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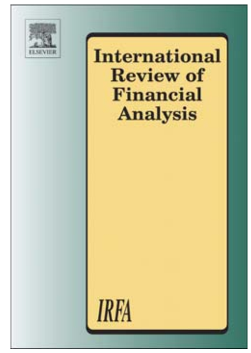


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# Funding liquidity risk and internal markets in multi-bank holding companies: Diversification or internalization? ☆

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**Abstract**

This study examines how a multi-bank holding company (MBHC) manages *funding liquidity risk* through its internal liquidity market, how its internal liquidity market works, and the benefits that its member banks enjoy. The results provide evidence that the diversification effect mostly dominates the internalization effect. A new entrant into an MBHC structure benefits from holding lower liquidity and raising deposits at lower costs than a non-MBHC structure, suggesting that MBHCs have enjoyed scant liquidity at the cost of mismatch risk. We find that other member banks also enjoy the benefits of diversified risk when a new entrant joins, suggesting that MBHCs manage liquidity in response to changes in funding liquidity risk. However, internalization is more important for MBHCs that have large numbers of subsidiaries. Whichever types of mergers/acquisitions are chosen by an MBHC, the diversification effect appears. Basel III liquidity regulations would mitigate the mismatch risk at the cost of distorted internal liquidity markets.

*Keywords:* funding liquidity risk, merger and acquisition, bank holding company, Basel III, Net Stable Funding Ratio

*JEL* classification: G21; G28; G18; G14; G32    Version 7 December 2017

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## 1. Introduction

The last two decades have witnessed the intensive expansionary process of mergers and acquisitions (M&A) of bank holding companies (BHCs) in the U.S. banking system. BHCs have recently attracted attention from policymakers and researchers because of their systemic importance[1]. From the viewpoint of systemic risk, stable funding and liquidity management are factors of importance. A bank that relies on less stable funding is more likely to fail[2]. For these reasons, the Basel committee proposed a Net Stable Funding Ratio (NSFR) regulation that will be implemented in 2021. However, the manners in which banks manage these ratios have been under-researched.

The essential factors of bank regulation act at best to serve the interests of depositors, investors and academic researchers in the financial markets. This study aims to investigate multi-bank holding companies (MBHCs) management of *funding liquidity risk* due to a number of important reasons. First, funding liquidity is defined as the ease with which an institution can obtain funding (Brunnermeier and Pedersen 2009). When a bank funds long-term illiquid assets with short-term debts, it is more likely to become unable to roll over borrowing during a financial crisis (Brunnermeier 2009, Diamond and Rajan 2009, Afonso et al. 2011, Acharya and Merrouche 2013). Banks must manage the risk arising from such funding liquidity by reducing illiquid assets or increasing stable sources of funding. MBHCs are different from stand-alone banks and banks in single-bank holding companies in their liquidity management because MBHCs have internal liquidity markets[3]. Understanding MBHC and non-MBHC structure could provide better insight into the liquidity risk of banks faced by depositors. Second, Ly et al. (2017b) find that targets that are acquired by MBHC affiliates are smaller and have to hold higher capital. If the economic rationale underpinning

[1]For example, see Cetorelli et al. (2014).
[2]See Bologna (2015) and Vazquez and Federico (2015) for empirical analyses.
[3]We call stand-alone banks and banks in single-bank holding companies non-MBHC banks hereafter.

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the M&As wave of banks outside the MBHC structure is indeed due to internal liquidity markets, this thereby increases the banks ability to withstand a crisis. Hence, such a derived concept could help investors with making the right decisions on their investment portfolios.

Third, Ly et al. (2017a) find that if one BHC does not attempt to adjust funding risk quickly, this causes the joint probability of all BHCs to experience a liquidity shortfall simultaneously, which in turn increases systemic risk. Given the ever-increasing complexity of the BHC structure, academic researchers (Allahrakha et al. 2015, Huang et al. 2012) were attracted to estimate the measures to assess the systemic importance of BHCs and their risk contribution to the entire banking system. Our study, therefore, could draw their attention regarding the funding liquidity risk and expansionary process that could be the observable factors of BHCs systemic risk. Last, but not least, this paper is written at a time of signicant Basel III reform of liquidity. The decision of a bank manager to enter an MBHC during this transition period could provide an insight into the regulatory implication. Hence, our study contributes to a closer supervisory practice to identify the liquidity problem of MBHCs and the proposed determinants of Basel III liquidity standard in terms of bank structure.

As Carletti et al. (2007) argued, internal liquidity markets enable MBHC members to reshuffle their funding liquidity. MBHC members can diversify funding liquidity risk while they can also internalize the external benefits of holding liquidity. When an MBHC member can diversify funding liquidity risk, it does not need to hold more liquidity than other non-MBHC banks. When it can internalize the benefits of the liquidity needs of other member banks, it holds more liquidity than other non-MBHC banks because holding liquidity is more valuable. We call the former the diversification effect hypothesis and the latter the internalization effect hypothesis. Our empirical analyses examine which hypothesis holds in various ways.

Using quarterly data for U.S. commercial banks from 1995 to 2011, our primary analysis provides supportive evidence for the diversification effect. In other words, the diversification

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effect dominates the internalization effect in the internal liquidity market of MBHCs. MBHC members hold less liquidity than non-MBHC banks because liquidity needs are expected to be smaller than others. This finding is consistent with the argument that the threat to the U.S. financial stability is mainly due to unstable funding profiles of complex BHCs (Federal Register 2016). The other results are summarized as follows: (i) the dominance of the diversification effect persists for at least two years; (ii) the diversification effect hypothesis also holds for alternative traditional measurements of liquidity; (iii) the scant liquidity of MBHCs is accompanied by lower funding costs than that of non-MBHC banks; (iv) the effects of the funding liquidity of banks entering/leaving an MBHC spreads to other existing members; (v) this effect is U-shaped regarding the number of MBHC members; and (vi) the diversification effect hypothesis holds regardless of the type of merger that a BHC chooses.

Our paper contributes to the extant literature as follows. First, despite the importance of the theoretical work of Carletti et al. (2007), we have seen little empirical evidence regarding MBHCs liquidity risk management (Berger and Bouwman 2009, Ellul and Yerramilli 2013). Our study is the first to provide empirical evidence on the diversification effect in liquidity usage, which explains how internal liquidity markets work in MBHCs and the benefits that member banks could enjoy[4].

Second, we contribute to the growing literature on Basel III liquidity regulations (King 2013, Distinguin et al. 2013, Haan and van den End 2013, Hong et al. 2014, Schmaltz et al. 2014, Vazquez and Federico 2015, DeYoung and Jang 2016). DeYoung and Jang (2016) found a size effect in liquidity management. As banks increase in size, they set lower liquidity

[4]Berger and Bouwman (2009) found that large banks, MBHC members, retail banks, and recently merged banks created the most liquidity. Demsetz and Strahan (1997) argued that large BHCs are better diversified than small BHCs based on market measurements of diversification. Hughes et al. (1999) found that the economic benefits of consolidation are strongest for banks engaged in interstate expansion and, in particular, interstate expansion that diversifies banks macroeconomic risk. Campello (2002) found that stand-alone banks face more financial constraints than BHC subsidiaries during money contraction because stand-alone banks loan growth tends to rely more on their own cash flow, while the internal capital market within BHCs decreases the sensitivity of loan growth to the cash flows of subsidiaries.

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targets. Our results are robust in the sense that MBHC members hold lower liquidity after controlling for size effects. In other words, MBHC members benefit more from holding scant liquidity than non-MBHC banks of the same size because the former can diversify funding liquidity risk more efficiently through internal liquidity markets than the latter.

Third, our study is closely related to a large body of bank consolidation literature (Rhoades 1993, 1998, Calomiris 1999, Focarelli and Panetta 2003, Amel et al. 2004, Craig and Dinger 2009, Deng et al. 2013, Dinger 2015)[5]. Among them, Craig and Dinger (2009) noted that the banking literature has not reached a consensus on the impact of bank mergers on deposit rates. Our analysis adds new evidence to the literature. The structure of MBHCs allows their subsidiary banks to save funding costs. This finding is also consistent with the evidence that when liquidity dries up, banks experience funding inflows, as argued in Gatev and Strahan (2006). They argued that banks can provide firms with insurance when firms face market-wide liquidity shocks in the commercial paper market since they seek safe haven for their wealth. We extend their rationale to emphasize the unique ability of MBHC structure to hedge against systematic liquidity shocks by conserving their liquidity needs with lower costs.

Fourth, our results have direct implications for upcoming NSFR regulations. Large BHCs suffered the most serious losses among the various financial intermediaries. Indeed, these huge losses drove the argument for the tightening of bank regulation[6]. The NSFR regulation is designed to reduce the funding risk arising from the mismatch between assets and liabilities.

