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zhang, zhichao and Xie, Li and lu, xiangyun and zhang, zhuang

Durham University - Durham Business School, Durham University - Durham Business School, University of Southampton, Durham University - Durham Business School

31 January 2014

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This draft version: Jan 2014

Zhichao Zhang[a], Li Xie[a,b], Xiangyun Lu[a] and Zhuang Zhang[a]

a. Durham University Business School
b. Corresponding Author. Postal address: Durham University Business School, Mill Hill Lane, DH1 3LB, UK. Tel: +44(0)7545217178. Email: li.xie@duram.ac.uk

ABSTRACT

With a sample of 354 U.S. large bank holding companies, this paper investigates the determination of financial distress in financial institutions. We find that: (1) the house price index is consistently significant and positively associated with the Distance-to-Default (DD) measure in the U.S. banking market; (2) all the three major banking risk characteristics i.e. non-performing loans, short-term wholesale funding, and the credit-risk indicator are reliable factors behind DD determination; (3) for the two alternative measures of BHC activity diversification, non-interest income is positively related with BHCs' DD whereas off-balance-sheet activity is negatively associated to the financial distress measure; and (4) Relevant capital requirements indicators including Tier I Risk-Based Capital Ratio, Total Risk-Based Capital Ratio, Tier I Leverage Ratio should be taken in regulatory assessment of BHCs' financial distress.

Key Words: Bank Holding Company; Distance-to-Default; Financial distress; Bank regulation; Capital requirements; Non-interest income; Off-balance-sheet activities.

JEL numbers: C53, G14, G21, G28

Determinants of Financial Distress in U.S. Large Bank Holding Companies

1 Introduction

Recent years have witnessed that many large U.S. financial institutions failed or came close to failing due to their lending practices and trading behaviour (Allen, Babus, and Carletti, 2009; Laeven, 2011). Such failures have triggered a sharp contraction in both advanced and emerging economies, and the government rescues associated with these failures have given rise to substantial fiscal costs (Laeven and Valencia, 2012). These events highlight the critical importance of understanding the determinants of financial distress of large financial institutions in the promotion of financial stability. Because almost all U.S. banking assets are controlled by bank holding companies (BHCs) (Avraham, Selvaggi, and Vickery, 2012), this paper focuses on BHCs for the study of the determinants of large financial institutions' default risk.

Recent studies of the general issue of the BHCs can be found, for example in Avraham, Selvaggi, and Vickery (2012), Copeland (2012), Cetorelli, Mandel, Mollineaux (2012), and Adams and Mehran (2003). Other studies that examine a variety of aspects of BHCs include Ashcraft (2008) that investigates if bank holding companies are a source of strength to their banking subsidiaries. Curry, Fissel, and Hanweck (2008) assess if BHC risk ratings are asymmetrically assigned or biased

over the business cycles. Elyasiani and Wang (2008) examine the relation between asymmetry of BHCs and their non-interest income diversification. Cornett, McNutt, Tehranian (2009) probe the impact of corporate governance on earnings management in the U.S. BHCs. Studies on BHC diversification can be seen in Elyasiani and Wang (2012) and Goetz, Laeven, and Levine (2013). However, while studies on various aspects on bank holding companies have well advanced, few studies investigate what drives financial distress of bank holding companies, and the implications for financial regulations.

In this paper, we use a sample of selected 354 BHCs with 2288 observations of firm-years during 2003 to 2012 to investigate the effects of various factors on financial distress in terms of default risk in U.S. large BHCs. Default risk is the uncertainty surrounding a firm's ability to serve its debts and obligations (Crosbie and Kocagil, 2003). The approach that we use in measuring the default risk is the index of 'Distance to Default' (DD), originally derived from the models of Black and Scholes (1973) and Merton (1974). These original models have been well extended to investigating various bankruptcy-related problems (for recent review studies, see Sundaresan, 2000; Jarrow, 2009; and Sundaresan 2013).

