accounts of the United States", and the second ratio is obtained through aggregating commercial bank level data based on parent bank holding companies.

Exposure to Weak Borrowers: In order to investigate the importance of credit demand when explaining the post-crisis credit growth patterns, we measure each bank holding company's exposure to borrowers from the deteriorating sectors. Since DealScan provides the information on syndicated commercial and industrial loans, most of the loans are financed by a group of bank holding companies. The data includes each bank holding company's share of participations in the syndicated loans.

[13]For instance, JPMorgan Chase & Co., the largest bank holding company as of October 2017, manages 44 commercial bank subsidiaries. The organization hierarchy is documented here, which is based on the regulatory reporting form FR Y-10.

Thus, we can obtain the amount of commercial and industrial loans accessed by private and public firms from each bank holding company. In addition, the *DealScan-Compustat Linking Table* helps us to access *Compustat* and explore the information on each borrower's characteristics. Since the real estate sector (NAICS: 53) and the constructions sector (NAICS: 23) experienced the largest negatively shock after the subprime crisis, the borrowers from these two sectors are treated as the ones from the deteriorating sectors with weak credit demand. Thus, each bank holding company's exposure to weak borrowers is its participated lending to companies from the real estate sector and the constructions sector as a share of its total participated lending in the syndicated commercial and industrial loans market. The following formula is used to compute bank holding company i's exposure to weak borrowers at time t:

$$Exposure\ to\ Weak\ Borrowers_{i,t} = \frac{\sum_{n \in \Omega_{weak}} [Participate\ Rate_{i,n,t} \times Loan\ Amount_{i,n,t}]}{\sum_{n \in \Omega} [Participate\ Rate_{i,n,t} \times Loan\ Amount_{i,n,t}]}$$

where Ω is a set of all the borrowers that have historically accessed the syndicated commercial and industrial loans market, and Ω_{weak} is a subset of Ω that includes companies from the real estate sector and the constructions sector.

3.2 Empirical Strategy

The post-crisis periods of the U.S. banking sector is characterized by weak recoveries in bank credit. The premise of our empirical tests is that low market expectations of systemic bailouts to the shadow banking sector is the main contributor to the weak recovery of bank credit. Thus, we expect that bank holding companies with higher exposure to the the systemic bailout factor during the onset of the crisis (late 2008) would experience larger credit loss from its pre-crisis credit growth trend. Thus, the main hypothesis, the *systemic bailout expectations* hypothesis, is phrased as the following.

Systemic Bailout Expectations Hypothesis (H1). *Bank holding companies with higher pre-crisis exposure to shadow bank bailouts experience larger post-crisis credit deviation from the pre-crisis trend.*

For identification of *Hypothesis 1*, the main question that we want to address is whether banks with higher exposure to systemic shadow bank bailouts (i.e. put option beta) experience larger deviation in total credit from the pre-crisis trend. The empirical tests focus on the episodes around the recent

subprime crisis. Using the bank holding company level data on total credit from 2004Q1 to 2008Q4, we compute the pre-crisis average credit growth rate and the deviation of post-crisis total credit from the trajectory based on pre-crisis trend. we split the sample bank holding companies into two bins based on the exposure to systemic shadow bank bailouts during the last two quarters of 2008.

In order to study the variation in time series trajectories of bank holding companies in different bins, we turn to the local projection technique introduced by Jordà (2005). More formally, the dependent variable, $\Delta_h y_{i,T}$, is the cumulative deviation from the pre-crisis trend, which is computed as the difference between 100 times the log of total credit and 100 times the log of projected pre-crisis trend value at h quarters after crisis-quarter T (i.e. 2008Q4). The indicator variable denoted by $d_{i,T}$ distinguishes the groups of bank holding companies based on the exposure to systemic bailouts, and is equal to 1 if the exposure is higher than the median and zero otherwise. we also include control variables $X_{i,T}$[14] with 8 lags before T to address the issue of omitted variables bias. The impact of the exposure to systemic bailouts on post-crisis credit recovery can be measured using the following baseline local projection specification:

$$\Delta_h y_{i,T} = \mu_h + \gamma_h d_{i,T} + \Theta X_{i,T} + \epsilon_{i,T} \tag{4}$$

where μ_h measures the cumulative deviation from pre-crisis trend for bank holding companies in the group of lower exposure to systemic bailouts, while $\mu_h + \gamma_h$ measures the cumulative deviation for the group of high exposure.

However, some identification concerns may arise in terms of the main factors of weak credit recovery. First, the bank holding companies with higher exposure to the systemic bailout factor might have taken excessive risk during the run-up to the crisis, which eventually led to more adverse effect by the post-crisis financial regulations such as the Dodd-Frank Act. Indeed, securitization of balance sheet items have been one of the most common means of risk-taking by the U.S. banking sector before the subprime crisis. As such, the Dodd-Frank Act was designed to regulate the financial institutions that have significant participations in the securitization market through risk retentions[15].

[14]The control variables are the ones that show up most in the banking literature. They are size, leverage, total credit, return on asset (ROA), return on equity (ROE), systemic risk contributions (CoVar), non-performing loans ratio, liquidity etc. In order to address the endogenuity issue, I reduce the control variables to those that are extremely rigid in the ranking among all the sample banks. Table D.3 displays the transition matrix of these variables. We set 90% as the threshold of transition probability and ROA, ROE, and Liquidity are removed from our control variable list. Such change does not alter our empirical results.

[15]Both Title VII and Title IX of Dodd-Frank concerns the securitization activities of bank holding companies. Title VII "Wall Street Transparency and Accountability" regulates the structured financial products traded in the over the

Thus, we propose the second hypothesis, the *financial regulations* hypothesis, as the following.

Financial Regulations Hypothesis (H2). *The effect in H1 is stronger if a bank holding company's exposure to the securitization market during the crisis onset is higher.*

Second, in line with the literature on investigating the impact of weak credit demand[16], we take into account the effect of credit demand shock on total bank credit growth patterns. In fact, banks might have lowered lending standards when issuing credit during the crisis run-up. However, the credit demand by distressed borrowers or borrowers from a distressed sector could be persistently weak during recovery periods. Thus, we form the next alternative hypothesis, the *credit demand* hypothesis as the following.

Credit Demand Hypothesis (H3). *The effect H1 is stronger if a bank holding company's exposure to borrowers from deteriorating sectors is higher.*

The *financial regulations* hypothesis (H2) and the *credit demand* hypothesis (H3) are both built on the effect explained in the *systemic bailout expectations* hypothesis (H1). We argue in these two hypotheses that the effect is stronger for the bank holding companies with higher exposure to the securitization market, or with higher exposure to borrowers from the deteriorating sectors. Therefore, we modify the baseline local projection specification (4) by interacting the exposure to systemic bailouts dummy $d_{i,T}$ with i) a measure of the exposure to the securitization market, or ii) a measure of the exposure to the borrowers from deteriorating sectors. The modified local projection specification is

$$\Delta_h y_{i,T} = \mu_h + \gamma_h^{HI} d_{i,T} \times \delta_{i,T} + \gamma_h^{LO} d_{i,T} \times (1 - \delta_{i,T}) + \Theta X_{i,T} + \epsilon_{i,T} \tag{5}$$

where the dummy variable $\delta_{i,T}$ equates to 1 if bank i's average exposure to the securitization market in 2008 is above the median across sample bank holding companies for H2, or if bank i's average exposure to borrowers from deteriorating sectors in 2008 is above the median for H3. We report the estimates of $\mu_h + \gamma_h^{HI}$ and $\mu_h + \gamma_h^{LO}$, which are respectively the cumulative trend deviations for the two groups of bank holding companies: high exposure to systemic shadow bank bailouts but differ in

counter swaps markets. Title IX "Investor Protections and Improvements to the Regulation of Securities" provides a regulatory guideline in Subtitle D that 5% of the risk must be retained during the asset-backed securitization process.

[16]Khawaja and Mian (2008) study the loan level data in Pakistan, Jimenez et al. (2012, 2014) study the loan level data in Spain, and Duchin and Sosyura (2014) focus on the U.S. mortgage and Syndicated loan level data.

the exposure to the securitization market or the exposure to weak borrowers. The two estimates help us to find the evidence of whether financial regulations or the weak credit demand is the dominant (or only) reason for the weak recovery of bank credit recovery after the subprime crisis. For instance, if the group of bank holding companies with high exposure to systemic bailouts but less exposure to the securitization market (less adverse effect by the Dodd-Frank Act) also presents significant credit growth deviations from the pre-crisis trend (especially after 2010Q3, the enactment quarter of Dodd-Frank), we argue that financial regulations do not completely explain what we have observed in the main hypothesis (H1) and the substantial decline in market expectations of systemic bailouts might also be of great importance. The same argument applies to the treatment of the exposure to weak borrowers.

4 Main Empirical Results

4.1 Results for the Main Hypothesis

We start with the results obtained from the baseline specification. Using the local projection technique, we estimate the response of post-crisis credit deviation from pre-crisis trend to the outbreak of the subprime crisis. The main results are presented in Fig. 5 for the estimates of two groups with different degree of exposure to systemic bailout factor (left panel), as well as the difference in post-crisis deviation, γ_h, for the two groups (right panel). In order to show the long-run impact, we present the estimation results up to 20 quarters after T (2009Q1-2012Q4).

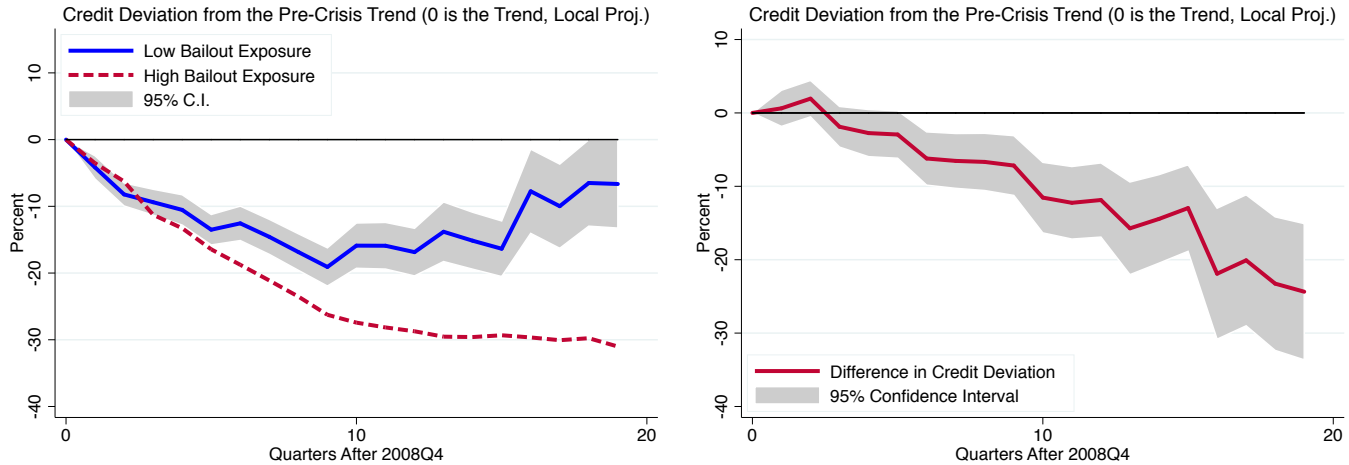

Fig. 5. Baseline local projections. This set of figures display the estimation results based on the baseline local projection specification $\Delta_h y_{i,T} = \mu_h + \gamma_h d_{i,T} + \Theta X_{i,T} + \epsilon_{i,T}$, where the dependent variable, $\Delta_h y_{i,T}$, is the cumulative

deviation from the pre-crisis trend, $d_{i,T}$ is a dummy variable that is equal to 1 if bank holding company i's exposure to systemic bailouts is higher than the median, and $X_{i,T}$ is a vector of control variables. The left panel shows the cumulative percentage deviations of bank credit from its pre-crisis trend (the horizontal zero line) for the two groups of bank holding companies (i.e. μ_h and $\mu_h + \gamma_h$), where a negative percentage indicates a growth path below the pre-crisis trend. The right panel shows the difference in growth path, γ_h, between the two groups.

The main estimation result reveals two characteristics of the post-crisis credit growth patterns among U.S. bank holding companies. First, as the left panel of Fig. 5 shows, although the group of bank holding companies with higher exposure to the systemic bailout factor had an additional 4.89% loss in the bank credit 8 quarters after 2008Q4, both groups have experienced a significant decline from the pre-crisis trend since the onset of the crisis (18.57% and 23.46%). The initial deviation from the trend for both groups is consistent with what has been described in the empirical literature that banks go through a process of painful deleveraging during the crisis episodes (e.g. Ivashina and Scharfstein 2010, Gorton and Metrick 2012). Second, there is a quite significant divergence in total credit growth path for the two groups of bank holding companies starting from the 8th quarter after 2008Q4. On the left panel of Fig. 5, bank holding companies with lower exposure to systemic shadow bank bailouts had almost caught up with the pre-crisis trend at the end of the sample periods (20 quarters after the onset of crisis), but the deviation from the pre-crisis trend for the high exposure to systemic bailouts group remains significant. In total, the high exposure group experience an additional 24.96% credit deviations from the trend and there is no evidence of convergence up to 5 years after the crisis onset. The right panel displays the estimates of the post-crisis trend deviations difference between the two groups (i.e. γ_h) as well as their 95% confidence intervals, which are generated by the same local projection specification. Comparing with their respective pre-crisis trend, there is a significant long-run difference in trend deviation between the two bank holding company groups. These findings based on the baseline local projection specification are in line with the *Systemic Bailout Expectations Hypothesis* which states that high expectation on systemic bailouts to shadow banks may be growth enhancing during pre-crisis episodes but could be followed by a larger deviation from pre-crisis trend when a large decline in market expectations of systemic bailouts arises.

The previous results based on dummies that indicate groups of banks with different exposure to the systemic bailout factor are illustrating but somewhat restrictive. The setup assumes that the effect on the banks in the same group is alike. However, as the degree of exposure to the

systemic bailout factor varies, the credit growth pattern might also vary. A natural way to relax this assumption is to use the continuous exposure to systemic bailouts variable in the empirical tests, instead of making it discrete. Thus, in the baseline local projection specification, we replace the dummy variable $d_{i,T}$ by the continuous variable of each bank holding company's exposure to the systemic bailout factor (measured in Equation 1). Fig. 6 shows the estimation the credit growth path divergence for bank holding companies with 10 units difference in the put option beta (i.e. exposure to the systemic bailout factor) based on the new specification. Perhaps surprisingly, bank holding companies with different exposure to the systemic bailout factor exhibit a persistent and notable divergence in long-term credit growth. The estimation implies that a 1 unit difference in the put option beta led to about an additional 5% total credit deviations from the pre-crisis trend.