[5]See Rhoades (1998) and Amel et al. (2004) for the classic works in the literature. Calomiris (1999) argued that bank consolidation waves produce substantial efficiency gains associated with reduced operating costs and the enrichment of bank-customer relationships. Successful banks that are highlighted in his study, for example, Nations Bank and US Bancorp, are called "universal banking American-style" and are structured as BHCs to serve as a platform for customer relationships through a variety of separate corporate entities. Calormiris (1999) emphasized that analyses of the motives underlying merger activity are valuable in determining the efficiency consequences of mergers. Deng et al. (2013) suggested that BHCs pursue multiple dimensions of diversification, such as geographic, revenue, non-traditional activity and asset diversification, at the same time. Ly et al. (2017) found that BHCs tend to adjust the NSFR quickly in response to the Basel III liquidity requirement, hence reducing systemic risk.

[6]Frankel (2013) provided a good illustration of the problems that large BHCs pose to the financial system.

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From this perspective, our findings of scant liquidity in the internal markets of MBHCs suggest that the structure of MBHCs was fragile in their liquidity funding risk, providing the rationale for the strict liquidity regulations for MBHCs. Since MBHCs have less available stable funds relative to their required counterparts or they have more required funds relative to their available funds, sooner or later, the mismatch risks become apparent. Although we interpret that low NSFRs arise from diversification effects, it might suggest that MBHC members have low NSFRs because they recognize themselves as "too-big-to-fail"[7].

Our evidence suggests that the large MBHCs enjoyed scant liquidity at the cost of mismatch risk. Hence, upcoming regulations distort the efficient workings of the internal liquidity market of MBHCs. The regulator should introduce a penalty if MBHCs distort the internal liquidity market to mitigate the mismatch risk. It is more costly for MBHC banks to achieve the target NSFR than for non-MBHC banks. Another concern is that facing the required compliance with the NSFR standards in 2021 (Federal register 2016), banks might arbitrage their liquidity by acquiring banks with high NSFRs, particularly during stress periods. On the one hand, such acquisition reduces the regulatory burden. On the other hand, it reduces the effectiveness of NSFR regulations because this arbitrage does not change aggregate liquidity.

The organization of this paper is as follows. Section 2 develops the baseline and extended hypothesis. Section 3 describes our data sets, provides summary statistics, and explains our econometric methodology. Section 4 provides empirical evidence. Section 5 summarizes our conclusions.

[7]However, Hong et al. (2014) argued that the NSFR has limited effects on bank failures, but the systemic liquidity risk was a major contributor to bank failures in 2009 and 2010.

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## 2. Hypothesis development

The regulation of the NSFR that measures funding liquidity risk is designed to promote more stable funding of more illiquid assets. BCBS (2014) defines the NSFR as the ratio of the available amount of stable funding (ASF) divided by the required amount of stable funding (RSF)[8]. Since the weight for a class of asset in RSF is higher as the class becomes more illiquid, RSF is greater as the composition of bank assets becomes more illiquid. Since the weight for a class of liabilities in ASF is higher as the class becomes more stable, ASF is higher as the composition of bank liabilities becomes more stable. Hence, the NSFR is higher as bank assets become more liquid, and the funding becomes more stable[9].

### *2.1. Funding liquidity effects in MBHCs: Diversification and internalization*

Avraham et al. (2012) define a BHC as a corporation controlling one or more banks on the basis of ownership of all or part of banks equity. In particular, single-bank holding company owns one bank. By contrast, an MBHC is a group of separately incorporated banks sharing a common corporate ownership and their managements are associated closely with that of a lead bank (Kane, 1996). The Gramm-Leach-Bliley Act 1999 allowed MBHCs to engage in a wide range of activities beyond traditional banking businesses (Lopez-Espinosa et al., 2012). Therefore, MBHCs have had more opportunities to diversify into non-traditional banking activities. The legislation has highlighted non-traditional powers and geographic advantages for an MBHC structure and resulted in banking companies that were larger and more complex than non-MBHC banks. Such nonbank expansion may increase risk and, therefore, indirectly have an influence on the safety and soundness of the banking system.

MBHCs create their internal markets to exchange certain classes of asset, liability, and capital. For example, in the internal capital market, conglomerates can provide subsidiaries

[8]If RSF is higher than ASF, banks are exposed to the risk of selling assets at fire sale prices to repay the liabilities claim on demand.
[9]See King (2013) or DeYoung and Jang (2016) for the weight on each class of the assets and liabilities.

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with less restricted fund access using pooled cash flows (Stein 1997)[10]. The internal liquidity market works similarly. Carletti et al. (2007) argued that a merger affects banks liquidity management. Banks demands for liquidity depend on uncertainty about deposit withdrawals (Diamond and Dybvig 1983). Mergers change the distribution of liquidity shocks, resulting in changes in liquidity needs. According to Carletti et al. (2007), there are two distinct effects of mergers on funding liquidity, namely, *funding liquidity effects*. One is the diversification effect. Mergers allow banks to diversify funding liquidity risk by pooling idiosyncratic liquidity shocks. The opposite argument is the internalization effect. Mergers increase the marginal value of each unit of liquidity holdings that can be used to meet withdrawals from any of the banks in the same MBHC.

Therefore, the diversification effect indicates that MBHC members hold less liquidity than non-MBHC banks because the expected liquidity needs are smaller than those of the others. In contrast, the internalization effect indicates that an MBHC member holds more liquidity than non-MBHC banks because liquidity is more valuable in the sense that the MBHC member has an opportunity to use liquidity to meet the deposit outflow of other members in the same MBHC. Hence, we postulate the following.

Hypothesis 1 (Diversification): MBHC members have lower NSFRs than non-MBHC banks.

Hypothesis 2 (Internalization): MBHC members have higher NSFRs than non-MBHC banks.

Our primary analysis investigates these two hypotheses.

Hypothesis 1 implies that MBHCs have scant liquidity and use it efficiently in their internal liquidity markets. However, this hypothesis is also consistent with the "too-big-to-fail" story. MBHC members find it unnecessary to have high liquidity because they are

[10]Stein (1997) argued that the internal capital market alleviates cash constraints and allows for more efficient capital allocation. As noted in Scharfstein and Stein (2000) and Rajan et al. (2000), however, inefficient internal capital markets can lead to excessive cross-divisional subsidies.

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confident that they are "too-big-to-fail". Hypothesis 2 implies that MBHCs have abundant liquidity in their internal liquidity markets. Entering an MBHC allows a bank to have access to stable funding sources that the MBHC already has.

### *2.2. Funding costs*

The third analysis complements the baseline. A bank can collect more stable funds by offering higher deposit rates. In particular, such behaviour is remarkable at the onset of a crisis, when deposit inflows into banks weaken (Acharya and Mora 2015)[11]. As the deposit rate increases, the NSFR increases because its numerator, ASF, increases. That is, the funding cost should be positively related to the NSFR based on its composition. The following hypotheses complement the previous Hypothesis 1 or 2, whichever of the two holds, as long as this positive relationship is found.

Hypothesis 3a: MBHC members raise deposits at lower costs than non-MBHC banks when the diversification hypothesis holds.

Hypothesis 3b: MBHC members raise deposits at higher costs than non-MBHC banks when the internalization hypothesis holds.

In other words, we predict that Hypothesis 3a holds when Hypothesis 1 holds and that Hypothesis 3b holds when Hypothesis 2 holds. The former implies that an MBHCs funding cost is lower than others because the MBHC member requires fewer stable funds. The latter implies that an MBHCs funding cost is higher than others because the MBHC member requires more stable funds. Several studies have documented the change in deposit rates when banks experience M&As. Among them, Dinger (2015) found that merging banks are more likely to change their deposit rates in the first months following a merger[12][13].

[11] However, Gatev and Strahan (2006) provided evidence that when liquidity dries up and commercial paper spreads widen, banks experience funding inflows.

[12] Dinger (2015) examined the frequency of deposit-rate changes around the time of a merger and did not mention the direction of changes.

[13] The internal capital market theory suggests that the creation of an internal capital market, in which

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*2.3. Brother/sister effects on liquidity in MBHCs*

When a new bank enters an MBHC, the funding liquidity risk changes within the MBHC. As the number of members increases, the existing members can also diversify the risk of withdrawals more efficiently and can value more highly the liquidity used for withdrawals in other member banks. We call the funding liquidity effect of new entry on other members the brother/sister effect. An example might be helpful to the readers. Figure 1 illustrates the new entry method. Examining the (i) parent-subsidiary case, suppose that MBHC A had members A1 and A2. When a new bank B1 enters MBHC A and becomes a member, this new member is regarded as a newborn child in the family. B1 becomes a brother/sister of A1 and A2. In this case, not only B1 but also A1 and A2 can enjoy the benefits of the more efficient internal liquidity market[14]. In other words, A1 and A2 have brother/sister effects.

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Figure 1

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Accordingly, we hypothesize the following.