The determining factors behind US BHCs' financial distress are to be investigated in our tests for the four hypotheses. In the first hypothesis, we use the housing price

index to test whether the DD of BHCs is positively associated with the pro-cyclical macroeconomic conditions. In the second hypothesis, we employ three important measures of BHC risk characteristics, i.e. the non-performing loan ratio, net charge-off ratio (the measure of credit risk), and short-term wholesale funding, to investigate their relations with the DD measure. The third is to use three alternative capital requirements, i.e. the Tier I risk-based capital ratio, total risk-based capital ratio, Tier I leverage ratio, to examine their linkages with the DD index. The fourth is to employ two alternative measures of BHC activity diversification, i.e. the non-interest income, and the off-balance-sheet activity to test whether they are negatively associated with DD. We control five variables, including the four variables in the first two hypotheses and the size factor, in our empirical estimation. Based on this, we deploy three alternative measures of regulatory capital requirements and two alternative proxies of BHC activity diversification to run 6 multivariate regressions with various sample periods, including the periods of 2003-12, 2003-06, 2007-08, and 2009-12, respectively.

Our main findings show that (1) the housing price index is always statistically significant determinant and is positively associated with the DD index, implying that as a proxy for macroeconomic conditions, it critically drives financial distress of U.S. BHCs; (2) the three measures of BHC risk characteristic i.e. the non-performing loan ratio, the measure of credit risk, and short-term wholesale funding can be taken as the

reliable indicators for determinants of the DD measure. Additionally, the short-term wholesale funding is found to be a significant factor exhibiting interconnectedness between financial institutions and their exposures to liquidity risk; (3) the two alternative measures of BHC activity diversification show no consensus in determining default risk: non-interest income is positively associated with BHCs' DD, which is on the contrary to our expectation, whereas the off-balance-sheet activity is negatively related to DD; and (4) for the three regulatory capital requirements, they are all statistically significant implying that they are good indicators of the degree of BHCs' default risk.

The remainder of the paper is organized as follows. Section 2 reviews the literature on bank holding companies. Section 3 develops the hypotheses that we will examine and also specifies our default risk model and the econometric formulation. Section 4 discusses the data and provides conventional descriptive statistics. Section 5 presents the empirical findings and their analysis. Section 6 concludes.

2. Literature Review

As a corporation controlling one or more banks, a large U.S. parent BHC typically engages a broader range of banking and non-banking activities (Avraham, Selvaggi,

and Vickery, 2012). In 1999, the Gramm-Leach-Bliley Act (GLBA)[1] amended the Bank Holding Company Act of 1956 (BHCA)[2], the primary legislation delineating the allowable scope of BHC activities. Under the GLBA, a BHC is allowed to register as a financial holding company (FHC), and may engage in a broad range of activities from insurance underwriting, securities underwriting and dealing, to merchant banking (Elyasiani and Wang, 2012). Avraham et al. (2012) illustrate that, at the end of 2011, almost all U.S. banking assets were governed by bank holding companies. In total, U.S. BHCs controlled over $15 trillion in total assets at that time.

In recent studies on BHCs, Avraham, Selvaggi, and Vickery (2012) provide a structural view of U.S. BHCs, depicting their organizational structures, the size, complexity, and diversity of these organizations, and outlining the different types of regulatory data filed by the Federal Reserve for U.S. BHCs. From an income perspective, Copeland (2012) explores BHCs' income from 1994 to 2010, using detailed income data from the Federal Reserve Y-9C regulatory filings. He finds that large BHCs have become more diverse over time, due to the fact that they have developed new sources of income by delivering new financial services, and concludes that the transformation of the U.S. financial sector has had a considerable impact on BHCs over the last two decades. Cetorelli, Mandel, and Mollineaux (2012) probe the

[1] See Furlong (2000) for a detailed discussion on the GLBA.

[2] See Klebaner (1958) for a detailed discussion on the BHCA.

evolution of U.S. banks and financial intermediation from the view of bank holding companies, and suggest an analytical frame of principles and guidelines for monitoring and identifying future transformations in the U.S. financial system. Adams and Mehran (2003) investigate the systematic differences between the governance of banking and manufacturing firms, and find that the governance structures of banking are industry-specific.