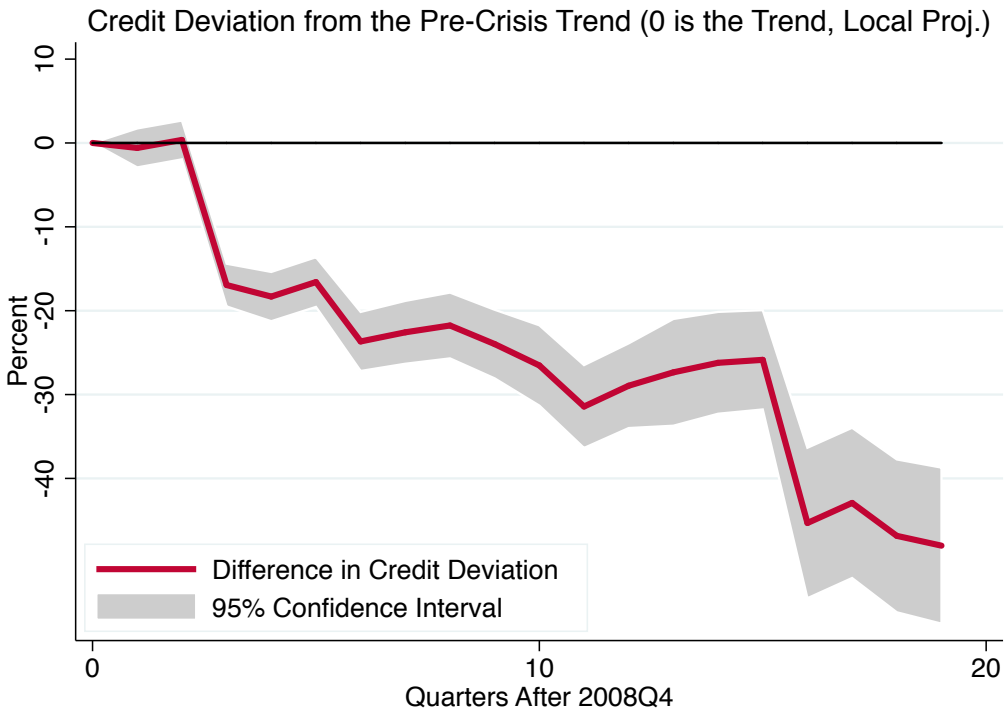

Fig. 6. Baseline local projections (continuous measure of exposure to the systemic bailout factor). This figure displays the estimation results based on the baseline local projection specification $\Delta_h y_{i,T} = \mu_h + \gamma_h Exposure_{i,T} + \Theta X_{i,T} + \epsilon_{i,T}$, where the dependent variable, $\Delta_h y_{i,T}$, is the cumulative deviation from the pre-crisis trend, $Exposure_{i,T}$ is a continuous variable that indicates bank holding company i's exposure to the systemic bailout factor, and $X_{i,T}$ is a vector of control variables. The estimates show the divergence in growth path for bank holding companies with 10 units difference in the exposure to the systemic bailout factor (i.e. $10 \times \gamma_h$) .

4.2 Results for the Alternative Hypotheses

Next, we turn to local projection specification (5) and investigate the importance of other factors such as the post-crisis financial regulations on shadow banking and weak credit demand recovery in driving the effect in the *systemic bailout expectations* hypothesis. Thus, given high exposure to systemic bailouts, we test the two alternative hypotheses: *financial regulations* hypothesis and *credit demand* hypothesis. Our purpose is to observe if bank holding companies that are more negatively affected by post-crisis financial regulations or weak credit demand would experience larger deviations from the pre-crisis credit trend.

In the *financial regulations* hypothesis, should financial regulations on shadow banking be the main contributor, we expect that the trend deviations for banks that are less affected by regulations (lower exposure to the securitization market) would be notably smaller, especially after 2010Q3 (the enactment of Dodd-Frank). Otherwise, financial regulations such as the Dodd-Frank Act may not be the dominant factor explaining the empirical findings in Fig. 5 and Fig. 6.

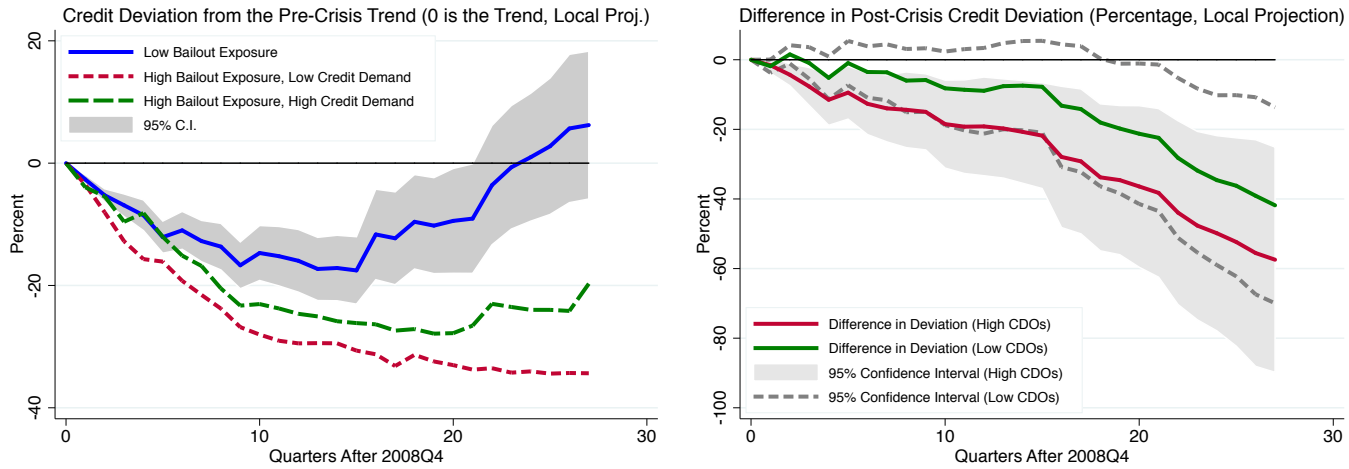

Fig. 7. Local projections for the financial regulations hypothesis. This set of figures display the estimation results based on the baseline local projection specification $\Delta_h y_{i,T} = \mu_h + \gamma_h^{HI} d_{i,T} \times \delta_{i,T} + \gamma_h^{LO} d_{i,T} \times (1 - \delta_{i,T}) + \Theta X_{i,T} + \epsilon_{i,T}$, where the dependent variable, $\Delta_h y_{i,T}$, is the cumulative deviation from the pre-crisis trend, $d_{i,T}$ is a dummy variable that is equal to 1 if bank holding company i's exposure to the systemic bailout factor during 2008Q3-Q4 is higher than the median, $\delta_{i,T}$ is a dummy variable that equates to 1 if bank holding company i's average exposure to the securitization market during 2008Q3-Q4 is above the median across the 384 sample bank holding companies, and $X_{i,T}$ is a vector of control variables. The left panel shows the cumulative percentage deviations of bank credit from its pre-crisis trend (the horizontal zero line) for three groups of bank holding companies (i.e. μ_h, $\mu_h + \gamma_h^{HI}$, and $\mu_h + \gamma_h^{LO}$), where a negative percentage indicates a growth path below the pre-crisis. The right panel shows the differences in growth path for the two treatment groups, γ_h^{HI} and γ_h^{LO}. The measurement of each bank

holding company's exposure to the securitization market is described in Section 3.1.

Fig. 7 presents the estimation results based on the specification (5), in which the left panel shows the cumulative deviation from the trend for i) the group with low exposure to the systemic bailout factor (blue solid), ii) the group with high exposure to the systemic bailout factor and high exposure to the securitization market (red dash), and iii) the group with high exposure to systemic bailouts low exposure to the securitization market (green dash). As is shown in the left panel of Fig. 7, both groups with high exposure to the systemic bailout factor experienced permanent deviations from the pre-crisis long-run credit trend. We find the difference in trend deviations for the two groups of bank holding companies that have high exposure to the systemic bailout factor is small even in the long-term. In particular, the estimated credit deviation for the group of low exposure to the securitization market is 34.26% 7 years after the crisis onset while the same figure for the group of high exposure to the securitization market is 42.81%. Moreover, the right panel of Fig. 8 reveals that the deviation from the pre-crisis trend for the group with high exposure to the systemic bailout factor but low exposure to the securitization market is insignificantly different from our benchmark group (the group with low exposure to the systemic bailout factor). These empirical regularities are inconsistent with the *financial regulations hypothesis*, in which higher likelihood of being regulated by the post-crisis financial sector regulations would amplify the effect characterized in the *systemic bailout expectations hypothesis*. This supports our presumption that financial regulation alone is not the only explanation for the post-crisis persistent credit growth deviation from the trend.

In order to test the *credit demand hypothesis*, we stick to the specification (5) but redefine the dummy variable $\delta_{i,T}$ as an indicator of whether the bank holding company's exposure to the borrowers from the deteriorating sectors is higher than the median in the sample in 2008. As Fig. 8 illustrates, both groups with high exposure to the systemic bailout factor but different levels of exposure to weak borrowers exhibit substantial downward deviations from the pre-crisis credit trend in the recovery periods. Although the group with higher exposure to weak borrowers and higher exposure to the systemic bailout factor shows stronger credit loss especially during the periods immediately after the crisis onset, the group with lower exposure to weak borrowers but higher exposure to the systemic bailout factor have also experience very strong credit loss from the pre-crisis trend. Thus, the results shown in Fig. 8 cannot support the *credit demand hypothesis*. In other words, this finding suggests that the very weak recovery of bank credit after the subprime

crisis is not dominantly explained by the deteriorating credit demand.

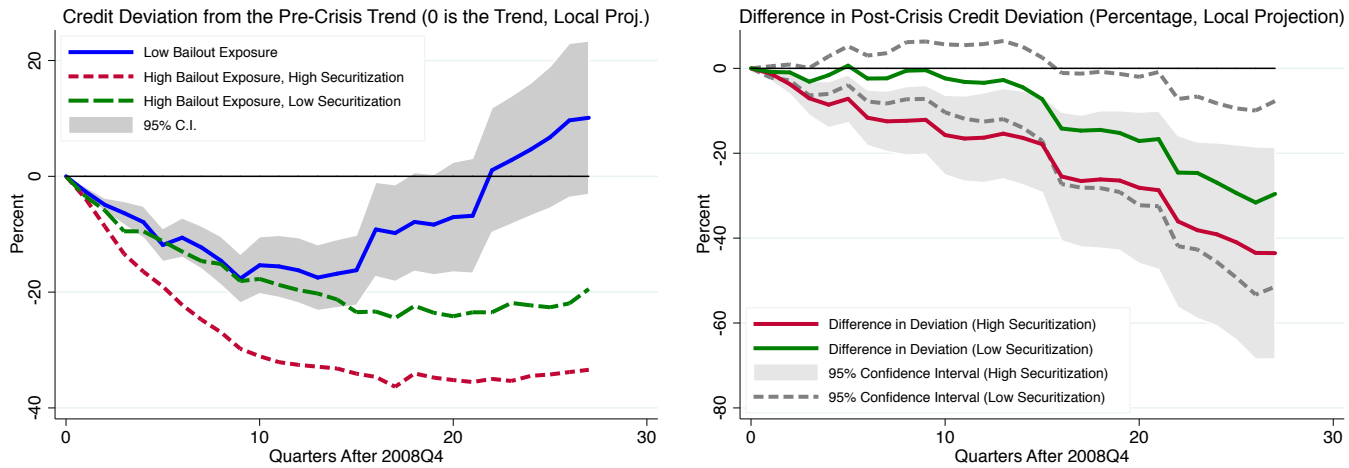

Fig. 8. Local projections for the credit demand hypothesis. This set of figures display the estimation results based on the baseline local projection specification $\Delta_h y_{i,T} = \mu_h + \gamma_h^{HI} d_{i,T} \times \delta_{i,T} + \gamma_h^{LO} d_{i,T} \times (1 - \delta_{i,T}) + \Theta X_{i,T} + \epsilon_{i,T}$, where the dependent variable, $\Delta_h y_{i,T}$, is the cumulative deviation from the pre-crisis trend, $d_{i,T}$ is a dummy variable that is equal to 1 if bank holding company i's exposure to systemic bailouts during 2008Q3-Q4 is higher than the median, $\delta_{i,T}$ in the interaction terms is a dummy variable that equates to 1 if bank holding company i's average exposure to borrowers from deteriorating sectors during 2008Q3-Q4 is above the median across sample bank holding companies, and $X_{i,T}$ is a vector of control variables. The left panel shows the cumulative percentage deviations of bank credit from its pre-crisis trend (the horizontal zero line) for three groups of bank holding companies (i.e. μ_h, $\mu_h + \gamma_h^{HI}$, and $\mu_h + \gamma_h^{LO}$), where a negative percentage indicates a growth path below the pre-crisis. The right panel shows the differences in growth path for the two treatment groups, γ_h^{HI} and γ_h^{LO}. The measurement of each bank holding company's exposure to borrowers from deteriorating sectors is described in Section 3.1.

5 Evidence from Commercial Bank Level Data

Bank holding companies with higher put option beta (i.e. exposure to the systemic bailout factor) during the crisis onset would experience a larger credit loss from the pre-crisis trend. Section 4 has provided evidence based on bank holding company level data. Could we find more supporting evidence if we drill down to the commercial bank level data and compare credit growth patterns of different commercial bank subsidiaries within the same bank holding company? Do the changes in the market expectations of systemic bailouts affect credit growth of commercial banks differently even though they are under the umbrella of the same bank holding company? Commercial bank subsidiaries of the same bank holding company have same put option beta but have different exposure

to the securitization market and deteriorating borrowers. In this section, we use the merged commercial bank level data from the Call Report and empirically examine if commercial banks within the same bank holding company could experience different credit loss after the financial crisis. Moreover, we take into account the merger and acquisition information of commercial bank subsidiaries and restrict the empirical tests with the sample of commercial banks that have survived after the subprime crisis. In this way, we address the concern that acquired failed commmercial banks might be irrelevant to the parent bank holding company's put option beta that is measured during the crisis onset.

5.1 Fixed Effects Regressions

According to the *systemic bailout expectations hypothesis*, weak recovery of bank credit is due to the notable reduction in market expectations of systemic bailout guarantees. In addition, the commercial bank subsidiaries (on balance sheet) and the shadow bank subsidiaries (off balance sheet) of a bank holding company are by their nature in different safety nets, where guarantees to the former is explicit and to the latter is implicit. Thus, changes in the market expectations of systemic bailouts would first affect shadow bank subsidiaries' borrowing constraint, which is sensitive to market perceptions of systemic bailouts, before such shock is transmitted to commercial bank subsidiaries. In other words, credit growth patterns of commercial bank with different characteristics (e.g. exposure to the securitization market and exposure to weak borrowers) should be similar as long as they are within the same parent bank holding company. In contrast, if the effect driven by post-crisis financial regulations and weak credit demand is significant, we would expect to see commercial bank within the same bank holding company but have distinct exposure to the securitization market and weak borrowers would experience different levels of post-crisis credit loss.

The key for the empirical tests is a commercial bank level dataset so that we can control for the bank holding company fixed effects. Table D.4 displays the fixed effects regression results with the following specification.

$$\ln\left(g_{i,c}^{post}\right) = \beta_1 d_i + \beta_2 d_i \times \delta_{i,c} + \Theta X_{i,c} + \alpha_i + \epsilon_{i,c} \tag{6}$$

where d_i has the same definition with previous sections (dummy variable that indicates the level of bank holding company i's exposure to the systemic bailout factor or put option beta), $g_{i,c}^{post}$ is

the average quarterly credit growth rate of the commercial bank subsidiary c under the parent bank holding company i during post-crisis periods (2009Q1-2012Q4), $\delta_{i,c}$ is a dummy variable that indicates the level of exposure to the securitization market and exposure to weak borrowers at the commercial bank level [17], and $X_{i,c}$ is a vector of commercial bank level control variables. In Table D.4, we present the estimation results of specification (6). As Column (1) shows, the effect of higher parent bank holding company's put option beta (exposure to the systemic bailout factor) is disruptive to the credit growth of the commercial bank subsidiaries. For bank holding companies with high put option beta, the affliated commercial banks experience an additional 4.223% quarterly loss in post-crisis credit growth. Column (2) and (4) reports the estimations with the interaction, which reveals the additional effects due to higher exposure to the securitization market (financial regulation hypothesis) or higher exposure to weak borrowers (credit demand hypothesis). The estimation implies that commercial banks with higher exposure to the securitization market experience an additional 2.252% reduction in the quarterly credit growth rate. Similarly, commercial banks with higher exposure to weak borrowers incur an additional 2.643% loss in the quarterly credit growth rate. However, such seemingly strong adverse effects caused by financial regulations and weak credit demand are significantly reduced by more than half when we control for parent bank holding company fixed effects. As Column (3) and (5) display, the additional losses in credit growth due to higher exposure to the securitization market or higher exposure to weak borrowers are respectively reduced to 1.019% and 1.450%. In other words, the difference in credit growth across commercial banks is absorbed by the bank holding company fixed effects which are identical for commercial bank subsidiaries under the same umbrella.