Hypothesis 4a: If the diversification hypothesis holds, the other members of an MBHC that has acquired a new member have lower NSFRs than other banks that experience no mergers.

Hypothesis 4b: If the internalization hypothesis holds, the other members of an MBHC that has acquired a new member have higher NSFRs than other banks that experience no mergers.

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the headquarters allocates capital across different projects, could limit the distortions arising from external financing costs (Shin and Stulz 1998, Lamont 1997, Stein 1997). However, this theory is not the case in the banking industry. Houston and James (1998) examined the relationship between organizational structure and bank lending by comparing the lending behaviours of MBHC members and those of non-MBHC banks. They found lower cash flow sensitivity for member banks, indicating that holding company affiliation reduces the cost of raising funds externally. In such a case, non-MBHC banks face a higher cost of financing.

[14]The coinsurance effect was first introduced for mergers between U.S. conglomerates by Lewellen (1971). He found that combining two or more firms with cash flows that are imperfectly correlated can reduce the merged firms risk of default, hence increasing the debt capacity of the combined firm.

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Whichever hypothesis holds, we consider that the brother/sister effect depends on the number of subsidiaries of the MBHC. Along with the theoretical argument in Carletti et al. (2007), the internalization effect and the diversification effect are naturally strengthened by increasing the number of members of an MBHC. However, we have no reason to determine the range of the number at which the former effect dominates the latter. For this reason, we consider a U-shaped or an inverted U-shaped relationship. A U-shaped relationship indicates that the internalization overweighs the diversification when the number of members is large, while the diversification overweighs the internalization when the number of members is small. The inverted U-shaped relationship indicates the opposite. In this regard, the fifth hypothesis becomes the following.

Hypothesis 5a: The funding liquidity effect of a new entry/exit on NSFRs of the other members exhibits a U-shaped relationship.

Hypothesis 5b: The funding liquidity effect of a new entry/exit on NSFRs of the other members exhibits an inverted U-shaped relationship.

### *2.4. New entry types: Parents remarriage and the son/daughters marriage*

MBHCs employ several methods to change their structure: (i) parent-subsidiary mergers; (ii) subsidiary-subsidiary mergers; and (iii) parent-parent mergers. Figure 1 illustrates these three methods. Suppose that MBHC A had two subsidiaries A1 and A2. There is a target bank B1, which might or might not be a subsidiary of another BHC B. To acquire the target, the MBHC can force A2 to acquire or merge with the target B1, which is a subsidiary-subsidiary merger. The second option to acquire the target is that MBHC A directly acquires the target B1 by purchasing its equity stocks, which is a parent-subsidiary merger. If the target is a subsidiary of a BHC, the third option is available. Parent A acquires or merges with parent B, which is a parent-parent merger[15]. From the viewpoint of the liquidity theory

[15] B1 is a newcomer both in (ii) subsidiary-subsidiary mergers and (iii) parent-parent mergers. In (i) parent-subsidiary mergers, B1 disappears. However, A2 inherits the funding liquidity risk of B1.



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of Carletti et al. (2007), these three types of mergers produce the same results regarding MBHCs funding liquidity risk[16].

Therefore, we hypothesize the following.

Hypothesis 6: In each of the three methods of new entry, the internalization or diversification effect emerges as its result.

## 3. Data, variables, and methodology

### *3.1. Sample data*

We use quarterly data from U.S. commercial banks from 1995:Q1 to 2011:Q4. The data sources are the Consolidated Reports of Condition and Income (Federal Financial Institutions Examination Council call reports). We obtain bank-level and BHC-level M&A data from the Federal Reserve Bank of Chicago. We excluded 36 M&A deals from among 4,045 BHC-level M&A deals for a technical reason[17]. The calculation of the NSFR requires detailed information on the items held by BHCs. Since the call reports changed the definitions of items disclosed, we cannot trace the data after 2011:Q4[18].

### *3.2. Variables*

Deyoung and Jang (2016) find that U.S. banks actively manage their liquidity. When banks successful circumvent the new regulation through some types of liquidity arbitrage, banks could reduce their required stable funding and operate with fewer expensive stable

[16]Cremers et al. (2011) found that capital allocations from the headquarters in the banking group compensate for deposit shortfalls at the bank level, suggesting that the effect of parent-parent mergers is the same as the effect of subsidiary-subsidiary mergers in that the number of subsidiaries decreases. However, diversification at the parent level enhances parents ability to obtain better external financing deals to enrich the internal financing available to their subsidiaries, thereby increasing the ability of the parent to relieve the financial difficulties faced by their subsidiaries.

[17]Some BHCs merged with or acquired other BHCs more than once during a quarter. Since our balance sheet data are quarterly, it is necessary to break down the M&A data into quarterly data to create quarterly M&A variables, thus maintaining consistency.

[18]See Appendix A of DeYoung and Jang (2016) for items used to calculate the NSFR.

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funds. Since their study is in line with our objective of this paper, we aim to study whether M&A is a typical type of liquidity arbitrage that non-MBHC banks attempt to join the MBHC structure to benefit from lower liquidity holding. Therefore, we find that the determinants of the NSFR in DeYoung and Jang (2016) are important to our study. In this regard, we follow DeYoung and Jang (2016) and use *Assets*, *Capital*, *Growthplan*, *Public*, *Mortgages*, and *Commitments* as the determinants of the NSFR. The definitions of the variables are provided in Appendix Table A1. Bank size is measured by *Assets*, defined as the log of total assets. As the bank size becomes larger, we expect that the banks are easily able to solve the liquidity risk by selling large brokered deposits or by liquidating marketable loans, such as syndicated loans. *Capital* is defined as book equity (common equity, preferred equity, and subordinated notes) as a percentage of total assets. As the bank is better capitalized, it has greater debt capacity and can afford to absorb the liquidity shock more easily.

*Growthplan* is defined as the inflation-adjusted internal asset growth rate (net of acquisitions) over the next two years. Fast-growing banks have lower NSFRs because it is difficult to fund rapid asset or loan growth by raising new stable funds. *Public* is a dummy variable, which equals one when a bank or its holding company is publicly traded, and zero otherwise. The listed banks are expected to have faster and less expensive access to sources of liquidity. *Mortgages* is 1–4 family mortgage loans as a percentage of total loans. Since such residential mortgage loans have long durations, the bank must mitigate the risks of maturity mismatches between the asset and liability sides. As the proportion of *Mortgages* increases, the bank is expected to choose a higher NSFR. *Commitments* is unused loan commitments as a percentage of total assets. As the proportion increases, the bank is expected to have a lower NSFR, all else being equal.

We consider several other variables. As argued by Carletti et al. (2007), the internalization effect dominates if the cost of refinancing is low, while the diversification effect dominates when it is high. Accordingly, we measure the cost of refinancing by *Fundingcost*, defined as

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deposit funding cost per total deposits. Additionally, we control for *Deposit*, measured by total deposits divided by total assets. We control for a measurement of income diversification, *Incomediv*, defined as non-interest income divided by operating income because the business mix of banks affects their illiquidity ratios.

We expect that MBHCs can diversify the funding liquidity risk more by obtaining funds from different regions. If two banks are subsidiaries of the same MBHC in a different state, each might have different liquidity shocks[19]. From this viewpoint, we control for several state-level economic conditions. *GDPgrowth*, *Unemployment*, and *Inflation* represents basic macroeconomic conditions of the state. The house price index (*HPI*) measures aggregate demand for mortgage loans and commercial and industrial loans. *Branches* is the number of branches as a percentage of assets (in million dollars). *HHI* is the Herfindahl-Hirschman index for deposits. These two variables measure the competitiveness of deposit markets in a state. Finally, *Failure* is the frequency of bank failures in a state. As this rate increases, a distressed bank is more likely to be acquired. The data sources are the Federal Deposit Insurance Corporation for *Branches*, *HHI* and *Failure*, the U.S. Census Bureau for *GDPgrowth* and *Inflation*, the Federal Housing Finance Agency for *HPI*, and the Bureau of Labor Statistics for *Unemployment*.

*3.3. Summary statistics*

Table 1 displays descriptive statistics for two sub-samples of non-MBHC banks and MBHC members during the period from 1995 to 2011. Non-MBHC banks comprise stand-alone banks and subsidiary banks of single-bank holding companies. Each observation is counted as a bank-quarter. To remove outliers, all of the variables are winsorized at the 1% and 99% percentiles. The last column presents the t-test for the equality of means across sub-samples. The statistics are significant at the 1% level for all of the variables except for *Fundingcosts*.

[19]Hughes et al. (1999) and Deng and Elyasiani (2008) found that MBHCs operate in distant geographic horizons.

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In particular, non-MBHC banks have a higher NSFR, a smaller size, a higher growth plan, a higher mortgage, a smaller commitment, and a smaller proportion of income diversification but higher deposits than MBHC members.