Ashcraft (2008) investigates whether BHCs are a source of strength to their banking subsidiaries. The findings show that a bank affiliated with a multi-bank holding company (MBHC) is much safer than a stand-alone bank or a bank affiliated with a one-bank holding company. The MBHC affiliation can mitigate the probability of future financial distress, and that the distressed affiliated banks tend to receive capital injections more readily, recover more quickly, and are not subject to failure over the subsequent year. Curry, Fissel, and Hanweck (2008) evaluate whether BHC risk ratings are asymmetrically assigned or biased over business cycles during the 1986-2003 period, and conclude that bank exam ratings display inter-temporal characteristics. Elyasiani and Wang (2008) probe the issues between asymmetry of BHCs and their non-interest income diversification, and find that the more diversified the non-interest income activities of BHCs are, the more information asymmetry there is, making BHCs more opaque and curtailing their value. Cornett, McNutt, and Tehranian (2009) investigate whether corporate governance mechanisms impact on

earnings and earnings management at the largest publicly traded U.S. BHCs. They suggest that performance, earnings management, and corporate governance are endogenously determined. Elyasiani and Wang (2012) examine whether BHC diversification can improve or impair their production efficiency. They conclude that technical efficiency is negatively associated with BHCs' diversified activities.

Bennett, Güntay, and Unal (2012) evaluate the relation between the structure of CEO's compensation package and the default risk and performance of U.S. BHCs in the context of the recent global financial crisis. Their results show that, compared to inside equity measures, inside debt can be taken as a better indicator of both the BHC's performance and default risk. Abreu and Gulamhussen (2013) assess dividend payouts of 462 U.S. BHCs before and during the 2007-09 global financial crisis. Their results have implications both for corporate and governance theories and for the regulatory forms. Goetz, Laeven, and Levine (2013) examine the effect of the geographic diversification of BHC assets across the U.S. on their market valuations. Their findings show that exogenous increases in geographic diversity reduce BHC valuations, and that geographic diversification of BHC assets increases insider lending and reduces loan quality. Ellul and Yerramilli (2013) use the U.S. BHC data over the period 1995 to 2010 to construct a risk management index (RMI) to measure the strength and independence of the risk management function of BHCs. They find

that, all else being equal, BHCs with a higher lagged RMI have lower tail risk and higher return on assets.

Although various issues regarding BHCs have been researched, there are few studies examining the determinants of default risk in bank holding companies, a very important issue that can provide critical insights on how to improve the regulation of key segment of the financial sector. In this light, we investigate the effects of various factors driving the movements of distance-to-default as proxy for default risk to find the determinants of financial distress in large U.S. BHCs.

3. Hypothesis Development and Model Specification

3.1. Hypothesis Development

Based on the literature in the field, we construct the four hypotheses as follows.

1. *The Business Cycle Hypothesis (H1): As a pro-cyclical macroeconomic factor, housing prices are positively related to the distance-to-default of BHCs.*

In this hypothesis, the default risk is associated with the macroeconomic state of the economy. Following Blundell-Wignall and Roulet (2012), we use housing prices as

the proxy. They show that, in the country location of the assessed bank, housing prices have the property to capture business cycles driving asset prices.

2. *Risk Characteristic Hypothesis (H2): Indicators of BHC risk characteristics such as the non-performing loan ratio, net charge-off ratio, and short-term wholesale funding are negatively related to the distance-to-default.*

Existing studies have investigated the impact of BHC risk characteristics on its default risk, performance, or executive compensation. Bennett et al. (2012) find that higher levels of non-performing assets/total asset ratio are negatively associated with the distance-to-default measure. Deng and Elyasiani (2008) use the net charge-off ratio (net charge-offs on loans and leases/total loans) as an indicator of credit risk in their valuation and risk models. Balboa, López-Espinosa, and Rubia (2012) probe whether the factor causing increases in systemic risk in the banking industry, i.e. short-term wholesale funding, could arise from the desire of bank managers to increase their variable compensation, and find that this factor is positively related to high levels of variable compensation. Balboa et al. (2012) also suggest that short-term wholesale funding is unstable, which can be taken to imply interconnectedness among financial institutions and exposures to liquidity risk. In these lights, our hypothesis employs all the three BHC risk characteristics, i.e. non-performing loan ratio, net charge-off ratio as the measure of credit risk, and short-term wholesale funding, as the control variable, to investigate whether these factors can affect DD.