[INSERT TABLE D.4 HERE]

In addition, we consider a fixed effect specification with corresponding continuous variables instead of dummy variables. Table D.5 reports the estimations in the same fashion as Table D.4. As Column (1) shows, the disruptive effect following higher exposure to the systemic bailout factor is robust to the change in regression variables. Moreover, the comparison between Column (2) and (3) reveals that different impact by higher exposure to the securitization market is notably reduced after controlling for the bank holding company fixed effects. Perhaps surprisingly, the additional effects due to higher exposure to the weak borrowers still exist even after the inclusion of bank

[17] Since DealScan only provides lenders' information at the bank holding company level, we re-define the exposure to weak borrowers as the fraction of commercial bank loans that are real estate loans (RIAD 4246 in Commercial Bank Call Report).

holding company fixed effects. Such pattern is even stronger when we only consider the sub-sample of commercial banks with above median exposure to the real estate sector. In the subsection that follows, we show that such pattern is mostly caused by some bank holding companies' acquisitions of failed commercial banks which have extremely high pre-crisis exposure to the real estate sector.

[INSERT TABLE D.5 HERE]

5.2 Subsample of Surviving Commercial Banks

The commercial banks with extremely high exposure to the real estate sector experience substantially higher credit loss from the pre-crisis trend even after the inclusion of parent bank holding company fixed effects. This finding is seemingly against our conclusions in the previous empirical tests, in which weak credit demand caused by borrowers from the deteriorating sectors is not the dominant reason for slow credit recovery. In fact, the empirical evidence from the sample covering all commercial banks regardless of merger and acquisition history does not inform us about whether the bank holding company fixed effects fully absorb the difference across comemrcial banks. Indeed, some commercial banks might have been required by their charters to specialize in real estate lending. This may lead to bank failure and the subsequent acquisitions by outside bank holding companies. Meanwhile, some bank holding companies have grown through acquiring failed commercial banks with heavy exposure to the real estate sector. In either cases, bank holding company fixed effects may not explain the variations across commercial banks. In another word, the effect of systemic bailout expectations on shadow bank subsidiaries is irrelevant to the credit growth of commercial bank subsidiaries before acquisitions. Before proposing the strategy to resolve this issue, we provide two examples of bank acquisitions during the aftermath of subprime crisis to illustrate our argument.

Acquisition of Guaranty Bank by BBVA Compass: Guaranty Bank (Texas) was the second largest commercial bank in Texas, with 162 branches across Texas and California and $13 billion in assets at the end of the first quarter of 2009. BBVA Compass is an US-based bank holding company and is the subsidiary of BBVA (the second largest bank in Spain). According to its charter, Guaranty Bank is required to keep 70% of its assets in housing related investments. This requirement has led to extremely high exposure to the housing market collapse risk. To make it worse, in April 2009, the Office of Thrift Supervision ordered Guaranty Bank to write off its loss in mortgage-backed securities related business. This order has cost the bank a total amount of $1.5 billion capital, which

left the bank with inadequate Tier 1 capital ratio. As a result, the bank's share price plummeted from $18.50 to 15 cents by the end of the second quarter. Eventually, the majority of bank assets were taken by the Federal Deposit Insuarance Corporation (FDIC) and sold to BBVA Compass, a bank holding company which had no presence in California and low presence in Texas before the acquisition.

Acquisitions of IndyMac and other commercial banks by OneWest Bank: OneWest Bank is a bank holding company that was founded at March 19, 2009. Since its establishment, OneWest Bank has grown through acquiring failed commercial bank assets that are closely related with mortgages or mortgage-backed securities. For instance, it began operations immediately after acquiring distressed assets of the Independent National Mortgage Corporation (also called IndyMac Bank, the seventh largest mortgage originator in the US until its failure) from the FDIC. On December 18, 2009, it completed the acquisition of First Federal Bank of California ($6 billion in assets and $5 billion in deposits). On February 19, 2010, it aquired La Jolla Bank ($4 billion in assets and $3 billion in deposits). Obviously, the development of OneWest Bank is through acquiring outside commercial banks.

As illustrated by the examples above, the parent bank holding company could be unrelated with its commercial bank subsidiaries especially before acquisitions. If the acquisition of failed commercial banks is a result of commercial banks' excessive pre-crisis exposure to distressed borrowers, higher exposure to the real estate sector could be followed by significant bank credit deviations from the trend even after controlling for bank holding fixed effects. Thus, we consider a subsample that only includes commercial banks with a full history (2005Q1-2012Q4) of affiliations to their parent bank holding companies. Table D.6 reports the fixed effect regression results. Importantly, with the filtered sub-sample, the additional effects on post-crisis credit growth following higher exposure to the weak borrower decreases substantially after the inclusion of parent bank holding company fixed effects.

[INSERT TABLE D.6 HERE]

6 A Model of the Banking System

We presents a model of the modern banking system that features both commercial banks and shadow banks. What connects commercial banks and shadow banks is the "originate-to-distribute" (OTD) securitization market, where commercial banks originate mortgages and sell part of them to shadow banks that have an exclusive technology of portfolio diversification. we discuss key assumptions of the model in Section 6.3.

In the model, each commercial banker issues mortgages that are funded by risk-less deposits. To circumvent regulatory equity requirement, commercial bankers sell a portion of their mortgages to shadow bankers. However, the OTD business model goes hand in hand with a moral hazard problem–commercial banks may not screen and monitor the mortgages that are supposed to be transferred from their balance sheets to shadow banks. Thus, risk retention during securitization is necessary, where a certain fraction of the mortgages that has been securitized is required to be insured by commercial banks. Moreover, the degree of risk retention is higher as the market value of securitized mortgages is lower, since monitoring provides less extra value to commercial banks. Because the market value of securitized mortgages is determined by the liquidity position in shadow banks, the second half of the model draws attention to various bonds issuance strategies that are available to shadow banks.

Shadow banks have access to three types of security issuance strategies: non-defaultable bonds, defaultable bonds, and option-like catastrophe bonds. All three bonds require portfolio diversification. In line with Gennaioli, Shleifer, and Vishny (2013), the non-defaultable bonds guarantees creditors a risk-less return and improves financial stability. The defaultable bonds (DB), however, allow occasional default but is associated with higher leverage. Finally, the option-like catastrophe bonds (CB) that only repays a full amount in the bad state. Catastrophe bonds emerge as government provides at least partial bailout guarantees to shadow banks and feature a higher leverage when the bailout guarantee is generous enough. The latter two strategies is different from the first one in two perspectives. First, the defaultable bonds and the catastrophe bonds require government bailout guarantee with a certain probability. Second, since bailouts are systemic in a manner that creditors will be guaranteed only when all the shadow banks default on the same type of bonds, shadow banks are incentivized to hold a substantial amount of market portfolio so that they are exposed to systemic risk and the banking system is fragile.

6.1 Model Set-up

Agents and Environment Time is discrete and infinite. There are competitive and risk-neutral investors who can lend any amounts as long as they are promised an expected payoff of $1+r$. Meanwhile, there are also overlapping generations of bankers who live for two periods and have linear preferences over consumption goods: $c_t + \frac{1}{1+r}c_{t+1}$, where $1+r$ is the risk free rate. Commercial bankers and shadow bankers are both endowed with one unit of banking labor ($l_t^j = 1$, $j \in \{c, s\}$). In the first period of her life, a banker supplies inelastically her unit labor. At the end of the first period, she receives wage income v_t^j and uses it as net worth w_t^j for banking activities. In the second period of her life, a banker receives profit and consumes.

Investment Projects Commercial bankers are located on "islands" indexed by $i \in \Omega_I$. Each island bears idiosyncratic shocks that follow $\theta_{i,t} \sim F_{\theta,\omega}$ and $\theta_{i,t} \in \Omega_\theta \equiv \left[\underline{\theta}, \bar{\theta}\right]$, where $\omega \in \{g, b\}$ indicates aggregate state (i.e. good or bad). A bad state b arrives with a probability λ and a lower expected value of $\theta_{i,t}$ (i.e. $E_b\left[\theta_{i,t}\right] < E_g\left[\theta_{i,t}\right]$). The island specific productivity $Z_{i,t}^j$ is dependent on idiosyncratic risk $\theta_{i,t}$ and capital $k_{i,t}^j$ funded by commercial banks and shadow banks. More specifically, $Z_{i,t}^c = \theta_{i.t}\left(k_{i,t}^c\right)^{1-\alpha}$ and $Z_{i,t}^s = \theta_{i.t}\left(k_{i,t}^s\right)^{1-\beta}$.

Besides consumption goods, there are also mortgages (i.e. investment goods) in the economy with relative price $p_t = p_t^{Mortgage}/p_t^{Consumption}$. Capital in an investment project can is funded by mortgages issued by bankers in the previous period and fully depreciates after one period (i.e. $k_t^c = I_{t-1}^c$ and $k_t^s = I_{t-1}^s$)[18]. For securitized mortgages, the realized value of $\theta_{i,t+1}$ at $t+1$ is dependent on whether commercial bankers on the same island have screened and monitored mortgage quality during securitization. Without screening and monitoring, we assume $\theta_{i,t+1} = \underline{\theta}$ for $\omega \in \{g, b\}$. Otherwise, $\theta_{i,t+1}$ is drawn from its distribution $F_{\theta,\omega}$. All young bankers maximize their expected profit immediately after knowing aggregate state ω. Since idiosyncratic shocks are uncorrelated across islands, and they are realized at the end of each period, it is convenient to write the optimization problem by dropping the i-subscript[19].

C-Banks Commercial bank (thereafter C-bank) i produces mortgages y_t^c using bank funded capital

[18]This set-up is in line with Kalantzis, Ranciere, and Tornell (2015) and Begenau and Landvoigt (2017) where bankers invest in borrowers' capital.

[19]In the rest of this paper, we will drop i-subscript for convenience. However, one should keep in mind the model describes bankers' decisions on each island, and later we will aggregate the credit growth and return on equity for all the islands.

k_t^c and young banker's labor l_t^c , and operates a Cobb-Douglas production technology

$$y_t^c = Z_t^c \left(k_t^c\right)^{\alpha} \left(l_t^c\right)^{1-\alpha} \tag{7}$$

In the beginning of each period t, aggregate state ω is known, and young C-bankers decides (i) a fraction $1-\phi_t$ of mortgages that they intend to obtain from old C-bankers[20], and (ii) whether they will screen and monitor the quality of the mortgage pool transferred to shadow banks (χ_t[21]). Since young C-bankers choose ϕ_t at the beginning of t, whereas θ_t is unknown until the end of t, the amount of mortgages inherited by young C-bankers is based on the expected output given only aggregate state ω[22]

$$I_t^c = (1-\phi_t)\, E_{\omega}\left[y_t^c\right] \tag{8}$$

Meanwhile, the rest of mortgages are purchased by young shadow bankers (thereafter S-bankers). Since young C-banks may not screen and monitor the quality of transferred mortgages, the input for young S-bankers at the beginning of t is

$$I_t^s = \phi_t \left(\chi_t E_{\omega}\left[y_t^c\right] + (1-\chi_t)\, \underline{\theta} I_{t-1}^c\right) \tag{9}$$

To fund their investment projects, young C-bankers use their wage income v_t^c as net worth and issue deposit that guarantee safe return at the end of her first period. Thus, the budget constraint of a C-bank is $p_t I_t^c \leq w_t^c + b_t^c$ where $w_t^c = v_t^c$. Both wage and deposit are denominated by consumption goods for young C-bankers to purchase mortgages from old C-bankers. The deposit b_t^c promises a repayment $L_{t+1}^c = (1+r)b_t^c$ and is fully guaranteed by the government. With that being said, the old C-banker i's cash flow at $t+1$ is $p_{t+1}y_{t+1}^c - v_{t+1}^c l_{t+1}^c - L_{t+1}^c$ if she is solvent, but is zero if she is insolvent[23].

Since monitoring securitized mortgages is costly to C-banks, a moral hazard problem arises during securitization. Thus, buyers (S-bankers) have to ask C-bankers to insure against a certain fraction φ_t of transferred mortgages. For each dollar of insured mortgages, C-banks pays mortgage

[20] $1-\phi_t$ can be understood as the investment share within the commercial banking sector, while ϕ_t is the securitization scale.

[21] χ_t indicates the monitoring decision, which is equal to 1 if C-banks monitors the quality of the transferred mortgage pool at t.

[22] Such notion of decision making before idiosyncratic risk realization captures the delay from mortgage origination to final sales in the originate-to-distribute business model (Purnanandam, 2010) and, more importantly, guarantees single price in the securitization market such that arbitrage across islands is impossible.

[23] C-banker i is insolvent if $p_{t+1}y_{t+1}^c - v_{t+1}^c l_{t+1}^c - L_{t+1}^c < 0$.

buyers $E_t[\theta_{t+1}] - \theta_{t+1}$ after θ_{t+1} is realized. Given that $\theta_{t+1} = \underline{\theta}$ without monitoring, the incentive-compatibility (risk retention) constraint imposed by S-bankers is

$$\varphi_t p_t I_t^s \left(E_t[\theta_{t+1}] - \int \theta_{t+1} dF(\theta) \right) + C_t \leq \varphi_t p_t I_t^s \left(E_t[\theta_{t+1}] - \underline{\theta} \right) \tag{10}$$

where $C_t = C(w_t^s)$ is an upfront cost of screening mortgage quality at t which is linear in buyer's equity size: $C(w_t^s) = c \cdot w_t^s$[24]. Under this constraint, C-banks are granted partial ownership of securitized mortgage, with which they are responsible for all the return uncertainty. Thus, the required risk retention fraction set by S-bankers satisfies $\varphi_t \geq \dfrac{C_t \cdot E_t[\theta_{t+1}]}{p_t I_t^s \left(E_t[\theta_{t+1}] - \underline{\theta} \right)}$.

The profit maximization problem of young C-bankers at t is

$$\max_{\phi_t, \chi_t} E_t \left[\delta \zeta_{t+1}^c \left(p_{t+1} y_{t+1}^c - v_{t+1}^c l_{t+1}^c - L_{t+1}^c \right) - \chi_t C_t \right]$$

where $\delta = 1/(1+r)$ is the discount rate, ζ_{t+1}^c is equal to 1 if the C-bank is solvent, and the risk retention constraint (10) holds. Moreover, C-banks are subject to the equity requirement

$$\kappa p_t \left(I_t^c + \varphi_t I_t^s \right) \leq w_t^c \tag{11}$$

where C-banks' minimum equity holding is a fixed multiple κ of total assets plus the insured mortgage portfolio. The timing is illustrated in Fig. 9 at the end of this subsection.

S-Banks The S-banks are also located on different islands, where young S-bankers manage capital funded by mortgages with Cobb-Douglas production technology

$$y_t^s = Z_t^s \left(k_t^s \right)^\beta \left(l_t^s \right)^{1-\beta} \tag{12}$$

and use net worth w_t^s and S-bank bonds b_t^s to purchase the mortgages from C-banks. However, since the securitization transaction is accomplished before $\theta_{i,t}$ is known, the market clearing condition is conditional on the aggregate state: $p_t \phi_t E_\omega [I_t^s] = E_\omega [w_t^s + b_t^s]$. Taking as given the amount of mortgages transferred from C-banks, the market value of the mortgage, p_t, is contingent upon the liquidity in the S-banks.

In contrast to C-banks, S-banks are subjected to less regulations. First, there is no minimum

[24] Alternatively, one could model monitoring cost as a fixed cost or a function of securitized mortgage pool size. However, we will show in the next section that the current formulation is the simplest one that ensures we have binary risk retention scale $\varphi_t \in \{\varphi_H, \varphi_L\}$ over time.

equity requirement imposed on S-banks. Second, S-bankers are allowed to issue bonds with default risk. Section 6.2 elaborates on three types of S-bank bonds. Third, S-bankers may divert all the funds they have raised without committing to promised repayment.