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Table 1

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*3.4. Matching method*

To test the hypotheses previously mentioned, we need to identify the differences in funding liquidity effects between MBHC members and non-MBHC banks. This section explains how we use the matching method to identify the funding liquidity effects in the baseline estimation. The method comprises the following four steps.

Step 1: We define treatment group and control group in the baseline analysis. The treated group comprises *Changer*, which is a bank that was not initially a member and entered MBHC during the sample period. The control group comprises *non-MBHC bank*, which has never belonged to MBHCs throughout the period. An indicator variable $D_{it}$ takes one when the bank $i$ belongs to the treated group at period $t$, and zero otherwise.

Step 2: We estimate propensity score by yearly probit estimation. Unlike experimental studies where a random assignment of treatment guarantees that each unit has the same likelihood of treatment ex-ante, the selection bias due to observable/unobservable differences between the treated and control should be corrected(Dehejia and Wahba 2002, Smith and Todd 2005). The propensity score $\widehat{p}_{it}$ is estimated by probit equation as

$$\Pr(D_{it} = 1) = \Phi\left(\sum_{k=1}^{K} \widehat{\gamma}_k x_{i,t-1}^k\right) \equiv \widehat{p}_{it} \tag{1}$$

for each period $t$. $\Phi$ is a cumulative normal distribution function and $\widehat{\gamma}_k$ is the estimated coefficient of $k$-th control variable $x_{i,t-1}^k$. Since it is necessary that the control variables should



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not be affected by the treatment, we take at least one lag for all the control variables.

Step 3: We match a bank belonging to the treated group with a bank belonging to the control group one by one, using nearest-neighbour propensity score matching (PSM) (Rosenbaum and Rubin 1983) or the kernel matching method (Heckman et al. 1998a).

Step 4: We consider average treatment effects of a new entry into an MBHC on the treated. An indicator variable $s$ is defined to denote pre-treatment period and post-treatment period. $s = 0$ denotes pre-treatment period and $s = 1$ post-treatment period, respectively. From the definition of our treatment and control group, $D_{i0} = 0$ for both groups, $D_{i1} = 1$ for the treatment group, and $D_{i0} = 0$ for the control group. To simplify the notation, we represent the indicator variable as $D_s$ omitting the subscript $i$ when possible. In addition, we denote the outcome variable NSFR by $y_s$ without subscript $i$. Let $y_1^0$ be the outcome without treatment and $y_1^1$ be the outcome with treatment.

If we assume conditional mean independence

$$E(y_1^0|x, D_1) = E(y_1^0|x) \text{ and } E(y_1^1|x, D_1) = E(y_1^1|x), \tag{2}$$

the effect of the treatment on the treated becomes

$$E(y_1^1 - y_1^0|x, D_1 = 1) = E(y_1^1 - y_1^0|x). \tag{3}$$

The conditional mean independence assumption, which is sometimes called the unconfoundedness assumption, assumes away potential bias arising from the selection on observables (Imbens 2004, Smith and Todd 2005). It means that once conditioning on covariates $x$, the treatment produces no systematic differences in outcomes attributable to the treatment effect.



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If we further assume an overlapping condition [20]

$$0 < Pr(D_1 = 1|x) < 1 \tag{4}$$

for all $x$, the average treatment effect on the treated(ATT) becomes

$$ATT = E\left(\frac{(D_1 - p(x))\, y_1}{1 - p(x)}\right)\frac{1}{Pr(D_1 = 1)} \tag{5}$$

where $p(x) = Pr(D_1 = 1|x)$ is propensity score. The matching estimator of ATT is

$$ATT_1 = \frac{1}{N}\sum_{i:\, D_{i1}=1}\left(y_{i1} - \sum_{j\in C_i} w_{ij} y^0_{i1}\right) \tag{6}$$

where $w_{ij}$ is a weight for $j$-th bank matched with $i$ in the comparison group $C_i$, and $N$ is the number of treated banks[21]. We use matching on the propensity score (Rosenbaum and Rubin 1983)[22]. When we use the one-nearest-neighbour matching with propensity score, $w_{ij'} = 1$ only for the nearest neighbour $j'$ and $w_{ij} = 0$ for other $j \neq j'$. The comparison group $C_i$ is restricted to the set that the calliper, i.e., the maximum distance at which two observations are far from each other, is 0.01. When we use the kernel matching estimator,

[20] This assumption means that there should be a positive probability of either entering MBHC ($D_1 = 1$) or not ($D_1 = 0$), which ensures the existence of potential matches for each *Changer* among *non-MBHC banks*. This assumption is sometimes called common support. When this assumption is satisfied, matching eliminates the bias arising from the differences in the supports of covariates between the treated and controls and the bias arising from the differences in the distributions of covariates between the two groups in the common support(Heckman et al. 1998b).

[21] Such a counterfactual framework mitigates the issue of selection bias when we estimate the NSFR in a usual parametric outcome regression. Let $\epsilon_{it}$ be an individual transitory shock in the regression. Then, a sufficient condition for identification is that selection for treatment does not depend on the individual transitory shocks. That is, $Pr(D_{i1} = 1|\epsilon_{it}) = Pr(D_{i1} = 1)$. If this holds, we have $E(D_{i1}\epsilon_{it}) = 0$ so that we can estimate the outcome regression equation. However, if that equation does not hold, i.e., the treatment variable is correlated with the error in the outcome equation, selection bias arises so that we cannot identify the outcome equation. The assumption of conditional mean independence essentially rules out confounding due to this correlation.

[22] PSM avoids the curse of dimensionality.

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the weight is calculated using kernel function $K$ as $w_{ij} = K(p_i - p_j)/\sum_{j:D_{i1}=0} K(p_i - p_j)$, and the comparison group is the same across $i$, $C_i = \{j : D_{i1} = 0\}$.

### *3.5. Alternative average treatment effects*

In our definition of the treated and control groups, we have $E(y_0^0|x, D_1 = 1) = E(y_0^0|x)$ because $D_{i0} = 0$ for both groups. Since Eq. (2) implies

$$E(y_1^1 - y_1^0|x, D_1) = E(y_1^1 - y_1^0|x) \tag{7}$$

under our construction of the sample, then Eq. (3) is easily expressed as

$$E((y_1^1 - y_0^0) - (y_1^0 - y_0^0)|x, D_1 = 1) = E(\Delta y^1 - \Delta y^0|x) \tag{8}$$

where $\Delta y^1 = y_1^1 - y_0^0$ and $\Delta y^0 = y_1^0 - y_0^0$. These two differences are changes from the pre-treatment to post-treatment for the treated and the control, respectively. Therefore, this can be seen the difference-in-difference estimator, and its sample ATT is

$$ATT_2 = \frac{1}{N} \sum_{i:D_{i1}=1} \left( \Delta y_{i1} - \sum_{j \in C_i} w_{ij} \Delta y_{i1}^0 \right) \tag{9}$$

An alternative approach is proposed by Abadie (2005). Instead of Eq. (2), we assume

$$E\left(y_1^0 - y_0^0|x, D_1\right) = E\left(y_1^0 - y_0^0|x\right) \tag{10}$$

It states that conditional on the covariates, the average NSFR for treated and controls would have followed parallel paths in absence of the treatment. This assumption reduces to selection on observables restriction

$$E\left(y_1^0|x, D_1 = 1\right) = E\left(y_1^0|x, D_1 = 0\right) \tag{11}$$

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under our construction that $D_0 = 0$ and $E(y_0^0|x, D) = E(y_0^0|x)$ for all banks. Together with the overlapping assumption, the consistent estimator of the average treatment effect $E(y_1^1 - y_1^0|x, D_1 = 1)$ becomes

$$ATT_3 = (\rho N)^{-1} \sum_{i=1}^{N} \frac{(D_{i1} - \widehat{p}_{i1})\Delta y_i}{1 - \widehat{p}_{i1}} \tag{12}$$

where $\rho$ is the fraction of the treated, and $\Delta y_i = y_{i1} - y_{i0}$ is the observed difference of the NSFR.

For the robustness, we pick up the *first-time changer* from a group of *Changer*[23]. This is identified as the bank that enters MBHC for the first time and remains a member during the sample period among *Changer*. Restricting to the *First-time changer* excludes the possibility that the bank in the treated group is different from the bank in the control group before the treatment. Once entering MBHC and exiting afterwards, banks may have net stable funding and/or covariates different from that of the bank staying at MBHC. In particular, if the past NSFR affects the decision to enter MBHC, the effects of the entering MBHC on the NSFR may be different between the banks that were previously MBHC members and the banks that have not been.

## 4. Empirical results

### *4.1. Funding liquidity effects of new entry into MBHCs: Baseline analysis*

We use the matching method to identify the differences in funding liquidity effects between MBHC members and non-MBHC banks. In the baseline analysis, we examine three types for the treatment group: *Changer*, *First-time changer*, or *Repeater*. *Changer* is a bank that was not initially a member and that entered the MBHC at the time of the sample period. *First-time changer* is identified as a bank that enters MBHC for the first time and remains a

[23] Casu et al. (2013) examine the first-time treatment for the reason described below.