3. *Capital Requirement Hypothesis (H3): BHCs' capital requirement measures, including the Tier I Risk-Based Capital Ratio, Total Risk-Based Capital Ratio, and the Tier I Leverage Ratio, are positively associated with their distance-to-default.*

A U.S. BHC needs to report three separate capital ratios to the regulator: the Tier 1 risk-based capital ratio, Total risk-based capital ratio, and Tier I leverage ratio, whereby the regulator determines whether the bank is well-capitalized, adequately capitalized, or under-capitalized[3] (Kisin and Manela, 2013). In our hypothesis, we use these three regulatory capital ratios as the alternative capital requirements to test the relation between them and the distance-to-default.

4. *Activity Diversification Hypothesis (H4): The diversified activities of BHCs such as reflected in non-interest income, or off-balance-sheet activity are negatively associated with their distance-to-default.*

Over the last two decades, the activities of financial institutions have diversified considerably, shifting from traditional ones (borrowing and lending) toward related activities, e.g., proprietary trading and private OTC market-making services (Flannery,

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[3] According to Kisin and Manela (2013), a bank is regarded as well-capitalized if all of the following are true:

a. Core capital (leverage) ratio ≡Tier 1 (core) capital as a percentage of average total assets - ineligible intangibles ≥ 3% to 5% depending on its composite CAMELS rating;

b. Tier 1 risk-based capital ratio ≡ Tier 1 (core) capital as a percentage of risk-weighted assets ≥ 6%; Total risk-based capital ratio ≡ Total risk-based capital as a percent of risk-weighted assets ≥ 10%.

2012). Many studies have examined various aspects of BHC activity diversification. Some related studies investigate the issue of non-interest income. For example, Stiroh (2004) reports that between 1984 and 2001, non-interest income, i.e. the revenue associated with trading and advising activities, expanded from 25% to 43% of total revenue of U.S. commercial banks. Related studies are Stiroh and Rumble (2006) and Brunnermeier, Dong, and Palia (2012). Other studies probe the issue of banks' off-balance-sheet activity. Minton, Williamson, and Stulz (2005) investigate whether the use of credit derivatives by U.S. BHCs can reduce bank risk, finding that a small group of banks that uses credit derivatives seems not to increase the soundness of these banks. Li and Marinč (2013) assess the effect of financial derivatives on the systematic risk of publicly listed BHCs in the U.S., and find that greater use of credit derivatives reflects higher systematic credit risk. Deng and Elyasiani (2008) employ the ratio of notional principal on interest rate contracts to total assets as the measure of off-balance-sheet activity risk for their hypothesis testing. In our hypothesis, we use the non-interest income ratio and off-balance-sheet activity as alternative measures of BHC activity diversification to test the linkage between them and the DD measure.

3.2. Model Specification

3.2.1. The default risk model

To identify our dependent variable, we follow Black and Scholes (1973) and Merton (1974) to calculate the distance-to-default as our default risk measure. The assumption of the Merton model suggests that the market value of assets A_t follows a random log-normal process expressed by:

$$\Delta A_t / A_t = \varepsilon\left(\mu_A \Delta t, \sigma_A \sqrt{\Delta t}\right) \qquad (1)$$

where μ_A is the expected return and σ_A is the volatility of assets. According to the Black-Scholes pricing of call options, the value of equity E_t at any time t prior to the maturity can be written as:

$$E_t = A_t N(d_1) - Le^{-r(T-t)} N(d_2) \qquad (2)$$

where r is the risk-free rate, L is the book value of the firm's debt, and T is the maturity time. The terms d_1 and d_2 are calculated by:

$$d_1 = \frac{\ln\left(A_t / L\right) + \left(r + \frac{1}{2}\sigma_A^2\right)\left(T - t\right)}{\sigma_A \sqrt{T - t}} \qquad (3)$$

$$d_2 = d_1 - \sigma_A \sqrt{T - t} \qquad (4)$$

The Black-Scholes pricing in (2) can provide the linkage between the volatility of equity and the volatility of assets through Ito's Lemma:

$$\sigma_E = \left(\frac{A_t}{E_t}\right) N(d_1) \sigma_A \qquad (5)$$

The Merton model implies that the current value of assets A_0 and its volatility σ_A can be derived from the two equations (2) and (5) with $t = 0$.