An S-bank's borrowing constraint arises when creditors impose a non-diversion constraint, but the tightness of borrowing constraint is dependent on creditors' choice of S-bank bonds. To implement a diversion scheme in the second period of her life, an S-banker has to incur a liquidation cost that is proportional to total investable funds $h[w_t^s + b_t^s]$, in which h measures law enforceability and loss in the process of assets liquidation. S-bankers will not divert as long as the diversion cost surpasses the current value of expected repayment $E_t\left[L_{t+1}^s\right]$

$$\delta E_t\left[L_{t+1}^s\right] \leq h\left[w_t^s + b_t^s\right] \tag{13}$$

The profit maximization problem of a young S-banker at t is

$$\max_{\Omega_{B,t},\xi_t} E_t\left[\delta\zeta_{t+1}^s\left(p_t y_{t+1}^s - v_{t+1}^s l_{t+1}^s - (1-\xi_t)L_{t+1}^s\right) - \xi_t h\left(w_t^s + b_t^s\right)\right]$$

where ζ_{t+1}^s is equal to 1 if the S-banker does not default, ξ_t is equal to 1 if she sets up a diversion scheme at t, and $\Omega_{B,t}$ is a menu of bonds issuance strategies.

Without the occurrence of default at t, a young S-banker's net worth is her competitive wage $w_t^s = v_t^s = (1-\beta)p_{t-1}y_t^s$. Otherwise, default leads to old S-bankers' revenue being wiped out and young S-bankers' net worth becoming $w_t^s = \mu p_{t-1}y_t^s$[25].

[25] Default procedure causes substantial loss to banks and I assume what can be recovered by young S-bankers is tiny ($\mu < 1-\beta$).

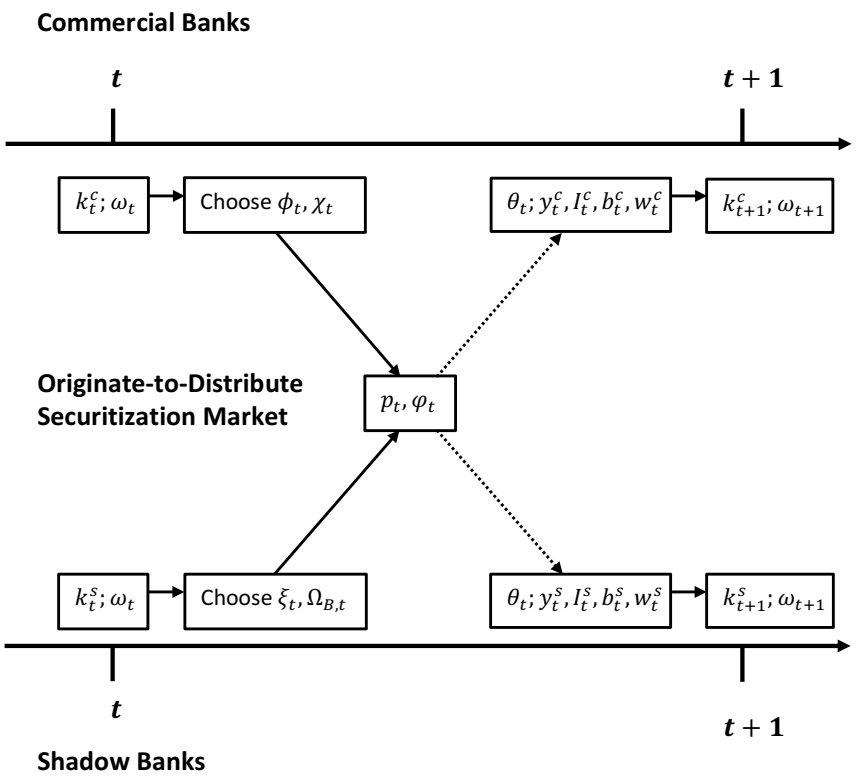

Fig. 9. Timeline from t to $t+1$. This figure illustrates the timeline of the full model. Aggregate state is known in the beginning of each period. C-bankers and S-bankers maximize expected profit in the second period of their life by choosing $\{\phi_t, \chi_t\}$ and $\{\xi_t, \Omega_{B,t}\}$, which pins down the price p_t and risk retention degree φ_t in the originate-to-distribute securitization market. With the realization of θ_t at the end of period t, all the investment and capital structure are settled. Afterwards, young C-bankers and S-bankers enter period $t+1$ and consume their realized profit at the end of $t+1$.

6.2 Shadow Bank Bonds

S-banks offer a menu with three types of bonds. The first type, non-defaultable standard bonds, is risk-less. However, the other two types, defaultable standard bonds and catastrophe bonds, feature occasional defaults. This subsection presents the detail of these bonds.

Non-Defaultable Standard Bonds (NB) S-banks are different from C-banks not only because of loose regulations, but also due to their access to other islands for swapping mortgage portfolio (i.e. risk diversification). Therefore, the pool of S-bank i's original mortgages that is diversified has a sure productivity in each aggregate state of next period $Z_{t+1}^{s,\omega} = E_\omega\left[\theta_{t+1}\right]\left(k_{t+1}^s\right)^{1-\beta}$. Ex ante, the diversified pool and undiversified pool have the same unconditional expectations on θ_{t+1} (i.e. $E_t\left[\theta_{t+1}\right] = (1-\lambda)E_g\left[\theta_{t+1}\right] + \lambda E_b\left[\theta_{t+1}\right]$). Denote the fraction of original mortgage that is diversified

as η_t. The expected amount of mortgages generated by S-banks in the next period is

$$E_t\left[y_{t+1}^s\right] = \eta_t \underbrace{\left((1-\lambda)E_g\left[\theta_{t+1}\right] + \lambda E_b\left[\theta_{t+1}\right]\right) I_t^s}_{\text{diversified pool}} + (1-\eta_t) \underbrace{E_t\left[\theta_{t+1}\right] I_t^s}_{\text{undiversified pool}} \tag{14}$$

Furthermore, after paying wage to young S-bankers at $t+1$, old S-bankers are still able to fully repay NB creditors in the most unlucky realization of productivity (i.e. $\theta_{t+1} = \underline{\theta}$):

$$(1+r)b_t^s \leq \beta\left(\eta_t \cdot E_b\left[\theta_{t+1}\right] + (1-\eta_t)\underline{\theta}\right) p_t I_t^s \tag{15}$$

Note that Condition (15) guarantees the stability of S-banks. Accordingly, government bailout guarantee is unnecessary under the issuance of NB.

Finally, since $E_t\left[L_{t+1}^s\right] = (1+r)b_t^s$, the non-diversion constraint is

$$\delta(1+r)b_t^s \leq h(w_t^s + b_t^s) \tag{16}$$

which limits the leverage ratio of S-banks who issue NB. With the leverage ratio that meets Condition (16), one determines the minimum diversification scale η_t through Condition (15).

Defaultable Standard Bonds (DB) NB characterizes the shadow banking system that is repressed by infinitely risk-averse creditors. However, with risk-neutral investors, S-banks may also issue bonds with default risk. The key assumption in this model is that the government bailouts to S-banks is systemic. Therefore, S-bankers intend to be exposed to systemic risk to the extent that all of them become insolvent simultaneously. This can be accomplished when S-banks diversify an enough portion of their mortgage pool such that

$$(1+\rho_t)b_t^s \leq \beta\left(\eta_t E_g\left[\theta_{t+1}\right] + (1-\eta_t)\underline{\theta}\right) p_t I_t^s \tag{17}$$

$$(1+\rho_t)b_t^s \geq \beta\left(\eta_t E_b\left[\theta_{t+1}\right] + (1-\eta_t)\bar{\theta}\right) p_t I_t^s \tag{18}$$

where Condition (17) ensures that all shadow banks are solvent in the good state even when all islands encounter $\theta_{t+1} = \underline{\theta}$, and Condition (18) guarantees systemic insolvency in the bad state even when all islands end up with $\theta_{t+1} = \bar{\theta}$.

Given systemic insolvency of S-banks, DB creditors expect government could step in and guarantee them with a probability u. Thus, creditors are willing to hold DB as long as

$$1 + r = (1 - \lambda + \lambda u)(1 + \rho_t) \tag{19}$$

where the right hand side of Equation (19) validates that creditors are fully repaid when 1) good state arrives or 2) bad state arrives but government guarantees creditors.

The non-diversion constraint is in a similar fashion as that for NB with the exception that S-bankers now have full liabilities to creditors only in the good state

$$\delta (1 - \lambda)(1 + \rho_t) b_t^s \leq h (w_t^s + b_t^s) \tag{20}$$

Catastrophe Bonds (CB) Behaving like a credit default swap issuer, issuer of catastrophe bonds repays creditors a small premium $L_{t+1}^s = \Delta$ if she is solvent, but promises to repay $L_{t+1}^s = (1+\rho_t)b_t^s$ she turns out to be insolvent. In order to obtain systemic bailouts in case of default, Conditions (17) and (18) still hold for S-banks who issue CB. Thus, S-bankers either pay an infinitesimal amount Δ to creditors in the good state or default on CB and exploit systemic bailouts in the bad state. Note the non-diversion constraint is never binding for issuers of CB. In the model, I assume government purchases S-banks' assets $w_t^s + b_t^s$ with a predetermined price g. Thus, risk-neutral creditors are willing to hold CB as long as

$$(1 + r)b_t^s = (1 - \lambda)\Delta + \lambda u g(w_t^s + b_t^s) \tag{21}$$

For simplicity, I set $\Delta \to 0$ so that S-banks have no liabilities to creditors in the good state. The interest rate, hence, can be derived as $1 + \rho_t = g(w_t^s + b_t^s)/b_t^s$.

6.3 Discussion of the Model Set-up

Originate-to-Distribute Securitization: In the model, C-banks and S-banks are connected through the originate-to-distribute (OTD) securitization model. C-banks originate mortgages and sell a portion of originated mortgage portfolio to S-banks who have the capability to diversify idiosyncratic risk of transferred mortgage pool. Such OTD model is a substitution of the traditional originate-to-hold model and became especially popular after the Gramm–Leach–Bliley Act which

removed the barrier among commercial banks, investment banks, security companies, insurance companies, etc. Bord and Santos (2012) document the rise and evolution of the OTD model with the U.S. loan level data.

Moral Hazard in Securitization: The moral hazard problem arises with the prevalence of the OTD securitization model in the banking sector. Lack of incentives to monitor securitized mortgage quality[26] is documented by Ashcraft and Schuermann (2008) as one of seven agency problems that arise in the securitization market. In this model, the moral hazard problem emerges because monitoring the quality of securitized mortgages is costly to C-bankers. As such, S-banks require C-banks to retain a certain fraction of securitized mortgages so that the latter may have enough monitoring incentive. Such risk retention through mortgage risk insurance is studied in Acharya, Schnabl, and Suarez (2013) who found asset-backed commercial paper conduits that are sponsored by commercial banks retained most mortgage risk within the banking sector. The set-up of risk retention is in line with many theoretical papers in modeling agency problems over the course of loan sales (e.g. Pennacchi, 1988; Gorton and Pennacchi, 1995; Parlour and Plantin, 2008).

Catastrophe Bonds: The catastrophe bonds in our model are theoretical securities that capture out-of-the-money (OTM) put options and credit default swaps (CDS). The similarity between these two types of securities is that they promise to repay only if a bankruptcy state realizes. However, the toxic cocktail that combines catastrophe bonds and government bailouts guarantee could lead to a "financial black-hole" where negative net present value projects are funded (Ranciere and Tornell, 2012). In the model extension, we argue that the issuance of shadow bank catastrophe bonds could also lead to the break-down of financial discipline where risk retention constraint does not hold any more.

7 Analysis

The equilibrium of the model is a set of choices made by C-bankers and S-bankers across islands. They follow a credit market game *a la* Schneider and Tornell (2004) and Ranciere and Tornell (2016). When aggregate state ω is known, young C-banks decides the scale of securitization ϕ_t and whether

[26]Such information friction also appears as adverse selection in which arrangers (C-banks) securitize bad loans to third parties (S-banks) and keep the good ones.

they will monitor securitized mortgages χ_t. Young S-bankers decide a diversion scheme ξ_t, a risk retention requirement for C-banks φ_t, and a menu of bonds issuance plans $\Omega_{B,t} = \{B_t^{NB}, B_t^{DB}, B_t^{CB}\}$. Each plan is characterized by a set of decisions on interest rate, leverage, and diversification scale made by S-bankers: $B_t^k = (\rho_t^{s,k}, \Gamma_t^{s,k}, \eta_t^{s,k})$, where $k \in \{NB, DB, CB\}$. The market value p_t of banking goods (I_t^c and I_t^s) is determined such that securitization market clears. All the decisions are made before θ_t is realized.

Definition: *An equilibrium of the model consists of a collection of stochastic processes* $(\phi_t, \chi_t, \xi_t, \Omega_{B,t}, I_t^c, I_t^s, y_t^c, y_t^s, w_t^c, w_t^s)$ *and a set of prices* (p_t, v_t^c, v_t^s) *such that on each island:*

(1) The profit maximization problems of C-banks and S-banks are solved;

(2) The securitization market of mortgages (I_t^s) *and the labor market of bankers* (l_t^c,l_t^s) *clear;*

(3) Young bankers at $t = 0$ *are endowed with net worth* $w_0^c = (1-\alpha)p_0 y_0^c$ *and* $w_0^s = (1-\beta)y_0^s$*, and net worth of bankers during* $t \geq 1$ *evolves such that* $w_t^c = v_t^c$ *and*

$$w_t^s = \begin{cases} v_t^s & \textit{if solvent} \\ \mu p_{t-1} y_t^s & \textit{if insolvent} \end{cases}$$

In the rest of this section, I characterize the optimal decisions of C-banks and S-banks in the equilibrium. Multiple equilibria emerges for S-banks because of less restrictions on bonds issuance and the existence of systemic bailout guarantee to creditors of S-banks. Then, I take stock and analyze the growth of total credit in each equilibrium, which varies when the probability of bailout guarantee changes.

7.1 C-Bank Optimization in Equilibrium

Young C-bankers' optimal decision at t includes a securitization scale ϕ_t and a monitoring choice χ_t. Moreover, young C-bankers' net worth at t is the competitive wage $w_t^c = v_t^c = (1-\alpha)\, y_t^c$. Given the risk retention constraint, we can derive the payoff of C-banks at $t+1$ as

$$\pi^c_{t+1} = \max\left\{\alpha p_{t+1} y^c_{t+1} - b^c_t(1+r), 0\right\} = \max\left\{\alpha p_{t+1}\theta_{t+1} I^c_t - (1-1/\Gamma^c_t) p_t I^c_t (1+r), 0\right\}$$
$$= \Gamma^c_t w^c_t \left(1\left[\theta_{t+1} \geq \frac{(1-1/\Gamma^c_t)(1+r)}{\alpha\cdot(p_{t+1}/p_t)}\right](\alpha\theta_{t+1}p_{t+1}/p_t - (1-1/\Gamma^c_t)(1+r))\right) \tag{22}$$

where $\Gamma^c_t = p_t I^c_t / w^c_t$ is the leverage ratio of C-banks at t. Taking the expectation of this expression with respect to θ_{t+1}, one obtains

$$E_t\left[\pi^c_{t+1}\right] = \Gamma^c_t w^c_t \left[\left(1 - F_\theta\left(\frac{(1-1/\Gamma^c_t)(1+r)}{\alpha\cdot(p_{t+1}/p_t)}\right)\right)\left(\alpha\theta^+_{t+1}p_{t+1}/p_t - (1-1/\Gamma^c_t)(1+r)\right)\right] \tag{23}$$

where $F_\theta\left(\frac{(1-1/\Gamma^c_t)(1+r)}{\alpha\cdot(p_{t+1}/p_t)}\right)$ is C-bank's probability of being insolvent at $t+1$ based on the cumulative distribution function of θ_{t+1}, and $\theta^+_{t+1} \equiv E_t\left[\theta_{t+1} \mid \theta_{t+1} \geq \frac{(1-1/\Gamma^c_t)(1+r)}{\alpha\cdot(p_{t+1}/p_t)}\right]$ is the expectation of idiosyncratic shock conditional on survival. Notice that the price p_t of mortgages at t is a decreasing function of the securitization scale ϕ_t. Thus, we obtain the following relation between securitization scale and C-banks' expected profit at t.