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member during the period[24]. *Repeater* is a bank that repeatedly joined and left the MBHC structure during the observable period. The control group comprises *non-MBHC banks* that never belonged to MBHCs throughout the period. Table 2 reports the frequency distribution of the treatment groups. There are 1,497 observations belonging to *Changer*. Among them, 857 observations are *First-time changers*. The remaining 647 observations are *Repeaters*.

Table 2

We match the treated with the controls, using nearest-neighbour PSM or kernel matching[25]. Table 3 indicates our main results. The estimated average treatment effect of entering an MBHC on those banks that actually entered is the difference in the outcome variable between the treated and controls. The treatment group is *Changer* in columns (i) to (iv). It is *First-time changer* in columns (v) to (vii) and is *Repeater* in column (viii). The outcome variable is either the NSFR or its difference, denoted DNSFR . The matching method is nearest-neighbour PSM, kernel matching, or Abadies method (Abadie 2005)[26]. In models 9 to 16, we include the previous NSFR as a covariate because lower liquidity might be the reason for the bank to enter the MBHC (Almeida et al. 2011)[27].

The estimated ATTs are significantly negative for all of the models. Therefore, we can

[24]Once entering an MBHC and exiting afterwards, banks might have net stable funding and/or covariates different from those of banks remaining in the MBHC. In particular, if the past NSFR affects the decision to enter the MBHC, the effects of entering the MBHC on the NSFR could be different between the banks that were previously MBHC members and the banks that were not.

[25]Our matching method is valid. Figure A3, Appendix Table A2 and Appendix Table A4 will be provided upon request from the authors as appendices. Figure A3 shows the estimated distribution of the propensity score by the kernel density method, indicating that the two distributions for treated and controls are almost similar, but that of the unmatched is quite different from the others. Appendix Table A2 reports the t-test results for each covariate, indicating no significant differences in any of the covariates or the two treatment groups. The balancing condition is satisfied regardless of the group that is considered treated.

[26]In the appendix, we explain the difference in Abadies method from the usual PSM.

[27]Almeida et al. (2011) theoretically showed that financially distressed firms are acquired by liquid firms in their industries, even in the absence of operational synergies. They call these transactions "liquidity mergers" since their purpose is to reallocate liquidity to firms that are otherwise inefficiently terminated.

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conclude that entering the MBHC caused a lower NSFR, conditional on that the bank actually entered an MBHC, even if we consider selection bias. The results support Hypothesis 1. The diversification effect dominates internalization effects. MBHCs create their internal markets to exchange their liquidity needs. Therefore, MBHC members dispense with holding more liquidity than non-MBHC banks because the expected liquidity needs are smaller than those of the others. However, the estimated ATTs seem economically small.

The results do not change whether we include the previous NSFR, which could be a potential reason for selection bias, as a covariate. As we discussed earlier, if the previous NSFR truly affects the decision to enter an MBHC and if we include the previous NSFR as a covariate, potential selection bias can arise. This inclusion does not change the ATTs much in any column. In addition, the matching methods do not produce different results. Furthermore, our results are robust to the subsample of *First-time changers* and *Repeaters*.

Table 3

*4.2. Robustness test*

The previous estimation examines the difference in the NSFR only one quarter after new entry. Calomiris (1999) suggested that the timing of the realization of gains from consolidation is important to constructing a proper counterfactual. He argued that gains from mergers could continue to accrue a couple of years after the merger occurred, or the costs outweigh the benefits of the merger in the first two years after the merger. In our context, the significant liquidity effect in the previous table might be due to the temporary reasons for mergers. Therefore, our second analysis examines whether the diversification effect persists for at least one or two years. The upper panel of Table 4 reports the estimated ATTs after one year, and the lower panel presents ATTs after two years. The results are almost identical to those in Table 3. The diversification effect persists over one or two years, and there is an



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increasing tendency over the period after the merger. The gains of liquidity from mergers continue to accrue for at least two years after the merger.

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Table 4

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Additionally, our results are robust to an alternative measurement of liquidity: the traditional loans-to-core deposits (LTCD) ratio (DeYoung and Jang 2016). Note that LTCD is higher when funding liquidity risk is higher, indicating movement in an opposite direction from the NSFR. As shown in models 5, 6, 11, and 12, the estimated average treatment effects are not significant for one year while the effects become significantly positive after two years.

*4.3. Funding costs*

Since the first analysis provides evidence for the diversification effect, the second analysis tests Hypothesis 3a. Table 5 reports the results of the estimated ATTs of funding costs. All of the estimated ATTs are significantly negative. The t-statistics are very high. The results support Hypothesis 3a. By entering an MBHC, the bank can afford to save funding costs because it requires fewer stable funds than before. The funding cost is positively related to the NSFR when a bank enters an MBHC. The result that entering an MBHC allows a bank to have a higher NSFR and lower funding costs because it enables the entrant to have access to the stable funding sources that the MBHC already has is non-intuitive[28].

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Table 5

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[28] Additionally, the second result is along the lines of the evidence provided by Cremers et al. (2011) that the headquarters offer deposit smoothing to member banks in the banking group.

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### *4.4. Funding liquidity effects of new entry into MBHCs: Brother/sister effects*

So far, we have analysed the funding liquidity effects of new members entries into an MBHC. The third analysis investigates the brother/sister effects of a new entry. We consider two treatment groups: the *Increase* group and *Decrease* group. When an existing bank experiences a new entry into its MBHC, and the number of members of this MBHC increases, the existing banks in this MBHC belong to the *Increase* group. Formally, the dummy variable $D_{it}$ equals one if the existing bank $i$ experiences an increase in the number of members, and zero otherwise. When an existing bank experiences an exit from its MBHC and the number of members decreases, the banks in this MBHC belong to the *Decrease* group. Formally, the dummy variable $D_{it}$ equals one if the bank $i$ experiences a decrease in the number of members, and zero otherwise.

Table 6 reports the estimated average treatment effects on the treated of experiencing new entry or exit. For the *Increase* treatment group, the differences are significantly negative in both model 1 and model 3. For the *Decrease* treatment group, the differences are significantly positive in models 2 and 4. The evidence supports Hypothesis 4a. The diversification effect dominates the internalization effect when the number of members changes. The NSFR decreases when a newcomer enters and increases when the existing bank exits from the MBHC.

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Table 6

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### *4.5. U-shaped relationship*

As highlighted by Cetorelli et al. (2014), BHCs have not only grown in size but also have become substantially more complex. The Federal Reserve Board is proposing NSFR requirements tailored to more complex BHCs. Federal Register (2016) argued that the threat to U.S. financial stability is mainly due to an unstable funding profile of complex BHCs. As

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mentioned earlier, our analysis is motivated by more complex BHCs perhaps facing challenges in liquidity risk management. For this reason, we enrich the above analysis by omitting the simplified assumptions.

The above analysis simplified the analysis by implicitly assuming that the funding liquidity effect does not depend on the number of members. However, as the previous argument suggests, if the number of members affects the liquidity held by existing members, they might have lower(higher) NSFRs as the number of members increases(decreases). The previous Table 2 reports the distribution of the number of members of MBHCs. A large number of MBHCs have two or three members. Additionally, there are many MBHCs with more than 10 members.

To test Hypothesis 5, the fourth analysis uses a regression approach. We specify the NSFR as

$$\mathrm{NSFR}_{it} = \alpha t + \beta(N_{it})D_{it} + \sum\nolimits_{k=1}^{K} \gamma_k X_{i,t-1}^k + \lambda_t + c_i + \epsilon_{it} \tag{13}$$

A time-specific component is denoted by $\lambda_t$, an individual-specific component by $c_i$, and an individual transitory shock by $\epsilon_{it}$, which has a mean of zero at each $t$. $X_{i,t-1}^k$ represents the control variables. The dummy variable $D_{it}$ takes 1 if the number of members changes (*Increase* or *Decrease*). $N_{it}$ is a log of number of members[29]. The coefficient $\beta(N_{it})$ is assumed to be a quadratic function $\beta_1 N_{it} + \beta_2 N_{it}^2$, including linear case.

The estimation method is a first-differenced estimation with time as a fixed effect. We difference the above equation to obtain

$$\Delta\mathrm{NSFR}_{it} = \alpha + (\beta_1 N_{it} + \beta_2 N_{it}^2)\Delta D_{it} + \sum\nolimits_{k=1}^{K} \gamma_k \Delta X_{i,t-1}^k + \eta_t + \nu_{it} \tag{14}$$

where $\eta_t = \lambda_t - \lambda_{t-1}$ and $\nu_{it} = \epsilon_{it} - \epsilon_{i,t-1}$. If we assume the strict exogeneity $E(\Delta D_{it}\nu_{it}) = 0$,

[29]We take log because the distribution of the number of subsidiaries is highly skewed.