As a result, the distance-to-default (DD), the number of standard deviations away from the default point, can be given by:

$$DD = \frac{\ln\left(A_0 / L\right) + \left(\mu_A - \frac{1}{2}\sigma_A^2\right)T}{\sigma_A\sqrt{T}} \qquad (6)$$

A bank defaults or is bankrupt when $DD = 0$

3.2.2. The econometric specification

For our independent variables, we first introduce the control variables. Five control variables are considered. First, we use the U.S. housing price index (HPI) to examine the first hypothesis – business cycle hypothesis (H1). Then, we employ the natural log of the total assets of BHCs (Size) to detect whether the size effect exists. Next, we use the three important indicators showing BHC risk characteristics, i.e. the short-term wholesale funding ratio (STWF), non-performing loan ratio (NPLR), and net charge-off ratio (CR), as control variables in our testing of the second hypothesis – Risk Characteristic Hypothesis (H2).

We use the three alternative capital requirements, i.e. the Tier 1 risk-based capital ratio (Tier1), Total risk-based capital ratio (TRBCR), and Tier I leverage ratio (LEV) to examine the third hypothesis (H3). Finally, we employ the two alternative measures of BHC activity diversification, i.e. the non-interest income ratio (NIN), and off-balance-sheet activity risk ratio (OBSA), to test the fourth hypothesis (H4).

OLS estimator is used to expound the determinants of the DD measure. The empirical model is specified in the following equation:

$$\begin{aligned} DD_{i,t} = {} & \alpha_{i,t} + \beta_1 * HPI_{i,t} + \beta_2 * Size_{i,t} + \beta_3 * STWF_{i,t} \\ & + \beta_4 * NPLR_{i,t} + \beta_5 * CR_{i,t} + \beta_6 * H3_{i,t} + \beta_7 * H4_{i,t} + \varepsilon_{i,t} \end{aligned} \quad (7)$$

where i denotes the bank and t shows the period.

4. Data and Descriptive Statistics

4.1. Data and Variable Definitions

Our sample selection procedure is as follows. We first select the 860 U.S. bank holding companies whose total assets exceed 1 billion U.S. dollars for the period from

2003 to 2012, as listed in the FR Y-9C form[4] – the quarterly report BHCs file to the regulatory authorities. From these 860 BHCs, we delete those that are private companies or miss important data, to finally obtain a total of 354 BHCs with 2288 observations, i.e. firm-years. The sample finally chosen is from 2003Q4 to 2012Q4, covering before, during, and after the recent global financial crisis. We retain the fourth-quarter figures from the FR Y-9C form as the basis for the annual figures.

To calculate the DD measure, the daily share prices of our selected BHCs from 2003 to 2012 are downloaded from the Center for Research in Security Prices (CRSP) database, the yearly debt data for that period from Compustat, and the daily risk-free rate over the same period from the website of the Federal Reserve Bank of St Louis.

Table 1 shows the variables used and their construction. All variables except housing price index and distance-to-default are obtained from FR Y-9C forms. In the table, the symbol within the brackets after each variable corresponds to the symbol shown in the regression results.

<Table 1 here>

[4] FR Y-9C is a regulatory report showing Consolidated Financial Statements of Bank Holding Companies. Our BHC database based on FR Y-9C is downloaded from the website of the Federal Reserve Bank of Chicago, available at http://www.chicagofed.org/webpages/banking/financial_institution_reports/bhc_data.cfm

4.2. Descriptive Statistics

Table 2 displays the descriptive statistics of all variables for our selected BHCs, during the periods 2003-2012, 2003-2006, 2007, 2008, and 2009-2012. All descriptive results are expressed in percentage, except Observations, DD, and Size. We can see from this Table that before the financial crisis, i.e. from 2003 to 2006, the maximum value of DD is 18.86, the mean of DD is 7.37, and the median of DD is 7.11; while during the crisis, in 2007 the maximum is 15.66, the mean is 3.21, and the median is only 2.82. In 2008 the maximum is only 5.93, the mean is just 1.19, and the median is only 1.22. In the aftermath of the recent crisis, i.e. during the period 2009-2012, the maximum value of DD has surged to 36.70, the mean value has gone back to 4.01, and the median is 3.75. In addition, the statistics of housing price index (HPI) are highly related to those of DD. Table 2 also shows that the selected BHCs have relatively stable size before, during and after the recent financial crisis.