Lemma 1. (C-Banks' Expected Profit)

The expected profit of young C-banks at t is higher when the securitization scale ϕ_t is lower.

$$\frac{\partial E_t\left[\pi^c_{t+1}\right]}{\partial \phi_t} \leq 0$$

Proof. For the proof, see Appendix A.1. □

Thus, maximizing C-banks' expected profit requires minimizing their securitization scale ϕ_t. However, the minimum equity requirement (11) kicks in and sets a lower bound for the securitization scale. The proposition that follows characterizes C-bankers' optimal decisions on securitization scale, leverage, and monitoring.

Proposition 1. ***(C-Banks: Securitization Scale, Leverage, and Monitoring)***

C-bankers' profit maximizing decisions on securitization scale ϕ_t, leverage Γ^c_t, and monitoring χ_t are all determined by risk retention degree φ_t. That is,

$$\phi_t = \frac{1-(1-\alpha)/\kappa}{1-\varphi_t}, \quad \Gamma^c = \frac{1}{\kappa}\left(1 + \frac{\phi_t}{1-\phi_t}\varphi_t\right) \tag{24}$$

and $\chi_t = 1$ *if* $\varphi_t \geq c \cdot E_t\left[\theta_{t+1}\right] / \left[\left(E_t\left[\theta_{t+1}\right] - \underline{\theta}\right)\Gamma_t^s\right]$.

Proof. Following the minimum equity requirement at t in Condition (11), it is straightforward to show that the lower bound for the securitization scale is $\phi_t \geq \underline{\phi}_t \equiv \dfrac{1-(1-\alpha)/\kappa}{1-\varphi_t}$. Since Lemma 1 shows that $E_t\left[\pi_{t+1}^c\right]$ is negatively related with ϕ_t, we conclude that $\phi_t = \underline{\phi}_t$ for C-bank profit maximization. Finally, since $C(w_t^s) = c \cdot w_t^s$, the risk retention degree φ_t set by mortgage buyers (S-bankers) is a function that is decreasing in the leverage ratio Γ_t^s. □

Proposition 1 presents the optimal decision of C-bankers. Minimizing securitization scale leads to higher expected profit. However, C-banks may still securitize and transfer a fraction of their mortgage pool to S-banks for maintaining a minimum equity requirement. This is in line with the theoretical literature on motivations of mortgage securitization (e.g. Pennacchi 1988, and Parlour and Plantin 2008) and the empirical literature on regulatory arbitrage in the process of securitization (e.g. Acharya and Schnabl 2009; Acharya, Schnabl, and Suarez 2013; Adrian and Shin 2009; Nadauld and Sherlund 2009; Pozsar et. al. 2012). Moreover, notice that risk retention degree φ_t connects C-banks and S-banks through transactions in the securitization market. On one hand, φ_t determines the optimal decisions made by C-bankers. On the other hand, S-bank's leverage ratio Γ_t^s governs the magnitude of φ_t. The latter is legitimate because shadow banks with higher leverage ratio can generate higher market value of securitized mortgages, which increases the value of monitoring mortgages to C-banks.

7.2 S-Bank Optimization in Equilibria

As described in the set-up of the model, S-banks issue three types of bonds. Here, I characterize symmetric equilibria under the issuance of non-defaultable standard bonds (NB), defaultable standard bonds (DB), and catastrophe bonds (CB).

Proposition 2. ***(S-Banks: Symmetric Equilibria)***
There exists three S-bank symmetric equilibria paths featuring one of three bonds among $\{NB, DB, CB\}$.
Moreover, given aggregate state ω *at* t*, the following conditions hold for each equilibrium:*
(1) Only one type of S-bank bonds is funded during tranquil periods where the interest rates on bonds $1+\rho_t^s$ *are respectively*

$$1+\rho_t^{s,NB} = 1+r, \quad 1+\rho_t^{s,DB} = \begin{cases} \dfrac{1+r}{1-\lambda+\lambda u} & \text{when } t \neq \tau \\ 1+r & \text{when } t = \tau \end{cases}, \quad 1+\rho_t^{s,CB} = \begin{cases} \dfrac{1+r}{\lambda u} & \text{when } t \neq \tau \\ 1+r & \text{when } t = \tau \end{cases}$$

where τ denotes crisis periods.

(2) S-banks' leverage ratio, which is defined as $\Gamma_t^s \equiv (w_t^s + b_t^s)/w_t^s$, for each symmetric equilibrium is

$$\Gamma_t^{s,NB} = \frac{1}{1-h}, \quad \Gamma_t^{s,DB} = \begin{cases} \dfrac{1}{1-h\left(1+\lambda u/(1-\lambda)\right)} & \text{when } t \neq \tau \\ \dfrac{1}{1-h} & \text{when } t = \tau \end{cases}, \quad \Gamma_t^{s,CB} = \begin{cases} \dfrac{1}{1-\lambda\delta ug} & \text{when } t \neq \tau \\ \dfrac{1}{1-h} & \text{when } t = \tau \end{cases}$$

(3) S-banks hold a portion $\eta_t \geq \bar{\eta}^k$ of market portfolio such that Condition (15) holds for $\bar{\eta}^{NB}$ and Condition (17) and (18) hold for both $\bar{\eta}^{DB}$ and $\bar{\eta}^{CB}$. The realized output at the end of $t+1$ is $y_{t+1}^s = \left[\eta_t E_\omega\left[\theta_{t+1}\right] + (1-\eta_t)\theta_{t+1}\right] I_t^s$.

(4) S-banks takes on systemic risk when issuing DB and CB such that all S-banks are insolvent when the bad state arrives, during which creditors are expected to be bailed out with a probability u. However, systemic bailouts cannot be granted in consecutive periods. Thus, DB and CB would not be funded during a crisis period, but the issuance may resume immediately afterwards.

(5) Given realized w_t^s at the end of t, the net worth w_{t+1}^s evolves such that

$$w_{t+1}^s = \begin{cases} (1-\beta)p_t y_{t+1}^s & \text{when } t+1 \neq \tau \\ \mu p_t y_{t+1}^s & \text{when } t+1 = \tau \end{cases}$$

for DB and CB, or $w_{t+1}^s = (1-\beta)p_t y_{t+1}^s$ for NB.

Proof. For the proof, see Appendix A.2. □

According to this proposition, only one type of bonds is funded in a symmetric equilibrium. This is because the bailouts to S-bankers are granted systemically, on condition that all S-bankers simultaneously default on the same type of bonds. Thus, any collections of heterogeneous decisions are unstable. Without all the S-banks defaulting on the same type of bonds, systemic bailouts would not be granted.

Moreover, the equilibrium with NB distinguishes itself from the other two equilibria in two perspectives. First, issuing NB is safe to creditors. Thus, the shadow banking sector is stable and does not present boom and bust cycles. However, in the other two risky symmetric equilibrium paths, a substantial amount of young S-banker's net worth is wasted in the event of default (see Proposition 2(5)). Second, although all the three equilibria require certain degree of mortgage pool diversification, the reasons are distinct. For issuers of NB, mortgage pool diversification is associated

with the purpose of ensuring solvency even with the worst realization of idiosyncratic risk $\theta_{t+1} = \underline{\theta}$. However, issuers of DB and CB intend to take enough systemic risk so that systemic bailout guarantee is granted in the bad state. Thus, the systemic risk taking allows issuers of DB and CB to operate with a higher leverage within a certain range of u. The following corollary compares the leverage ratio of S-banks in different symmetric equilibria.

Corollary 1. ***(S-Bank Leverage Ratio)***

The leverage ratio of S-banks who issue non-defaultable bonds $\Gamma^{s,NB}$ is independent of the systemic bailout probability u. Yet, both $\Gamma_t^{s,DB}$ and $\Gamma_t^{s,CB}$ are increasing in u when $t \neq \tau$. Given restriction that $g \geq h/\left[\lambda(1-\lambda)\right]$, the relations of these three leverage ratio at $t \neq \tau$ are as follows: (1) $\Gamma_t^{s,DB} \geq \Gamma_t^{s,NB}$, (2) $\Gamma_t^{s,CB} \geq \Gamma_t^{s,NB}$ if $u \geq \bar{u} \equiv h/(\lambda g)$, and (3) $\Gamma_t^{s,CB} \geq \Gamma_t^{s,DB}$ if $u \geq \bar{\bar{u}} \equiv h/\left[g - h/(1-\lambda)\right]$.

Proof. For the proof, see Appendix A.3. □

7.3 Total Credit Growth

Corollary 1 shows that, within a certain range of bailout probability u, the equilibria with DB and CB relax S-banks' borrowing constraint in the tranquil periods. However, with systemic risk taking and high leverage, the shadow banking sector that issues DB and CB is unstable and prone to the banking crisis caused by systemic insolvency. Thus, the net worth of young S-bankers are mostly wiped out and the leverage is substantially restricted in the crisis periods[27]. With these two contradictory forces generated by systemic risk exposure, we take stock and assess the impact of S-bank bonds issuance on total credit growth. In addition, we treat the safe equilibrium with NB as a benchmark and investigate if issuing risky bonds (DB and CD) is growth enhancing when increasing the likelihood of systemic bailouts guarantee.

In this section, total credit provided by the banking sector includes mortgages held by C-banks and the mortgage pool held by S-banks after securitization. Indeed, besides the traditional commercial banking sector, shadow banks perform as financial intermediaries that channel funds from creditors in the wholesale funding markets to borrowers. Thus, the total credit provided by the banking sector at t is

[27] Note we assume in the model that the systemic bailout guarantee cannot be consecutive. Thus, S-banks may only issue the non-defaultable standard bonds (NB) in the crisis periods.

$$
\begin{aligned}
Credit_t \equiv p_t \left(I_t^c + I_t^s\right) &= \left(\frac{1-\phi_t}{\phi_t} + 1\right)\left(w_t^s + b_t^s\right) \\
&= \begin{cases} \dfrac{1-\beta}{\phi_t} E_g\left[\theta_t\right] \Gamma_t^s \cdot Credit_{t-1} & \text{when } t \neq \tau \\ \dfrac{\mu}{\phi_t} E_b\left[\theta_t\right] \Gamma_t^s \cdot Credit_{t-1} & \text{when } t = \tau \end{cases}
\end{aligned}
$$

where the second equality is derived from conditions (8), (9), and (12). As shown by Proposition 1, the value of ϕ_t is fixed in the equilibrium with NB ($\phi_t = \phi_H$) due to the constant leverage ratio $\Gamma^{s,NB}$. However, ϕ_t is binary overtime in an equilibrium with DB or CB, where $\phi_t \in \{\phi_H, \phi_L\}$ and the lower securitization scale ϕ_L occurs during tranquil or recovery periods.

In the safe equilibrium, S-banks never default on creditors and the leverage ratio $\Gamma^{s,NB}$ is always a constant. Thus, the long-run growth rate of total credit is

$$
\gamma^{NB} \equiv \frac{Credit_t}{Credit_{t-1}} = \frac{1-\beta}{\phi_H} E_\omega\left[\theta_t\right] \Gamma^{s,NB} \tag{25}
$$

which does not depend on the systemic bailout probability u.

However, the risky equilibrium with DB or CB presents systemic banking crises in which all S-banks simultaneously default on creditors. During tranquil periods ($t \neq \tau$), the growth rate of total credit is

$$
\gamma^{k,tr} \equiv \frac{Credit_t}{Credit_{t-1}} = \frac{1-\beta}{\phi_L} E_g\left[\theta_t\right] \Gamma^{s,k} \tag{26}
$$

where $k \in \{DB, CB\}$. Meanwhile, the average growth rate during a crisis period and the following recovery period ($t = \tau$ and $t = \tau + 1$) is

$$
\gamma^{k,cr} = \left(\frac{\mu}{\phi_H} E_b\left[\theta_t\right] \Gamma^{s,NB}\right)^{1/2} \left(\frac{1-\beta}{\phi_L} E_g\left[\theta_t\right] \Gamma^{s,k}\right)^{1/2} \tag{27}
$$

The term in the first brackets captures the growth rate during a crisis period, while the term in the second brackets shows the growth rate during a recovery period immediately after the crisis periods. S-banks only issue NB during a crisis period. Starting from a recovery period, S-banks revert to the previous risky equilibrium path and issue DB or CB.

To derive long-run credit growth path in a risky equilibrium k, we compute the limiting distribution of a three-state Markov chain over three period types: tranquil, crisis, and recovery. We

denote the limiting distribution as Π and the transition matrix as T. Each element $T_{i,j}$ of the transition matrix is the probability of transiting from period type i to period type j. Thus, the limiting distribution follows the pattern that $\Pi = T'\Pi$, with which we can obtain that

$$T = \begin{pmatrix} 1-\lambda & \lambda & 0 \\ 0 & 0 & 1 \\ 1-\lambda & \lambda & 0 \end{pmatrix}, \quad \Pi = \begin{pmatrix} (1-\lambda)/(1+\lambda) \\ \lambda/(1+\lambda) \\ \lambda/(1+\lambda) \end{pmatrix}$$

Accordingly, the long-run average credit growth rate of a risky equilibrium $k \in \{DB, CB\}$ is

$$\gamma^k = \left(\frac{1-\beta}{\phi_L} E_g\left[\theta_t\right] \Gamma^{s,k}\right)^{(1-\lambda)/(1+\lambda)} \left(\frac{\mu}{\phi_H} E_b\left[\theta_t\right] \Gamma^{s,NB}\right)^{\lambda/(1+\lambda)} \left(\frac{1-\beta}{\phi_L} E_g\left[\theta_t\right] \Gamma^{s,k}\right)^{\lambda/(1+\lambda)} \tag{28}$$

We now use the growth rate in the safe equilibrium as a benchmark and study if financial deregulations (i.e. the issuance of DB and CB) is growth enhancing for total credit. With (25) and (28), the percentage difference in credit growth between a risky equilibrium $k \in \{DB, CB\}$ and the safe equilibrium NB is

$$\Delta \log \gamma^k \equiv \log \gamma^k - \log \gamma^{NB} = \frac{\lambda}{1+\lambda} \log\left(\frac{\mu}{1-\beta}\right) + \frac{1}{1+\lambda} \log\left(\frac{\phi_H}{\phi_L}\right) + \frac{1}{1+\lambda} \log\left(\frac{\Gamma^{s,k}}{\Gamma^{s,NB}}\right) \tag{29}$$

By definition, a risky equilibrium k is growth enhancing if and only if $\log \gamma^k - \log \gamma^{NB} > 0$, which is equivalent as the following condition,

$$\Phi(k,u) \equiv \frac{\Gamma^{s,k}}{\Gamma^{s,NB}} \cdot \frac{\phi_H}{\phi_L} > \left(\frac{1-\beta}{\mu}\right)^{\lambda} \tag{30}$$

where $\Phi(k,u)$ measures the benefit to long-run growth due to a risky equilibrium k, whereas $\left(\frac{1-\beta}{\mu}\right)^{\lambda}$ measures the distress cost in crisis periods of a risky equilibrium path. The intuition of Condition (30) is formed on two contradictory effects. First, the risky equilibrium path relaxes S-banks' borrowing constraint. The relaxed borrowing constraint not only leads to higher leverage ratio, but also increases C-bankers' incentive to monitor securitized mortgage quality, which reduces risk retention during securitization. With less risk retention during tranquil periods (lower φ_L and ϕ_L), more credit is originated. Second, tranquil periods with higher credit growth are interrupted by systemic defaults, which gives rise to temporary distress in young S-bankers' net worth and borrowing capacity. The disruption in shadow banking system results in higher risk retention imposed on

mortgage originators (C-banks) and crowds out C-banks' balance sheet capacity for new mortgage originations. With these two effects, a risky equilibrium path k is growth enhancing if and only if the benefit from higher leverage $\Phi(u)$ dominates the cost due to financial distress ($[(1-\beta)/\mu]^{\lambda}$). Since $\Phi(u)$ is increasing in the probability of systemic bailouts u, the value of u is crucial in determining whether a risky equilibrium k is growth enhancing. The following proposition shows the conditions on u such that DB and CB lead to higher long-run credit growth. In other words, without satisfying these conditions on systemic bailouts to creditors of S-banks, deregulations on the shadow banking sector would otherwise restrict long-run credit growth.