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the above equation can be estimated by OLS with time fixed effects, which is the first-differenced estimator.

We exclude the observations that enter MBHCs by themselves for reasons of selectivity bias. We also exclude observations with numbers of subsidiaries that do not change, that is, if they experience the same numbers of entries and exits, because the effect might be ambiguous.

Table 7 reports the results of estimation. In model 1, in which both dummies are included, the $\beta$ coefficients are significant. Model 2 drops the *Decrease* group, and model 3 drops the *Increase* group. Additionally, in these two models, the $\beta$ coefficients are still significant. These three models consistently indicate that the NSFR is U-shaped with respect to *Increase* and has an inverted U-shape with respect to *Decrease*. Hypothesis 5a is supported by this result.

At the bottom of the table, we report the slopes of dummies evaluated at the mean, minimum, and maximum of the number of members. We can see that the slope for *Increase* is negative at the minimum and is positive at the maximum. The slope for *Decrease* is positive at the minimum and is negative at the maximum. Since the dummy equals positive one when the number of members is decreasing, these two slopes for *Increase* and *Decrease* are consistent with each other. In other words, the diversification effect dominates internalization when the number of members is small, while internalization dominates when the number of members increases. The complex MBHCs that have a large number of members manage liquidity very differently from the MBHCs that have relatively simple structures.

Across four models, the *Fundingcosts* coefficient is negative and significant at the 1% level. *Growthplan* is negatively associated with the NSFR, indicating that rapidly growing banks target lower NSFRs. The significantly positive coefficient of *Mortgages* indicates that when residential mortgages are an important line of a lending business, banks tend to increase their liquidity to eliminate their interest rate risk. Banks that invest in loan commitment

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activities tend to reduce their NSFR. The coefficient of *Incomediv* is insignificant. Banks with higher deposits are more likely to reduce their holdings in the NSFR.

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Table 7

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*4.6. Method of entry: Parental effect*

The last analysis aims at testing Hypothesis 6. The four treatment groups are defined as the subsample of the baseline analysis. The *SUB-SUB* group comprises members that acquired outside banks. The *PAR-SUB* group comprises members that were acquired by a parent BHC. The *PAR-PAR1* group comprises banks with parent BHCs that were acquired by other BHCs. The *PAR-PAR2* group comprises members whose parent BHC acquired other BHCs. Note that in subsidiary-subsidiary M&As, since the targets disappear after M&As, we include only the acquirers[30].

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Table 8

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Table 8 presents our findings. There are significantly negative differences for all four treatment groups. The evidence supports Hypothesis 6. Whichever type of merger the BHC chooses, the diversification effect appears after the merger.

## 5. Conclusions

This paper presents a comprehensive study of how an MBHC manages funding liquidity risk through its internal liquidity market and the funding liquidity effect of new entry into the

[30]In addition, note that in parent-parent M&As, the effect resembles the brother/sister effect in the sense that the subsidiary itself experiences no M&A.

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MBHC through the brother/sister and parental effects. We conduct our empirical analysis using quarterly U.S. commercial banks data from 1995:Q1 to 2011:Q4. The internal markets provide entrants with benefits of efficient allocation of funding liquidity risks. The banks in MBHCs allocate scant liquidity efficiently to each other and increase their deposits at low costs.

Our study contributes to the understanding and makes some recommendations for depositors, investors, academic researchers and regulators as follows. First, we find that the diversification effect dominates the internalization effect in the internal liquidity markets of MBHCs. MBHC members hold less liquidity than non-MBHC banks because the expected liquidity needs are smaller than those of the others. Our evidence shows that by entering an MBHC, the bank can afford to save funding costs because it requires fewer stable funds than before. Therefore, we would suggest depositors and/or regulators to check the funding liquidity risk of this structure carefully. In addition, depositors of MBHC banks could not earn high interest rates compared to those of non-MBHC banks.

Second, the findings related to the brother/sister effect suggest that the NSFR becomes lower when a newcomer enters and higher when an existing bank exits from the MBHC. Interestingly, the diversification effect dominates internalization when the number of members is small, whereas internalization dominates when the number of members increases. This evidence contributes to deeper understanding of the MBHC structure in that complex MBHCs holding a large number of members manage liquidity very differently from MBHCs with relatively simpler structures. Our study has highlighted the instability of large MBHC structure. The investors increasingly become aware of the efficiency of their investment portfolios between simple MBHCs and complex MBHCs, depending on their risk preference.

Third, we extend our analysis to different entry types: (i) parent-subsidiary mergers; (ii) subsidiary-subsidiary mergers; and (iii) parent-parent mergers. We find consistent results that regardless of the type of merger that the BHC chooses, the diversification effect appears

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after the merger. In line with our initial attempt, a merger is regarded as an observable factor of BHCs risk that the relevant academic researchers could apply to their studies.

Fourth, our study has presented the observable trend of joining the MBHC structure in order to benefit from holding lower liquidity and raise deposits at lower costs up to 2011[31]. However, our paper shows a shortcoming on the data sample period that limits the readers the observation in the recent years.

Given the ever-increasing systemic importance of BHCs, it is difficult for an outsider to distinguish between the risks arising from this complex structure. Apparently, more than 500 failed banks have been recorded from the peak of the crisis in 2007 to the early period of 2016[32]. Therefore, it is crucial to investigate the reasons why the banks failed and create pressure on the role of the regulators. As of the first implementation in 2021, the regulator should be aware that the regulatory burden of Basel III NSFR regulations might be more harmful to MBHCs than to non-MBHCs. These regulations distort the working of internal liquidity markets in the MBHCs. Internal liquidity markets are particularly important during the period when external liquidity markets do not work.

Since deregulation, the environments in which stand-alone banks and BHC affiliates exist have undergone many changes, e.g., under more competitive pressure from other types of finance institutions such as finance companies, brokerage firms, and money market mutual funds. The need for further research into the inherent risks of finance companies, brokerage firms or money market mutual funds has been highlighted, in particular for financial holding companies. Further investigation is needed in other countries, such as Japan, where the business group is well developed, therefore contributing to the Basel III regulatory debate for the regulatory context in Asia.

[31]As indicated in Ly et al. (2017b), there is a high M&A trend until 2012.
[32]The failed bank list can be found from https://www.fdic.gov/bank/individua l/failed /banklist.html.

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**Highlights**

- We study how a multi-bank holding company (MBHC) manages funding liquidity risk by using the U.S. bank sample between 1995 and 2011
- The diversification effect is found to dominate the internalization effect
- MBHCs enjoy scant liquidity at the cost of mismatch risk
- Whichever types of mergers/acquisitions are chosen by an MBHC, the diversification effect appears
- Basel III liquidity regulations would mitigate the mismatch risk at the cost of distorted internal liquidity markets

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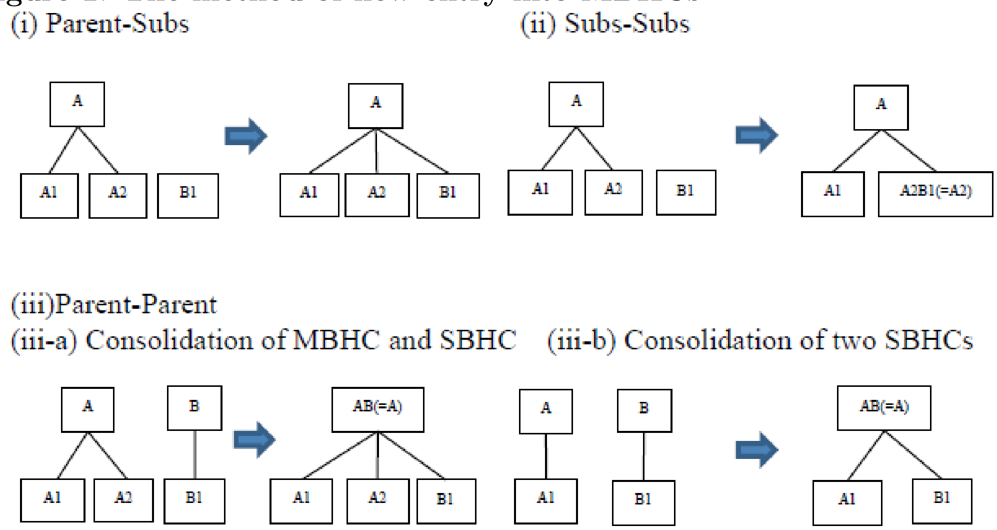
**Figure 1: The method of new entry into MBHCs**




Note: A and B are BHCs. A1, A2, and B1 are member banks of the corresponding BHCs. In (i), Parent A acquires B1. B1 is new entrant. A1 and A2 may have brother effect. In (ii), A2 acquires B1 and becomes A2B1. A1 may have brother effect. In (iii-a), Parent A acquires single-BHC (SBHC) B and becomes AB. B1 is new entrant. A1 and A2 may have brother effects. In (iii-b)Parent A and B were SBHC. Differently from (iii-a), A1 also becomes member of MBHC.