<*Table 2 here*>

Table 3 illustrates the Correlation Matrix among all the dependent and independent variables used for our selected BHCs during the period 2003-2012. We can see from this Table that DD is highly positively related to the housing price index (0.630), and positively related to the three regulatory capital ratios, i.e. Tier I risk-based capital ratio (Tier I), Total risk-based capital ratio (TRBCR), and Tier I leverage ratio (LEV). Whereas, the DD measure is negatively related to all three BHC risk characteristics,

i.e. the short-term wholesale funding ratio (STWF), the non-performing loan ratio (NPLR), and the measure of credit risk (CR). For the two alternative measures of BHC activity diversification, i.e. the non-interest income ratio (NIN) and the off-balance-sheet activity risk ratio (OBSA), DD is positively related to the first and negatively related to the second. In addition, OBSA is positively related to STWF, but slightly negatively related to NPLR and CR. NPLR is highly positively related to CR. Tier I is highly positively associated with the other two alternative capital requirements, i.e. TRBCR and LEV.

<Table 3 here>

5. **Empirical Results**

5.1. Univariate Regression Results

Table 4 shows the regression results derived using univariate models, which test all variables separately, for the period from 2003 to 2012. From Table 4, we can see that the housing price index (HPI) is statistically significant, indicating the positive linkage with the distance-to-default measure. Size is statistically significant, also indicating a positive relation with the DD measure. The three indicators of BHC risk characteristics, i.e. STWF, NPLR, and CR, are all statistically significant, showing the negative linkage with the DD measure. The two alternative measures of BHC activity diversification yield different results: the non-interest income ratio (NIN) is positively

related to the DD measure in a statistically significant manner; while the off-balance-sheet activity risk ratio (OBSA) is negatively related to DD. The distinct outcomes of these two alternative measures seem to show the complexity of the selected BHCs. For the three alternatives of regulatory capital requirement, Tier I leverage ratio (LEV) is positively related to DD in a statistically significant manner, as we expected. The Tier I capital ratio (Tier I) and Total risk-based capital ratio (TRBCR) have the same influence on the DD measure.

<Table 4 here>

5.2 Multivariate Regression Results

In this part, we derive the multivariate regression results for the determinants of the DD measure of the selected BHCs during the periods 2003-2012, 2003-2006, 2007-2008, and 2009-2012. Table 5 shows the multivariate regression results during the full sample period. Six multivariate regressions are conducted with the three alternative measures of regulatory capital requirements and the two alternatives of BHC activity diversification. From column 1 to column 3, in addition to our five control variables, we hold the non-interest income ratio (NIN), and run the regressions by changing the three alternatives of regulatory capital requirements. From column 4 to column 6, we hold the off-balance-sheet activity ratio (OBSA) and perform the same steps as for the first six columns.

According to Table 5, the housing price index (HPI) is statistically significant in all regression results, showing the strongly positive linkage with the DD measure. The statistic results of Size indicate that there exists a positive size effect on the BHCs' distance-to-default. The three important indicators of BHC risk characteristics, i.e. STWF, NPLR, and CR, are all statistically significant, showing the negative relationship with the DD measure, as we expected. The three alternative measures of regulatory capital requirements, i.e. LEV, Tier I, and TRBCR, are also statistically significant, suggesting their positive linkages with DD. However, of the two alternative measures of BHC activity diversification, i.e. NIN and OBSA, while OBSA is statistically significant, showing the negative linkage with DD, the non-interest income ratio (NIN) is positively related to DD in a statistically significant manner.

<Table 5 here>

Using the same steps as in Table 5, Tables 6, 7, and 8 report the multivariate regression results for the periods before the recent crisis, i.e. 2003-06; during the crisis, i.e. 2007-08; and after the crisis, i.e. 2009-12, respectively. Comparing Table 6 with Table 7, with exception of the non-interest income ratio (NIN), all the other independent variables have similar association with the BHCs' DD in the two selected periods. Unlike NIN in Table 5, the non-interest income ratio (NIN) in Table 6 is statistically insignificant, suggesting that this measure of BHC activity diversification had no effect on the BHCs' DD before the recent financial crisis.