Proposition 3. ***(Systemic Bailouts and Credit Growth Enhancing)***

In an economy without deregulations on shadow bank bonds issuance among NB, DB, and CB, and given the following restriction on $\bar{\bar{u}}$ (defined in Corollary 1) for a risky equilibrium $k \in \{DB, CB\}$:

$$\Phi(k, \bar{\bar{u}}) > \left(\frac{1-\beta}{\mu}\right)^{\lambda}$$

There exists two thresholds of systemic bailouts probability, u^* and u^{**} ($u^{**} > u^*$), such that

(1) If $u < u^*$, both risky equilibria restricted long-run total credit growth,

(2) If $u \in [u^*, u^{**})$, only the risky equilibrium with DB is growth enhancing,

(3) If $u \geq u^{**}$, both risky equilibria are growth enhancing.

Proof. For the proof, see Appendix A.4. □

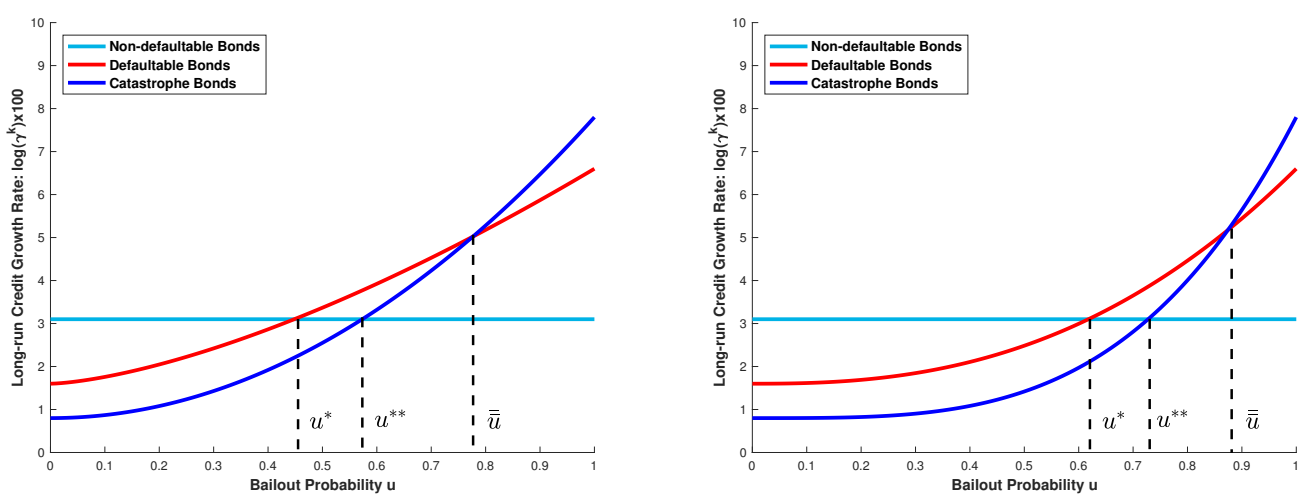

Fig. 10. Growth enhancing thresholds. This figure illustrates the growth enhancing thresholds of systemic bailout probability, u^* and u^{**}. The left panel characterizes the risky equilibrium paths with binary securitization

scale ϕ_H and ϕ_L that are determined by the risk retention constraint. The right panel features constant securitization scale $\phi_t = \phi_H$.

As numerical exercises to illustrate Proposition 3 imply comparative statics, Fig. 10 shows the growth enhancing thresholds of different S-bank bonds given the parameters discussed in Appendix B. We observe characteristics that are consistent with Proposition 3. However, the left panel shows the case where the risk retention constraint (10) leads to a binary securitization scale ϕ_H and ϕ_L. In this case, the growth enhancing thresholds of systemic bailout probability u is moderate ($u^* = 0.46$ and $u^{**} = 0.58$). The right panel, on the other hand, presents the case where the variations of ϕ_t through the risk retention constraint is shut down and $\phi_t = \phi_H$ $\forall t$. Following Condition (30), it requires higher u for the risky equilibrium paths to be credit growth enhancing ($u^* = 0.61$ and $u^{**} = 0.72$).

Fig. 11 provide a comparison of the two risky equilibrium paths (defaultable standard bonds vs. catastrophe bonds). We simulate the equilibrium credit growth paths for 100 periods with the assumption that the systemic crisis happens every 25 periods[28]. By varying the probability u of systemic bailouts to shadow bank creditors in the bad state, we observe that the long-term credit growth path could benefit more substantially from the increase in creditors' belief of systemic bailout likelihood.

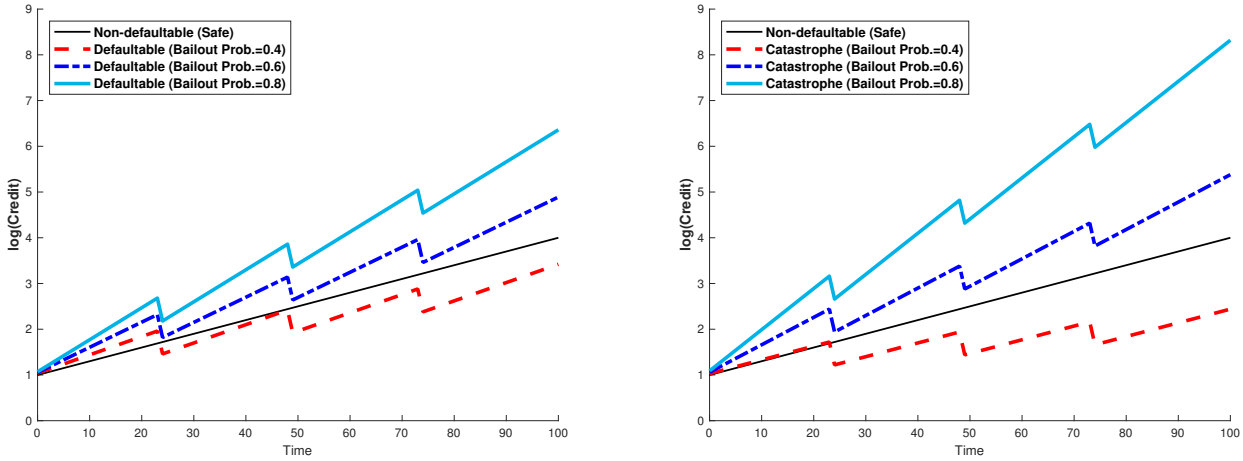

Fig. 11. Growth enhancing effect comparison (DB vs. CB). This figure shows a comparison between the two risky equilibrium paths. The growth paths follow simulations of 100 periods with the systemic banking crisis

[28]Note that this assumption is not strictly equivalent as $\lambda = 0.4$. However, the long-term growth trend with this setting would be the same as the alternative simulation with $\lambda = 0.4$.

happening every 25 periods. We vary the probability of systemic bailouts to shadow bank creditors in the bad state ($u = 0.4, 0.6, 0.8$).

7.4 Comparative Statics

Our model of the modern banking system with multiple equilibria exhibits the difference in long-run total credit growth paths due to different shadow bank bonds and different likelihood of systemic bailouts to shadow banks. Proposition 3 characterizes the conditions of systemic bailouts probability u such that the equilibrium with defaultable or catastrophe shadow bank bonds is growth enhancing. Now, we provide comparative statics for analyzing the impact of shadow bank systemic bailout expectations on long-run bank credit growth. Specifically, I propose three predictions from the model that validate the credit channel through the "originate-to-distribute" securitization market. Our three predictions are mainly obtained through differentiating $\Delta \log \gamma^k$ with respect to systemic shadow bank bailout probability u:

1. $\partial \Delta \log \gamma^k / \partial u > 0$**: An increase in systemic bailout probability increases the long-run credit growth enhancing effect for a risky equilibrium** $k \in \{DB, CB\}$**.** As Equation (29) shows, higher systemic bailout probability u affects long-run the credit growth gap through increasing shadow bank leverage. Higher shadow bank leverage not only increases market value of bank credit, but also reduces the crowding-out effect on new credit caused by risk retention.

2. $\partial \Delta \log \gamma^{CB} / \partial u > \partial \Delta \log \gamma^{DB} / \partial u$**: The growth enhancing effect in Prediction #1 is stronger for the risky equilibrium path with catastrophe bonds (CB).** This relation holds given the restriction of g in Corollary 1. The leverage is more sensitive to the systemic bailout probability u for CB issuers, which contributes to a larger growth enhancing effect characterized in Proposition 3.

3. $\partial \Delta \log \gamma^k / \partial u \partial \left[\phi(1-\varphi)\right] > 0$**: The growth enhancing effect in Prediction #1 is stronger for commercial banks with higher exposure to the securitization market**[29] **.** An increase in the securitization market exposure amplifies the impact of systemic bailout expectation to long-run total credit growth.

[29] I omit the time subscript because $\phi_t(1-\varphi_t) = 1 - (1-\alpha)/\kappa \ \forall t$.

7.5 Model Extension: Securitization without Risk Retention

We have established so far the model of a modern banking system with the securitization market. Without the risk retention constraint, a moral hazard problem of mortgage monitoring emerges. The unscreened mortgage or mortgage pool receives inferior return $\underline{\theta}$. They are considered as assets with negative net present value (NPV). In Appendix A.5, we show that S-banks that issue catastrophe bonds could still have a return on equity that is greater than the risk-less return $1+r$ (negative NPV), even without imposing the risk retention constraint. Although such equilibrium path with negative NPV projects could still be credit growth enhancing within a certain range, the financial discipline breaks down. To see the reason, note that S-banks have an infinitesimal amount of debt repayment when issuing catastrophe bonds ($\Delta \to 0$). As such, S-banks in an equilibrium with catastrophe bonds would fund any projects even with an inferior return $\underline{\theta}$. Without enforcing risk retention, C-banks have more capacity to originate new credit. However, the inferior return repressed long-run credit growth. Modifying (28), the long-run credit growth becomes

$$\gamma^k = \left(\frac{1-\beta}{\phi_L'}\underline{\theta}\Gamma^{s,CB}\right)^{(1-\lambda)/(1+\lambda)} \left(\frac{\mu}{\phi_H}\underline{\theta}\Gamma^{s,NB}\right)^{\lambda/(1+\lambda)} \left(\frac{1-\beta}{\phi_L'}E_g\left[\theta\right]\Gamma^{s,CB}\right)^{\lambda/(1+\lambda)} \tag{31}$$

where $\phi_L' = 1-(1-\alpha)/\kappa$ is the securitization scale without risk retention in tranquil periods. The following corollary characterizes the growth enhancing condition for a risky equilibrium without monitoring.

Corollary 2. ***(Credit Growth without Risk Retention)***

In a risky equilibrium with catastrophe bonds, when government fiscal outlays satisfy $g > g^* \equiv \dfrac{1-(1-\lambda)\delta\underline{\theta}}{1-\lambda\delta u}$, S-banks may not require mortgage monitoring during securitization, which leads to projects with negative NPV being funded during tranquil periods. Then,

(1) Such an equilibrium is credit growth enhancing if and only if

$$\Phi^{Inferior}(CB,u) = \frac{\Gamma^{s,CB}}{\Gamma^{s,NB}}\cdot\frac{\phi_H}{\phi_L'} > \left(\frac{1-\beta}{\mu}\right)^{\lambda}\left(\frac{\underline{\theta}}{E_g\left[\theta\right]}\right)^{1-\lambda}\left(\frac{\underline{\theta}}{E_b\left[\theta\right]}\right)^{\lambda}$$

(2) The growth enhancing threshold u^{***} is higher than its counterpart u^{**} in Proposition 3 if and only if the additional cost of no risk retention is greater than the benefit,

$$\left(\frac{\underline{\theta}}{E_g\left[\theta\right]}\right)^{1-\lambda}\left(\frac{\underline{\theta}}{E_b\left[\theta\right]}\right)^{\lambda} \geq \cdot\frac{\phi_L(u^{***})}{\phi_L'}$$

8 Conclusion

We study in this paper the market expectations of sector-wide systemic bailout guarantees, and their impact on shadow bank risky bonds issuance and the banking sector credit growth patterns. In the structural model, we link the traditional commercial banking sector to the shadow banking sector by the originate-to-distribute securitization market. Higher market expectations of systemic bailouts to the shadow banking sector could increase shadow banks' leverage in a risky equilibrium and lower risk retention by commercial banks in the securitization market, which increases the credit origination capacity of the banking sector. However, such growth enhancing effect comes at a cost due to the sector-wide banking crisis caused by shadow bank systemic risk exposure. This model implies that whether a risky equilibrium is growth enhancing or growth repressing depends on market expectations of systemic bailouts, the type of risky shadow bank bonds funded by creditors, and regulations on bonds issuance.

Merging U.S. bank holding companies out-of-the-money put options price data with consolidated regulatory balance sheet report and income statement (FR Y9-C and FFIEC 031/041), I measure each individual bank holding company's exposure to the systemic bailout factor (put option beta). Such novel bank level data allows us to test our main hypothesis: bank holding companies with higher exposure to sthe ystemic bailout factor during the crisis would experience larger credit deviation from the pre-crisis trend. With the local projection approach, we observe that the group of bank holding companies with high exposure to systemic bailouts experienced an additional 4.89% cumulative downward deviations from the pre-crisis total credit trend 2 years after the crisis onset, and such difference is even larger in a longer term. In order to identify whether such effect is driven by government regulations on risky shadow bank bonds or weak credit demand instead of low post-crisis market expectations of systemic bailouts, we also measure bank holding companies' exposure to the securitization market regulations and exposure to borrowers from deteriorating sectors. Our empirical results support our main hypothesis and show the evidence that banks even with less adverse effect by regulations or weak credit demand could still experience large credit loss as long as they are more affected by the significant drop in market expectations of systemic bailouts.

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Appendix

A Proof

A.1 Proof of Lemma 1 (C-Banks' Expected Profit)

Proof. By the securitization market clearing condition, the price of securitized mortgage p_t increases as the securitization scale ϕ_t decreases. Thus, we only need to show $\partial E_t\left[\pi_{t+1}^c\right]/\partial p_t \geq 0$. The following derivations follow the commercial bank profit maximization problem in Begenau and Landvoigt (2017). The expected value of commercial bank profit $E_t\left[\pi_{t+1}^c\right]$ can be rewritten as

$$E_t\left[\pi_{t+1}^c\right] = \left[\Gamma_t^c w_t^c\left(p_{t+1}/p_t\right)\alpha\right]\left[\left(1 - F_\theta\left(\frac{(1-1/\Gamma_t^c)(1+r)}{\alpha\cdot(p_{t+1}/p_t)}\right)\right)\left(\theta_{t+1}^+ - \frac{(1-1/\Gamma_t^c)(1+r)}{\alpha\cdot(p_{t+1}/p_t)}\right)\right]$$

$$= \left[p_{t+1} I_t^c \alpha\right]\left[\left(1 - F_\theta\left(\frac{(1-1/\Gamma_t^c)(1+r)}{\alpha\cdot(p_{t+1}/p_t)}\right)\right)\left(\theta_{t+1}^+ - \frac{(1-1/\Gamma_t^c)(1+r)}{\alpha\cdot(p_{t+1}/p_t)}\right)\right]$$

where $\theta_{t+1}^+ \equiv E_t\left[\theta_{t+1} \mid \theta_{t+1} \geq \frac{(1-1/\Gamma_t^c)(1+r)}{\alpha\cdot(p_{t+1}/p_t)}\right]$. Note that the term in the first square brackets is irrelevant to p_t. Then, it suffices to show that the term in the second square brackets is higher the higher the securitized mortgage price p_t. □

A.2 Proof of Proposition 2

Proof. Here, we provide the proof of Part (1)-(3) of the proposition, and Part (4)-(5) are both well explained in the main text.