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Table 1: Summary statistics by bank types

| Variable | *Non-MBHC banks* | | | *MBHC members* | | | t-test of difference in mean |
|---|---|---|---|---|---|---|---|
| | Number of obs. | Mean | Std. dev. | Number of obs. | Mean | Std. dev. | |
| *NSFR* | 268,350 | 1.19 | 0.23 | 78,606 | 1.16 | 0.26 | *** |
| *Assets* | 268,350 | 12.01 | 1.20 | 78,606 | 12.61 | 1.71 | *** |
| *Capital* | 268,350 | 0.11 | 0.04 | 78,606 | 0.10 | 0.05 | *** |
| *Growthplan* | 268,350 | 0.14 | 0.31 | 78,606 | 0.13 | 0.30 | *** |
| *Public* | 268,350 | 0.005 | 0.07 | 78,606 | 0.002 | 0.05 | *** |
| *Mortgages* | 268,350 | 0.19 | 0.14 | 78,606 | 0.17 | 0.12 | *** |
| *Commitment* | 268,350 | 0.08 | 0.09 | 78,606 | 0.12 | 0.14 | *** |
| *Incomediv* | 268,350 | -0.08 | 4.37 | 78,606 | 0.30 | 4.84 | *** |
| *Deposits* | 268,350 | 0.83 | 0.09 | 78,606 | 0.79 | 0.14 | *** |
| *Fundingcosts* | 268,350 | 0.01 | 0.01 | 78,606 | 0.01 | 0.01 | |
| *LTCD* | 267,913 | 0.95 | 0.31 | 78,265 | 1.00 | 0.33 | *** |

Note: This table reports summary statistics for two groups: non-MBHC banks and MBHC members. The last column presents t-test statistics for the equality of mean for each variable between MBHC members and non-MBHC banks. Number of observations is as of bank-quarter. *** denotes significance at 1% level. See table A1 in the appendix for the definitions of variables.

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Table 2: Frequency distribution of new entries and number of MBHC members

| | | | Frequency | (%) |
|---|---|---|---|---|
| *Changer* | | | 1,511 | |
| | *First-time changer* | | 853 | 56.45 |
| | *Repeater* | | 658 | 43.55 |
| | | first time | 478 | 31.63 |
| | | second time | 127 | 8.41 |
| | | third time | 30 | 1.99 |
| | | more than third time | 23 | 1.52 |
| Number of MBHC members | | | | |
| | 2 | | 25,792 | 32.81 |
| | 3 | | 11,539 | 14.68 |
| | 4 | | 7,846 | 9.98 |
| | 5 | | 5,494 | 6.99 |
| | 6 | | 4,150 | 5.28 |
| | 7 | | 2,549 | 3.24 |
| | 8 | | 1,822 | 2.32 |
| | 9 | | 2,500 | 3.18 |
| | Over 10 | | 16,914 | 21.52 |

(Note) The table reports the frequencies and percentages of new entries to MBHCs and number of members of MBHCs. Number of observations is as of bank-quarter. Changer is the new entrant to MBHCs. First-time changer is the bank that enters MBHC for the first time. Repeater is the changer that enters MBHC more than once.

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Table 3: Funding liquidity effects of new entry into MBHC

| Column # | i | ii | iii | iv | v | vi | vii | viii |
|---|---|---|---|---|---|---|---|---|
| Model | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Outcome vars | *NSFR* | *NSFR* | *DNSFR* | *DNSFR* | *DNSFR* | *DNSFR* | *DNSFR* | *DNSFR* |
| Number of obs | 1,511 | 1,511 | 1,511 | 1,511 | 853 | 853 | 853 | 658 |
| ATT | -0.032 ** | -0.068 *** | -0.007 ** | -0.009 *** | -0.009 ** | -0.009 ** | -0.007 ** | -0.008 ** |
| Standard error | 0.013 | 0.024 | 0.003 | 0.002 | 0.004 | 0.004 | 0.004 | 0.003 |
| t-stat | -2.551 | -2.869 | -1.962 | -3.582 | -2.268 | -2.529 | -1.886 | -2.478 |
| p-value | 0.011 | 0.004 | 0.050 | 0.000 | 0.024 | 0.012 | 0.043 | 0.043 |
| *including NSFRt-1 as a covariate* | | | | | | | | |
| Model | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| Outcome vars | *NSFR* | *NSFR* | *DNSFR* | *DNSFR* | *DNSFR* | *DNSFR* | *DNSFR* | *DNSFR* |
| Number of obs | 1,511 | 1,511 | 1,511 | 1,511 | 853 | 853 | 853 | 658 |
| ATT | -0.032 ** | -0.072 *** | -0.007 ** | -0.008 *** | -0.009 ** | -0.009 ** | -0.006 * | -0.008 ** |
| Standard error | 0.013 | 0.024 | 0.003 | 0.002 | 0.004 | 0.004 | 0.004 | 0.003 |
| t-stat | -2.565 | -3.062 | -2.260 | -3.511 | -2.222 | -2.513 | -1.719 | -2.412 |
| p-value | 0.010 | 0.002 | 0.024 | 0.000 | 0.027 | 0.012 | 0.086 | 0.016 |
| Treatment group | *Changer* | *Changer* | *Changer* | *Changer* | *First-time changer* | *First-time changer* | *First-time changer* | *Repeater* |
| Method | Nearest-neighbor PSM | Kernel matching | Nearest-neighbor PSM | Kernel matching | Nearest-neighbor PSM | Kernel matching | Abadie's DID | Kernel matching |

Note: The table reports the average treatment effects on the treated (ATT). Outcome variable is NSFR or its difference, DNSFR. The treatment group is Changer or First-time changer. Changer is the changer from non-MBHC bank to MBHC member. First-time changer is the bank that changed from non-MBHC banks to MBHC member for the first time. The control group consists of banks that are non-MBHC from the beginning to the end of the period when it exists in the sample. In the same columns, we use the same ATT, treatment group, countrol group, and method as indicated in the last four rows. In the model from 8 to 14, we use the lagged NSFR as a covariate. The matching method is nearest neighbor propensity score matching or kernel matching except for models 7 and 15. The methods of model 7 and 15 follow Abadie's semiparametric difference-in-differences estimate. Propensity score is estimated year by year. ***, **, * denotes significance at 1%, 5% and 10% level.

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Table 4: Funding liquidity effects of new entry into MBHC: One year and two-years estimation window

| | | | | | | |
|---|---|---|---|---|---|---|
| *One-year* | | | | | | |
| Model | 1 | 2 | 3 | 4 | 5 | 6 |
| Outcome vars | *NSFR* | *DNSFR* | *DNSFR* | *DNSFR* | *LTCD* | *DLTCD* |
| Number of obs | 1,444 | 1,444 | 529 | 529 | 1,509 | 1,509 |
| ATT | -0.049 *** | -0.025 *** | -0.033 *** | -0.027 *** | 0.015 | 0.002 |
| Standard error | 0.006 | 0.004 | 0.006 | 0.006 | 0.011 | 0.002 |
| t-stat | -8.755 | -6.546 | -5.940 | -4.710 | 1.327 | 1.029 |
| p-value | 0.000 | 0.000 | 0.000 | 0.000 | 0.185 | 0.303 |
| *Two-years* | | | | | | |
| Model | 7 | 8 | 9 | 10 | 11 | 12 |
| Outcome vars | *NSFR* | *DNSFR* | *DNSFR* | *DNSFR* | *LTCD* | *DLTCD* |
| Number of obs | 1,444 | 1,444 | 529 | 529 | 1,099 | 1,099 |
| ATT | -0.052 *** | -0.023 *** | -0.028 *** | -0.025 *** | 0.049 *** | 0.028 *** |
| Standard error | 0.006 | 0.005 | 0.008 | 0.008 | 0.014 | 0.010 |
| t-stat | -8.689 | -4.805 | -3.499 | -3.076 | 3.657 | 2.694 |
| p-value | 0.000 | 0.000 | 0.001 | 0.002 | 0.000 | 0.007 |
| Treatment group | *Changer* | *Changer* | *First-time changer* | *First-time changer* | *Changer* | *Changer* |
| Method | Kernel matching | Kernel matching | Kernel matching | Abadie's DID | Nearest neighbor | Nearest neighbor |

Note: The table reports the average treatment effects on the treated (ATT). Outcome variable is NSFR, DNSFR, LTCD, and its difference DLTCD. One-year or two-years after consolidations. The treatment group is Changer or First-time changer. Changer is the changer from non-MBHC bank to MBHC member. First-time changer is the bank that changed from non-MBHC bank to MBHC member for the first time. The control group consists of banks that are non-MBHC from the beginning to the end of the period when it exists in the sample. In the same columns, we use the same ATT, treatment group, countrol group, and method as indicated in the last four rows. Propensity score is estimated year by year. ***, **, * denotes significance at 1%, 5% and 10% level.