<*Table 6 here*>

For the recent 2007-08 crisis period, Table 7 shows that the housing price index remains statistically significant, implying the importance of macroeconomic conditions for financial institutions. The three measures of BHC risk characteristics, i.e. STWF, NPLR, and CR, are consistently statistically significant, illustrating the negative relation with the BHCs' DD measure. There is no clear size effect on DD during the crisis period. Comparing Table 7 with Table 5, NIN in Table 7 has the same effect as in Table 5. But during the crisis time OSBA shows a statistically insignificant relation with the DD measure. For the three alternative measures of capital requirements, when holding OBSA all the three are statistically significant, but when holding NIN, only the Tier I risk-based capital ratio (Tier I) is significant.

<*Table 7 here*>

Comparing Table 8 with Table 5, with the exception of Size, all the other independent variables have the same impact on the BHCs' DD in both the post-crisis period and the full sample period. Table 8 shows that the three measures of BHC risk characteristics can be taken as reliable indicators for determination of the DD measure. Also, the three alternatives of capital ratio can be regarded as reliable regulatory capital requirements. NIN is significantly positively related to the DD measure. OBSA performs better in determining DD in the post-crisis period than during the crisis.

<*Table 8 here*>

5.3 Possible Policy Implications from our Results

From a policy perspective, our empirical results provide several implications for financial regulation. First, for macro-prudential risk, our results indicate that housing prices are an important factor that the monetary policy and macro-prudential policy must take into consideration, as shown in Blundell-Wignall and Roulet (2012). Our univariate regression results in Table 4 suggest that an unexpected 1% fall in the housing prices may decrease DD by 0.37 standard deviations, suggesting the significant impact of housing prices on financial institutions' financial distress.

Second, for liquidity risk, short-term wholesale funding can be considered a reliable factor exhibiting interconnectedness between financial institutions and exposures to liquidity risk. Some studies, such as Acharya and Richardson (2012) and Greenwood and Scharfstein (2013), show that short-term wholesale funding is an important factor reflecting systemic risk, which is also considered a vital factor for formulating related provisions within the Dodd-Frank Wall Street Reform and Consumer Protection Act of 2010, i.e. the Dodd-Frank Act.

Third, with regard to activity diversification risk, our two diversity measures do not show the same effect on determining default risk. On the one hand, the statistically significant results on non-interest income show that it is positively related to the

BHCs' DD, which is contrary to the prediction of studies such as Stiroh (2004) and Stiroh and Rumble (2006). However, recent studies such as Köhler (2013) suggest that the impact of non-interest income on risk hinges on the business mode of a bank. More specifically, Köhler (2013) implies that banks with a retail-oriented business mode become significantly more stable with the increase in their share of non-interest income; whereas investment-oriented banks become significantly less stable. Thus, it seems from our results that the positive relationship between non-interest income and DD shows the complexity of our examined bank holding companies. On the other hand, off-balance-sheet activity can be used as a reliable factor for detecting the default risk of BHCs, which is in line with the stringency of provisions related to off-balance-sheet exposures within the Dodd-Frank Act (Acharya and Richardson, 2012).

Fourth, for regulatory capital requirements, the statistically significant results of our three measures of capital requirements imply that they are good indicators for the investigation of BHCs' default risk. However, there is ongoing debate as to whether capital requirements alone are the best tool of management of systemic risk for financial institutions. For example, studies such as Admati et al. (2010) and Duffie (2012) suggest that only capital requirements can manage the systemic risk of banks, while Acharya and Richardson (2012) imply that both capital requirements and

restrictions on asset holdings (e.g. using the Volcker rule within the Dodd-Frank Act) can effectively manage the systemic risk of financial institutions.

6. **Conclusions**

In this paper, we use a sample of 354 bank holding companies in the U.S. to probe the impact of various factors on the financial distress of BHCs, before, during and after the recent financial crisis. Our empirical model specification incorporates five variables as the determinants of large BHCs' DD measure, including the housing price index, size, the non-performing loan ratio, the measure of credit risk (net charge-off ratio), and the short-term wholesale funding ratio. In the modeling process, the first is used to proxy for pro-cyclical economic conditions and the last three capture different aspects of BHC risk characteristic. Additionally, we employ two measures of BHC activity diversity and three alternative measures of regulatory capital requirements. Our main findings are: First, the housing price index is consistently significant and is positively associated with the DD measure. In our univariate regression, an unexpected fall in the house prices by1% may decrease DD by 0.37 standard deviations.