Part (1) Since the non-defaultable standard S-bank bonds are equivalent as C-bank bonds (deposits), shadow bankers offer a competitive interest rate $1+\rho_t^{s,NB} = 1+r\ \forall t$. For the defaultable standard S-bank bonds (DB), Equation (19) leads to the interest rate on DB that $1+\rho_t^{s,DB} = (1+r)/(1-\lambda+\lambda u)$ in tranquil periods ($t \neq \tau$). However, since systemic bailouts are not granted in two consecutive periods, S-bank creditors will only fund non-defaultable bonds in crisis periods. Thus, $1+\rho_t^{s,DB} = 1+r$ when $t=\tau$. The interest rate on catastrophe bonds (CB) in tranquil periods is obtained from the condition that $(1+\rho_t^{s,CB})b_t^s = g(w_t^s + b_t^s)$. As will be shown later, the leverage of CB issuers is $\Gamma_t^{s,CB} = 1/(1-\lambda\delta u g)$. Therefore, $1+\rho_t^{s,CB} = (1+r)/(\lambda u)$ for $t \neq \tau$. Again, the interest rate in crisis periods is $1+\rho_t^{s,CB} = 1+r$ for $t=\tau$.

Part (2) The leverage ratio of S-banks in the safe equilibrium is obtained from the non-diversion constraint (16). Thus, the leverage ratio is $\Gamma_t^{s,NB} = 1/(1-h)\ \forall t$. In a similar fashion, the leverage ratio of S-banks in a risky equilibrium with defaultable bonds (DB) is obtained from its non-diversion constraint as well. Following constraint (20), the leverage ratio in tranquil periods is $\Gamma_t^{s,DB} = 1/\left[1 - h(1+\lambda u/(1-\lambda))\right]$ for $t \neq \tau$. Since S-banks are funded by non-defaultable bonds in crisis periods, $\Gamma_t^{s,DB} = 1/(1-h)$ for $t = \tau$. Since there is no non-diversion constraint in a risky equilibrium with catastrophe bonds (CB), the leverage ratio is derived from Condition (21). Thus, $\Gamma_t^{s,CB} = 1/\left(1 - \lambda\delta u g\right)$ for $t \neq \tau$, and $\Gamma_t^{s,CB} = 1/(1-h)$ for $t = \tau$.

Part (3) As mentioned above, portfolio diversification in the safe equilibrium is for the purpose of guaranteeing risk-less repayment to S-bank creditors. Such requirement leads to Constraint (15). Hence, the minimum diversification fraction of S-bank portfolio is

$$\bar{\eta}^{NB} \equiv \frac{1+r}{E_b\left[\theta\right] - \underline{\theta}} h\delta - \frac{\underline{\theta}}{E_b\left[\theta\right] - \underline{\theta}}$$

By contrast, portfolio diversification in a risky equilibrium is for enough systemic risk exposure such that the systemic bailouts will be granted in the bad state. The constraints (17) and (18) jointly determine that the minimum diversification fraction of S-bank portfolio in a risky equilibrium with DB is

$$\bar{\eta}_t^{DB} \equiv \max\left\{-\frac{1+\rho_t^{s,DB}}{\bar{\theta} - E_b\left[\theta\right]} \cdot \frac{1}{1-\Gamma_t^{s,DB}} + \frac{\bar{\theta}}{\bar{\theta} - E_b\left[\theta\right]}, -\frac{1+\rho_t^{s,DB}}{E_g\left[\theta\right] - \underline{\theta}} \cdot \frac{1}{1-\Gamma_t^{s,DB}} + \frac{\underline{\theta}}{E_g\left[\theta\right] - \underline{\theta}}\right\}$$

for $t \neq \tau$, and $\bar{\eta}_t^{DB} = \bar{\eta}_t^{NB}$ for $t = \tau$. Similarly, we can also derive the minimum diversification fraction of S-bank portfolio in a risky equilibrium with CB

$$\bar{\eta}_t^{CB} \equiv \max\left\{-\frac{1+\rho_t^{s,CB}}{\bar{\theta} - E_b\left[\theta\right]} \cdot \frac{1}{1-\Gamma_t^{s,CB}} + \frac{\bar{\theta}}{\bar{\theta} - E_b\left[\theta\right]}, -\frac{1+\rho_t^{s,CB}}{E_g\left[\theta\right] - \underline{\theta}} \cdot \frac{1}{1-\Gamma_t^{s,CB}} + \frac{\underline{\theta}}{E_g\left[\theta\right] - \underline{\theta}}\right\}$$

for $t \neq \tau$, and $\bar{\eta}_t^{CB} = \bar{\eta}_t^{NB}$ for $t = \tau$. Note that the minimum diversification fractions in both risky equilibria are proportional to the leverage ratio $\Gamma_t^{s,DB}$ and $\Gamma_t^{s,CB}$ in tranquil periods. Thus, with higher market expectations of systemic bailouts, leverage ratio in a risky equilibrium is higher. This in turn increases portfolio diversification fraction so that S-banks are more exposed to the systemic risk. □

A.3 Proof of Corollary 1

Proof. Proposition 3 has already shown that $\Gamma_t^{s,NB} = 1/(1-h)$, $\Gamma_t^{s,DB} = 1/\left[1 - h(1 + \lambda u/(1-\lambda))\right]$, and $\Gamma_t^{s,CB} = 1/\left(1 - \lambda\delta u g\right)$ for $t \neq \tau$. Since $\lambda u/(1-\lambda) > 0$ as long as $u > 0$, the leverage ratio of DB issuers is always greater than the leverage ratio of NB issuers in tranquil periods ($\Gamma_t^{s,DB} > \Gamma_t^{s,NB}$) when the likelihood of systemic bailouts is strictly positive. Similarly, $\Gamma_t^{s,CB} \geq \Gamma_t^{s,NB}$ if $u \geq \bar{u} \equiv h/(\lambda g)$ and $\Gamma_t^{s,CB} \geq \Gamma_t^{s,DB}$ if $u \geq \bar{\bar{u}} \equiv h/\left[g - h/(1-\lambda)\right]$. Since the fiscal outlay g determines the leverage ratio of CB issuers, we require that $g \geq h/\left[\lambda(1-\lambda)\right]$. □

A.4 Proof of Proposition 3

Proof. Since $\partial\Gamma^{s,k}(u)/\partial u > 0$ and $\partial\phi_L(u)/\partial u < 0$, it follows that $\partial\Phi(k,u)/\partial u > 0$. Then, we show the existence of both u^* and u^{**} (i.e. $u^*, u^{**} < 1$). Given the assumption that $\Phi(k,\bar{\bar{u}}) > \left(\frac{1-\beta}{\mu}\right)^{\lambda}$ $\forall k \in \{DB, CB\}$, it suffices to show that $\bar{\bar{u}}$ is greater than both growth enhancing thresholds u^* and u^{**}. Moreover, Corollary 1 proves that $\bar{\bar{u}} \leq 1$. Thus, $u^*, u^{**} \in (0,1)$. Finally, since $\Phi(CB,u)\mid_{u=0} < \Phi\left(DB,u\right)\mid_{u=0}$, it is obvious to show that $u^* < u^{**}$. □

A.5 Extension: Securitization without Risk Retention

In a symmetric equilibrium with systemic risk-taking and non-defaultable bonds issuance, a S-bank's expected return on equity (ROE) before paying out young banker's wage is written as,

$$\begin{aligned} E_t\left[ROE_{t+1}^{s,NB}\right] &= \delta\left(p_t\tilde{\theta}_{t+1}I_t^s - L_{t+1}^s\right)/w_t^s \\ &= \left(\delta\tilde{\theta}_{t+1} - h\right)\Gamma_t^{s,NB} \\ &= \frac{\delta\tilde{\theta}_{t+1} - h}{1-h} \end{aligned} \tag{32}$$

where $\tilde{\theta}_{t+1} = E_t\left[\theta_{t+1}\right]$ if C-banks monitor securitized mortgages, and $\tilde{\theta}_{t+1} = \underline{\theta}$ if without monitoring. The second equality is obtained with Condition (16). To guarantee positive expected ROE, it must hold that $\tilde{\theta}_{t+1} \geq 1 + r$. Hence, quality monitoring is necessary to sustain the equilibrium with NB. In the same manner, a S-bank's expected ROE in a symmetric equilibrium with defaultable bonds

is

$$E_t\left[ROE_{t+1}^{s,DB}\right] = (1-\lambda)\left(\delta\tilde{\theta}_{t+1} - h\right)\Gamma_t^{s,DB}$$
$$= \frac{(1-\lambda)\left(\delta\tilde{\theta}_{t+1} - h\right)}{1 - h\left(1 + \lambda u/(1-\lambda)\right)} \tag{33}$$

A necessary condition for this return on equity to be greater than risk-less rate is that $\tilde{\theta}_{t+1} \geq h(1+r)$[30]. Thus, as long as $\underline{\theta} < h(1+r)$, the securitization market without quality monitoring is not sustainable for the equilibrium with DB. Finally, a S-bank's expected ROE in a symmetric equilibrium with catastrophe bonds is

$$E_t\left[ROE_{t+1}^{s,CB}\right] = (1-\lambda)\,\delta\tilde{\theta}_{t+1}\Gamma_t^{s,CB}$$
$$= \frac{(1-\lambda)\delta\tilde{\theta}_{t+1}}{1-\lambda\delta u g} \tag{34}$$

With large enough government fiscal cost g on systemic bailout ($g > g^*$)

$$g^* = \frac{1-(1-\lambda)\delta\underline{\theta}}{1-\lambda\delta u}$$

S-banks are willing to hold unscreened negative NPV mortgages transferred from C-banks, while still having $E_t\left[ROE_{t+1}^{s,CB}\right] \geq 1$.

B Model Calibration

The behavior of the model economy as well as the long-run credit growth rate are governed by eleven parameters: λ, δ, κ, h, g, α, β, μ, c, $\bar{\theta}_g$ and $\bar{\theta}_b$. We set the discount rate δ, commercial bank minimum equity required ratio κ, the probability of crisis $1-\lambda$, labor share in the commercial banking sector and shadow banking sector $(1-\alpha, 1-\beta)$, and average TFP shocks in a good state and a bad state $(\bar{\theta}_g, \bar{\theta}_b)$ equal to empirical counterparts in the US. Given the values of these parameters, we set the liquidation cost h and expected fiscal outlays in asset purchase g to match the leverage ratio in the

[30] Strictly, $E_t\left[ROE_{t+1}^{s,DB}\right] \geq 1$ if and only if $\tilde{\theta}_{t+1} \geq \left[\frac{1-h\left(1+\lambda u/(1-\lambda)\right)}{1-\lambda} + h\right](1+r)$, which has a lower bound of $h(1+r)$. However, this lower bound is infeasible, as it requires S-bank's leverage ratio to approach infinity.

shadow banking sector and the leverage ratio among major credit default swaps issuers. We also set the monitoring cost c so that the risk retention scale in the safe equilibrium path matches the scale set by Dodd Frank risk retention rule. Finally, in line with Rancière and Tornell (2016), the distress cost $1-\mu$ is set to match the asset recovery rate in the financial sector.

As shown in the simulations, the crisis probability is set to 4%, which is between the unconditional crisis probabilities 4.49% in Schularick and Taylor (2012) and 2.8% in Gourinchas and Obstfeld (2012). The riskless discount rate $\delta = 1/(1+r)$ is determined by the average annualized mean of 1 year US Treasury nominal yield. We set $r = 2.10\%$ based on the average nominal yields on 1 year Treasury bonds during 2002-2011[31]. The minimum equity ratio κ is set in accordance with Basel II minimum capital ratio of risk-weighted assets, $\kappa = 8\%$. The labor share in both commercial banking sector and shadow banking sector are matched to US labor share obtained from NIPA such that $\alpha = \beta = 33\%$. We compute the average TFP shocks in a good state and a bad state based on according to US total factor productivity during no-recession periods and recession periods (since 1970). Thus, $\bar{\theta}_g = 0.98$ and $\bar{\theta}_b = 1.02$.

Proposition 2 has shown that the shadow bank leverage ratio in a risky equilibrium with defaultable bonds is $\dfrac{1}{1-h\left(1+\lambda/(1-\lambda)\right)}$ in tranquil periods (with the assumption that $u \to 1$ in the years leading to the subprime crisis). Since the liquidation cost h governs shadow banks' borrowing constraint, the parameter value of h is chosen such that the risky equilibrium shadow bank leverage ratio matches the leverage ratio of shadow banks during 2002Q1-2007Q2 from the Federal Reserve "Financial Accounts of the United States". We use the security brokers and dealers sector as a representative of the shadow banking sector, and the leverage ratio during tranquil periods is 27.27. Similarly, the leverage ratio of shadow banks who issue catastrophe bonds in Proposition 2 is $\dfrac{1}{1-\lambda\delta g}$ (we still assume $u \to 1$). We match such theoretical leverage ratio to the leverage ratio of the top 10 credit default swap issuers during 2002Q1-2007Q2 based on their 10K reports[32]. The computed leverage of these largest CDS issuers based on their 10K is 29.12 during 2002Q1-2007Q2. Since the monitoring cost c controls the risk retention incentive in the securitization market, we match the safe equilibrium risk retention ratio $\varphi_H = c/\Gamma^{s,NB}$ (we assume $\underline{\theta} = 0$) to the Dodd Frank risk retention rule that 5% of securitized assets have to be held by sponsors. Finally, the distress cost in the financial sector $1-\mu$ governs the asset recovery rate $\mu/(1-\beta)$ of the US financial sector.

[31] We adapt the time horizon in line with Philippon (2015). Piazzesi and Schneider (2006) take a much longer horizon (1952-2006) and obtain that the average nominal yield on 1 year Treasury bonds is 5.56%.

[32] The top 10 CDS issuers in the US banking sector are AIG, Bear Stearns, Lehman Brothers, Goldman Sachs, Merill Lynch, Citigroup, Wachovia, Morgan Stanley, Bank of America, and JPMorgan Chase.

Following Begenau and Landvoigt (2017), we set the recovery rate as 37% based on Moody's reports on financial sector bonds recovery rate. Summing up all the parameter calibration results, we have the following table:

Parameter	Definition	Value	Note
λ	Probability of crisis	0.04	Schularick and Taylor (2012), Gourinchas and Obstfeld (2012)
δ	Discount rate	0.98	Average 1 year US Treasury nominal yields: 2.10%
κ	Minimum equity ratio	0.08	Basel II requirement
h	Contract enforceability (1 - Liquidation cost)	0.92	Security brokers and dealers tranquil leverage: 27.27
g	Fiscal outlays in gov. asset purchase	1.03	Major CDS issuers tranquil leverage: 29.12
α	Labor share in C-banks	0.33	NIPA labor share
β	Labor share in S-banks	0.33	NIPA labor share
μ	1 - distress cost	0.42	Moody's financial sector recovery rate: 37%
c	Monitoring cost	0.63	Securitization risk retention ratio: 5%
$\bar{\theta}_g$	Cond. mean of TFP shock in good states	1.02	US TFP during non-resession periods
$\bar{\theta}_b$	Cond. mean of TFP shock in bad states	0.98	US TFP during resession periods

Table B. This table reports calibration results of key model parameters based on US aggregate data.

C Data

C.1 Aggregate Data

The aggregate data is from different sources. The first source is the "Financial Accounts of the United States" (Flow of Funds). In Table 1 of Section 2.1, we present the main items of the liability side of U.S.-Chartered Depository Institutions and Security Brokers and Dealers. Here, we list the item names as well as the identification numbers.