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Table 5: Treatment effects of new entry into MBHC on funding costs

| Model | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Outcome vars | *Fundingcosts* | *Fundingcosts* | *Fundingcosts* | *Fundingcosts* |
| Number of obs | 1,511 | 1,511 | 853 | 853 |
| ATT | -0.002 *** | -0.006 *** | -0.007 ** | -0.006 *** |
| Standard error | 0.000 | 0.000 | 0.000 | 0.001 |
| t-stat | -9.750 | -17.044 | -15.525 | -11.820 |
| p-value | 0.000 | 0.000 | 0.000 | 0.000 |
| *including* $Fundingcost_{t-1}$ *as a covariate* | | | | |
| Model | 5 | 6 | 7 | 8 |
| Outcome vars | *Fundingcosts* | *Fundingcosts* | *Fundingcosts* | *Fundingcosts* |
| Number of obs | 1,511 | 1,511 | 853 | 853 |
| ATT | -0.002 *** | -0.005 *** | -0.007 ** | -0.005 *** |
| Standard error | 0.000 | 0.000 | 0.000 | 0.001 |
| t-stat | -8.978 | -13.649 | -14.854 | -10.061 |
| p-value | 0.000 | 0.000 | 0.000 | 0.000 |
| Treatment group | *Changer* | *Changer* | *First-time changer* | *First-time changer* |
| Method | Kernel matching | Kernel matching | Kernel matching | Abadie's DID |

Note: The table reports the average treatment effects on the treated (ATT). Outcome variable is Fundingcost. The treatment group is Changer or First-time changer. Changer is the changer from non-MBHC bank to MBHC member. First-time changer is the bank that changed from non-MBHC bank to MBHC member for the first time. The control group consists of non-MBHC bank from the beginning to the end of the period when it exists in the sample. In the same column, we use the same ATT, treatment group, countrol group, and method as indicated in the last four rows. ***, **, * denotes significance at 1%, 5% and 10% level.

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Table 6: Funding liquidity effect of new entry into MBHC: Brother/sister effect

| Model | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Outcome vars | *DNSFR* | *DNSFR* | *DNSFR* | *DNSFR* |
| Number of obs | 5,018 | 4,702 | 5,018 | 4,702 |
| ATT | -0.003 ** | 0.003 * | -0.004 *** | 0.004 ** |
| Standard error | 0.001 | 0.002 | 0.001 | 0.002 |
| t-stat | -2.041 | 1.907 | -2.817 | 2.170 |
| p-value | 0.041 | 0.057 | 0.005 | 0.030 |
| Treatment group | *Increase* | *Decrease* | *Increase* | *Decrease* |
| Method | Nearest neighbor | Nearest neighbor | Kernel matching | Kernel matching |

Note: The table reports the average treatment effects on the treated (ATT). Outcome variable is NSFR or its difference, DNSFR. The treatment group is Increase or Decrease group. Increase group consists of the banks that experience an increase in the number of subsidiaries of MBHC. Decrease group consists of the banks that experience a decrease in the number of subsidiaries of MBHC. The control group consists of banks that are non-MBHC from the beginning to the end of the period when it exists in the sample. Propensity score is estimated year by year. ***, **, * denotes significance at 1%, 5% and 10% level.

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Table 7: Regression analysis: Funding liquidity risk and number of MBHC members

| Model | (1) | (2) | (3) |
|---|---|---|---|
| Sample | Increase, Decrease, non-MBHC | Increase, non-MBHC | Decrease, non-MBHC |
| Variables | | | |
| Number of subs. times Increase dummy | -0.003** | -0.004*** | |
| | (0.001) | (0.001) | |
| Squared ( Number of subs.) times Increase dummy | 0.001*** | 0.001*** | |
| | (0.000) | (0.000) | |
| Number of subs. times Decrease dummy | 0.003* | | 0.004** |
| | (0.002) | | (0.002) |
| Squared ( Number of subs.) times Decrease dummy | -0.001* | | -0.001** |
| | (0.001) | | (0.001) |
| *Fundingcost* | -0.194*** | -0.200*** | -0.180*** |
| | (0.053) | (0.054) | (0.054) |
| *Growthplan* | -0.041*** | -0.043*** | -0.043*** |
| | (0.003) | (0.003) | (0.003) |
| *Mortgages* | 0.223*** | 0.238*** | 0.232*** |
| | (0.016) | (0.017) | (0.016) |
| *Commitment* | -0.149*** | -0.153*** | -0.155*** |
| | (0.013) | (0.013) | (0.014) |
| *Incomediv* | -0.000 | -0.000 | -0.000 |
| | (0.000) | (0.000) | (0.000) |
| *Deposits* | -0.285*** | -0.294*** | -0.293*** |
| | (0.015) | (0.014) | (0.015) |
| Constant | 0.012*** | 0.012*** | 0.012*** |
| | (0.001) | (0.001) | (0.001) |
| Observations | 270,914 | 264,924 | 265,082 |
| R-squared | 0.025 | 0.026 | 0.026 |
| Slope | | | |
| at mean for Increase | -0.002 | -0.003 | |
| at min for Increase | -0.003 | -0.004 | |
| at max for Increase | 0.006 | 0.007 | |
| at mean for Decrease | 0.002 | | 0.003 |
| at min for Decrease | 0.003 | | 0.004 |
| at max for Decrease | -0.005 | | -0.007 |
| Exogenous test | 17.454 | 17.920 | 14.199 |
| p-value | 0.000 | 0.000 | 0.000 |
| Partial R-squared | 0.130 | 0.131 | 0.133 |
| F-stat for first stage | 6878.330 | 6808.370 | 6889.670 |
| p-value | 0.000 | 0.000 | 0.000 |

Note: This table reports the results of regressions. Dependent variable is the difference of NSFR, DNSFR. The dummy Increase equals 1 if the bank is a member in the MBHC into which a new member enters and 0 otherwise. The dummy Decrease equals 1 if the bank is a member in the MBHC which the existing bank left and 0 otherwise. Number of subsidiaries is calculated as a log of number of banks that are counted for each MBHCs in each quarter. The estimation method is first differenced estimation. See Appendix Table A1 for the definitions of other variables. Standard error is robust at bank level. ***, **, * denotes significance at 1%, 5% and 10% level.



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Table 8: Funding liquidity effects of new entry into MBHC by merger type

| Model | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Outcome vars | *DNSFR* | *DNSFR* | *DNSFR* | *DNSFR* |
| Number of obs | 88 | 396 | 338 | 684 |
| ATT | -0.022 | -0.012 | -0.015 | -0.009 |
| | ** | * | ** | ** |
| Standard error | 0.010 | 0.007 | 0.006 | 0.004 |
| t-stat | -2.265 | -1.727 | -2.458 | -2.329 |
| p-value | 0.026 | 0.085 | 0.014 | 0.020 |
| Treatment group | *SUB-SUB* | *PAR-SUB* | *PAR-PAR1* | *PAR-PAR2* |

Note: The table reports the average treatment effects on the treated (ATT). Outcome variable is the difference of NSFR, DNSFR. The four treatment groups are defined as: SUB-SUB group consists of MBHC members that acquired other banks. PAR-SUB group consists of banks that were acquired by MBHC. PAR-PAR1 group consists of banks whose parent BHC was acquired by other BHCs. PAR-PAR2 group consists of MBHC members whose parent acquired other BHCs. The control group consists of non-MBHC banks from the beginning to the end of the period when it exists in the sample. The matching method is nearest neighbor propensity score matching. ***, **, * denotes significance at 1%, 5% and 10% level.

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**Appendix Table A1: Definitions of variables [This table is to be published]**

| Variable | Definition |
|---|---|
| *MBHC dummy* | equals 1 if the bank is MBHC members and 0 if either single BHC affiliates or stand-alone banks |
| *NSFR* | Net Stable Funding Ratio |
| *Assets* | Logarithm of total assets |
| *Capital* | Capital / total assets |
| *Growthplan* | Internal asset growth rate (net of acquistions) |
| *Public* | equals 1 if bank stock is publicly traded |
| *Mortgages* | Mortage loans as percentage of loans |
| *Commitment* | Unused loan commitments as percentage of total assets |
| *Incomediv* | Non-interest income / operating income |
| *Deposits* | Deposit / total assets |
| *Fundingcosts* | Deposit interest payment/ total deposits |
| *GDPgrowth* | State-level economic growth |
| *Branch* | State-level number of branches as percentage of assets (in million dollars) |
| *HHI* | State-level Herfindahl- Hirschman Index |
| *HPI* | State-level House Price Index |
| *Failure* | State- level frequency of bank failure |
| *Unemployment* | State-level unemployment rate |
| *Inflation* | State-level inflation rate |
| *LTCD* | Loans to core deposits ratio |

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