U.S.-Chartered Depository Institutions (L.111)

FL764190005	**Total Liabilities**
FL764110005	**Net interbank liabilities**
FL763127005	**Checkable deposits**
FL763130005	**Time and savings deposits**
FL762150005	**Federal funds and security repos**
FL764122005	**Debt securities**
FL763169305	**Loans (other loans and advances)**
FL763178003	**Taxes payable (net)**
FL763190005	**Miscellaneous liabilities**

Security Brokers and Dealers (L.130)

FL664190005	**Total Liabilities**
FL662151003	**Security repurchase agreements**
FL663163003	**Debt securities (corporate bonds)**
FL763130005	**Time and savings deposits**
FL664123005	**Loans**
FL663170003	**Trade payables**
FL663178003	**Taxes payable**
FL763178003	**Taxes payable (net)**
FL663190005	**Miscellaneous liabilities**

Besides balance sheet items of U.S.-chartered depository institutions and security brokers and dealers, Flow of Funds also documents the aggregate data of securitized mortgages in the US. Such

aggregate data is used in Section **??**, when we are measuring bank holding companies' exposure to the securitization market by following Loutskina (2011).

Economy Wide Total Loans

FL893065105	**Home mortgages**
FL893065405	**Multifamily residential Mortgages**
FL893065505	**Commercial Mortgages**
FL893065603	**Farm Mortgages**
FL894123005	**Consumer Credit**

Economy Wide Securitized Loans

FL413065105	**Home mortgages**
FL673065105	
FL413065405	**Multifamily residential Mortgages**
FL673065405	
FL413065505	**Commercial Mortgages**
FL673065505	
FL413065605	**Farm Mortgages**
FL673070003	**Consumer Credit**

C.2 Commercial Bank Subsidiary Level Data (Call Report)

This section documents the commercial bank characteristic variables are constructed based on Call Report items (according to Huang (2017)).

Bank identifier: RSSD9001, the unique identifying number (RSSDID) assigned by the Federal Reserve.

Parent bank holding company id: RSSD9348, the RSSDID of the highest holding company. We aggregate balance sheet items of all commercial banks that have the same highest holding company.

Total loans: RCFD1400, the gross book value of total loans and leases.

Home mortgages: RCON1430, real estate loans backed by 1-4 family residential properties.

Multi-family residential mortgages: RCON1460, real estate loans backed by residential properties with more than 4 families.

Commercial mortgages: RCON1480, real estate loans backed by non-farm and nonresidential

properties, such as business and industrial properties, hotels, hospitals and dormitories.

Consumer credit: RCFD1975, loans, not secured by real estate, issued to individuals for family or personal expenditure such as purchasing automobiles and paying medical expenses.

Farm mortgages: RCON1420, real estate loans backed by farmlands

C.3 Bank Holding Company (BHC) Level Data (FR Y9-C)

Gross Total Assets (GTA): BHCK2170+BHCK3123+BHCKC435, total assets plus the allowance for loan and leases and the allocated transfer risk reserve as in Berger et al. (2015).

Capital Ratio: BHCKG105/GTA, equity capital divided by GTA.

Return on Assets (ROA): 4*BHCK4340/GTA, the Ratio of the annualized net income to GTA.

Return on Equity (ROE): 4*BHCK4340/BHCKG105, the Ratio of the annualized net income to equity.

Liquidity: (BHCK0081+BHCK0395+BHCK0397)/GTA, cash divided by GTA.

Total Credit: BHCK2122, total loans and lease financing receivables.

Asset Quality (NPLs Ratio): BHCK3123/BHCK2122, Non-performing loans to total credit

Synthetic CDO: (BHCKG340+BHCKG343)/GTA, sum of the amortized cost of held-to-maturity synthetic CDO and the fair value of available-for-sale synthetic CDO divided by GTA.

Credit Default Swaps: (BHCKC219+BHCKC220+BHCKC221+BHCKC222)/GTA, fair value of credit default swaps divided by GTA.

Interest Rate Derivatives: (BHCK8733 + BHCK8737+BHCK8741+BHCK8745)/GTA, fair value of interest rate derivatives divided by GTA.

D Tables

D.1 Stock Holdings in KBE

	12/31/2007		12/31/2009	
	Name	**Weighting**	**Name**	**Weighting**
1	JPMorgan Chase	8.40	Bank of American	8.94
2	Wells Fargo	8.33	JPMorgan Chase	7.46
3	Bank of American	8.23	Citigroup	7.39
4	Citigroup	7.43	US Bancorp	7.28
5	State Street	4.80	Wells Fargo	6.92
6	Wachovia	4.79	Suntrust Banks	4.87
7	PNC	4.71	Mcintosh Bancshares	4.51
8	US Bancorp	4.59	Regional Financial	4.51
9	Suntrust Banks	4.38	BB&T	4.24
10	Washington Mutual	3.72	PNC	4.18
11	Northern Trust	3.66	Fifth Third Bancorp	4.16
12	Regional Financial	3.61	Capital One Financial	4.07
13	BB&T	3.60	Comerica	3.49
14	Merrill Lynch	3.56	Huntington Bancshares	3.56
15	Capital One Financial	3.44	Merrill Lynch	3.36
16	Fifth Third Bancorp	3.30	State Street	2.89
17	KeyCorp	2.95	KeyCorp	2.81
18	Mcintosh Bancshares	2.87	Central Bancorp	2.73
19	National City	2.82	Commerce Bancshares	2.39
20	Comerica	2.55	People's United Financial	2.30

Table D.1. This table reports the top 20 banks with the largest weights in the banking sector index ETF, KBE, on 12/31/2007 and 12/31/2009. On 12/31/2007, there were 23 banks in KBE; on 12/31/2009, there were 24 banks. The weights are the relative market capitalizations of the top 20 holdings of the index.

D.2 Summary Statistics

	Full Sample (N = 16,896)				High Bailout Exposure BHCs (N = 8,448)				Low Bailout Exposure BHCs (N = 8,448)			
	Mean	Q1	Median	Q3	Mean	Q1	Median	Q3	Mean	Q1	Median	Q3
Gross Total Assets (GTA, $ million)	107.1	5.4	10.5	27.7	128.3	5.3	9.9	28.4	52.4	5.6	12.5	27.5
Capital Ratio (% of GTA)	11.8	9.7	11.2	12.7	12.1	9.7	11.3	12.9	10.9	9.7	10.8	12.3
ROA (% of GTA)	2.0	0.9	2.0	3.4	2.3	1.0	2.0	3.3	1.7	0.1	2.0	3.4
ROE (% of Equity)	5.9	7.3	16.2	27.4	3.6	6.8	15.7	26.8	12.1	7.3	16.6	27.7
Liquidity (% of GTA)	4.8	2.1	3.1	5.6	5.2	2.2	3.2	6.0	3.8	1.8	2.8	4.8
NPLs Ratio (% of Total Credit)	1.1	1.1	1.4	1.9	1.0	1.1	1.4	2.0	1.6	1.1	1.4	1.9
Liability ($ million)	364.5	5.4	10.8	31.2	133.2	5.2	10.5	31.1	63.3	5.7	13.6	32.8
Equity ($ million)	12.9	0.7	1.4	4.3	15.0	0.7	1.4	4.3	7.0	0.6	1.4	5.4
Total Credit ($ million)	46.6	3.4	6.3	16.5	55.9	3.4	6.0	16.8	22.7	3.4	7.5	16.1
Exposure to Securitization Market (%)	16.5	11.0	16.5	20.7	14.2	10.9	13.5	19.5	17.4	11.0	16.7	21.0
Put option beta (%)	6.3	1.2	5.9	12.6	11.4	4.8	9.8	15.1	-9.3	-12.2	-2.8	0.2
Synthetic CDO (bps of GTA)	0.5	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.3	0.0	0.0	0.0
CDS Holdings (bps of GTA)	55.7	0.0	0.0	0.0	56.8	0.0	0.0	0.0	52.9	0.0	0.0	0.0
Interest Rate Derivatives (% of GTA)	4.2	0.0	0.1	0.5	4.7	0.0	0.1	0.5	3.0	0.0	0.2	0.6
CoVaR (95% CI, in %)	0.7	0.3	0.6	1.0	1.1	0.5	0.9	1.2	0.5	0.2	0.5	0.6

Table D.2. Summary Statistics. This table reports summary statistics for all bank-level variables used in empirical tests, as well as the numbers in the two subsamples. The high bailout exposure subsample includes the upper 50 percent in put option beta (exposure to systemic bailouts); the low bailout exposure subsample includes the lower 50 percent. The data are collected from 4 different sources: First, the put option beta is calculated by the author with daily put option prices (OptionMetrics) and underlying stock prices (CRSP).

Second, the exposure to the securitization market is is calculated with commercial bank level data from the Call Report and aggregate data from the Flow of Funds. Third, CoVaR is a measurement of banks' contribution to the systemic risk calculated by Adrian and Brunnermeier (2016). Fourth, all the other variables are from FR Y9-C (BHCs consolidated reports).

D.3 Transition Matrices of Control Variables

(1) Gross Total Assets

	$T_i = 0$	$T_i = 1$
$T_i = 0$	98.38	1.62
$T_i = 1$	1.64	98.36

(2) Capital Ratio

	$T_i = 0$	$T_i = 1$
$T_i = 0$	93.78	6.22
$T_i = 1$	6.58	93.41

(3) Total Credit

	$T_i = 0$	$T_i = 1$
$T_i = 0$	98.81	1.19
$T_i = 1$	1.24	98.76

(4) Return on Assets

	$T_i = 0$	$T_i = 1$
$T_i = 0$	89.01	10.99
$T_i = 1$	11.36	88.64

(5) Return on Equity

	$T_i = 0$	$T_i = 1$
$T_i = 0$	89.55	10.45
$T_i = 1$	10.93	89.07

(6) CoVaR

	$T_i = 0$	$T_i = 1$
$T_i = 0$	93.21	6.79
$T_i = 1$	6.28	93.72

(7) Liquidity

	$T_i = 0$	$T_i = 1$
$T_i = 0$	84.54	15.46
$T_i = 1$	15.36	84.64

(8) NPLs Ratio

	$T_i = 0$	$T_i = 1$
$T_i = 0$	94.56	5.44
$T_i = 1$	5.14	94.86

(9) Total Equity

	$T_i = 0$	$T_i = 1$
$T_i = 0$	98.39	1.61
$T_i = 1$	1.98	98.02

Table D.3. Transition Matrices. This set of tables reports the transition matrices of the main control variables in the empirical tests. In the display of the transition matrices, $T_i = 0$ indicates the bank-quarter observation belongs to the lower than median group, while $T_i = 1$ indicates the bank-quarter observation belongs to the higher than median group. The rows are for observations in the current quarter, and the columns are for observations in the next quarter. For instance, the upper right cell of the "Gross Total Assets" matrix shows that the probability that the total assets this quarter is below median but the next quarter is above median is 1.62%.

D.4 Fixed Effects Regressions (Dummy Indicators)

Table D.4: Fixed effect regressions (dummy indicators)

	Baseline	Financial Regulations		Weak Demand	
	(1)	(2)	(3)	(4)	(5)
Bailout Exposure Indicator	-4.223***	-3.201***	-3.552***	-2.827***	-3.289***
	(1.32)	(0.88)	(1.04)	(0.97)	(1.11)
Bailout Exposure Indicator		-2.252**	-1.019*		
× **Regulation Indicator**		(1.05)	(0.61)		
Bailout Exposure Indicator				-2.643**	-1.450**
× **Weak Demand Indicator**				(1.28)	(0.71)
C-Bank Controls			✓		✓
BHC Fixed Effect			✓		✓
Observations	1456	1456	1456	1456	1456

Table D.4. Fixed Effects Regressions (Dummy Indicators). This table reports the fixed effects regressions of post-crisis commercial bank credit growth rates on the dummy indicators of parent bank holding company's put option beta (exposure to the systemic bailout factor), exposure to the securitization market (potential impact by post-crisis financial regulations), exposure to weak borrowers (potential impact by weak credit demand), as well as commercial bank level controls including asset size, leverage ratio, initial credit, systemic risk contributions (CoVaR), and non-performing loans ratio. Column (1) displays the baseline specification which estimates the additional effect on post-crisis commercial bank credit growth rates due to higher parent bank holding company put option beta. Column (2) and (4) show the results with a modified specification that take into account each commercial bank subsidiary's exposure to the securitization market and exposure to weak borrowers. Column (3) and (5) include both commercial bank level controls and bank holding company fixed effects. Standard errors are clustered at the commercial bank level. Robust t statistics are reported in parentheses. Coefficients denoted $*$, $**$, and $***$ are statistically significantly different from zero at the 10 percent, 5 percent, and 1 percent level, respectively.

D.5 Fixed Effects Regressions (Continuous Measure)

Table D.5: Fixed effect regressions (continuous measure)

	Baseline	**Financial Regulations**		**Weak Demand**	
	(1)	(2)	(3)	(4)	(5)
Bailout Exposure (Beta)	-0..241***	-0.205***	-0.223***	-0.193***	-0.206***
	(0.09)	(0.08)	(0.07)	(0.06)	(0.06)
Bailout Exposure (Beta)		-0.167***	-0.103*		
× Securitization Exposure		(0.06)	(0.06)		
Bailout Exposure (Beta)				-0.143**	-0.141**
× Weak Demand Exposure				(0.06)	(0.06)
C-Bank Controls			✓		✓
BHC Fixed Effect			✓		✓
Observations	1456	1456	1456	1456	1456

Table D.5. Fixed Effects Regressions (Continuous Measure). This table reports the fixed effects regressions of post-crisis commercial bank credit growth rates on the continuous measure of parent bank holding company's put option beta (exposure to the systemic bailout factor), exposure to the securitization market (potential impact by post-crisis financial regulations), exposure to weak borrowers (potential impact by weak credit demand), as well as commercial bank level controls including asset size, leverage ratio, initial credit, systemic risk contributions (CoVaR), and non-performing loans ratio. Column (1) displays the baseline specification which estimates the additional effect on post-crisis commercial bank credit growth rates due to higher parent bank holding company put option beta. Column (2) and (4) show the results with a modified specification that take into account each commercial bank subsidiary's exposure to the securitization market and exposure to weak borrowers. Column (3) and (5) include both commercial bank level controls and bank holding company fixed effects. Standard errors are clustered at the commercial bank level. Robust t statistics are reported in parentheses. Coefficients denoted $*$, $**$, and $***$ are statistically significantly different from zero at the 10 percent, 5 percent, and 1 percent level, respectively.

D.6 Fixed Effects Regressions (Continuous Measure, Only Incumbent Commercial Banks)

Table D.6: Fixed effect regressions (continuous measure, only incumbent)

	Baseline	**Financial Regulations**		**Weak Demand**	
	(1)	(2)	(3)	(4)	(5)
Bailout Exposure (Beta)	-0..239***	-0.201***	-0.220***	-0.195***	-0.211***
	(0.09)	(0.08)	(0.06)	(0.06)	(0.06)
Bailout Exposure (Beta)		-0.167**	-0.098*		
× Securitization Exposure		(0.07)	(0.06)		
Bailout Exposure (Beta)				-0.145**	-0.107**
× Weak Demand Exposure				(0.06)	(0.06)
C-Bank Controls			✓		✓
BHC Fixed Effect			✓		✓
Observations	1258	1258	1258	1258	1258

Table D.6. Fixed Effects Regressions (Continuous Measure, Only Incumbent Commercial Banks). This table reports the fixed effects regressions of post-crisis commercial bank credit growth rates on the continuous measure of parent bank holding company's put option beta (exposure to the systemic bailout factor), exposure to the securitization market (potential impact by post-crisis financial regulations), exposure to weak borrowers (potential impact by weak credit demand), as well as commercial bank level controls including asset size, leverage ratio, initial credit, systemic risk contributions (CoVaR), and non-performing loans ratio. Commercial banks that are acquired after the subprime crisis are excluded from the sample. Column (1) displays the baseline specification which estimates the additional effect on post-crisis commercial bank credit growth rates due to higher parent bank holding company put option beta. Column (2) and (4) show the results with a modified specification that take into account each commercial bank subsidiary's exposure to the securitization market and exposure to weak borrowers. Column (3) and (5) include both commercial bank level controls and bank holding company fixed effects. Standard errors are clustered at the commercial bank level. Robust t statistics are reported in parentheses. Coefficients denoted $*$, $**$, and $***$ are statistically significantly different from zero at the 10 percent, 5 percent, and 1 percent level, respectively.