Second, while short-term wholesale funding is negatively related to both the non-performing loan ratio and the measure of credit risk, these three measures of

BHC risk characteristic are negatively associated with the DD measure, making themselves significant driving forces determining the DD measure. Third, the two alternative measures of BHC activity diversification exhibit no consensus as the determinants of default risk. Non-interest income is positively related with the BHCs' DD, which is on the contrary to both our expectation and some previous studies. This positive relationship exhibits the complexity of the examined BHCs. However, the off-balance-sheet activity, which is an important consideration of the Dodd-Frank Act, is negatively associated to the DD measure. Fourth, even if there is ongoing debate about whether capital requirements are a better tool for the management of systemic risk in financial institutions, the statistically significant results of our three alternative capital requirements suggest that they are significantly related with BHCs' default risk, and hence can be used for evaluate BHCs' financial distress.

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Table 1 Variable Names and Construction

Variable	FR Y-9C Data Item or Sources
Alternative Regulatory Captial	
Tier I Leverage Ratio (LEV)	BHCK7204
Tier I Risk-Based Capital Ratio (Tier I)	BHCK7206
Total Risk-Based Capital Ratio (TRBCR)	BHCK7205
Alternative Bank Activity Diversification	
Non Interest Income Ratio (NIN)	BHCK4079/(BHCK4079+BHCK4107)
Off-Balance Sheet Activity Ratio (OBSA)	(BHCK3809+BHCK8766+BHCK8767)/BHCK2170
Control Variables	
House Price Index (HPI)	All-Transactions House Price Index for the United States, downloaded from http://research.stlouisfed.org/fred2/series/USSTHPI/
Size (Size)	ln(BHCK2170)
Short-Term Wholesale Funding (STWF)	(BHCK2309+BHCK3353+BHCK2332+BHDMA243)/BHCK2170
Non-Performing Loan Ratio (NPLR)	(BHCK5525+BHCK5526)/BHCK2170
Net Charge-Off Ratio (Credit Risk, CR)	(BHCK4635-BHCK4605)BHCK3516
Dependent Variable	
Distance-to-Default (DD)	Derived from equations from (1) to (6)

Notes: The listed variables are used in our empirical study. All variables except the Housing Price Index and Distance-to-Default are taken from FR Y-9C forms. FR Y-9C is a regulatory report showing Consolidated Financial Statements of Bank Holding Companies. Our BHC data based on FR Y-9C are downloaded from the official website of the Federal Reserve Bank of Chicago. The symbol within the brackets after each variable corresponds to the symbol shown in the regression results.

Table 2 Descriptive Statistics of All Dependent and Independent Variables for Our Selected BHCs

Variable	DD	HPI	Size	STWF	NPLR	CR	NIN	OSBA	LEV	Tier I	TRBCR
						2003-2012					
Obs	2288	2288	2288	2288	2288	2288	2288	2288	2288	2288	2288
Mean	4.93	1.21	15.43	0.09	1.36	0.55	0.21	0.45	9.35	12.57	14.25
Std. Dev.	3.43	5.84	1.55	0.08	1.66	0.84	0.15	3.23	4.07	5.88	5.68
Min	-3.32	-7.05	13.82	0.00	0.00	-0.15	-1.01	0.00	-1.03	-1.44	-1.44
Median	4.73	-1.02	14.94	0.07	0.75	0.24	0.18	0.01	8.86	11.71	13.35
Max	36.70	10.61	21.58	0.69	19.63	9.38	0.99	52.72	72.92	99.74	99.91
						2003-2006					
Obs	879	879	879	879	879	879	879	879	879	879	879
Mean	7.37	7.85	15.42	0.10	0.42	0.17	0.21	0.32	8.85	11.80	13.48
Std. Dev.	2.63	2.50	1.51	0.08	0.37	0.24	0.13	2.31	3.71	5.92	5.70
Min	-2.47	4.47	13.82	0.00	0.00	-0.08	-0.02	0.00	1.49	1.71	3.42
Median	7.11	6.71	14.93	0.08	0.34	0.10	0.19	0.00	8.44	10.88	12.45
Max	18.86	10.61	21.36	0.61	3.16	2.41	0.97	35.45	68.17	99.12	99.16
						2007					
Obs	230	230	230	230	230	230	230	230	230	230	230
Mean	3.21	-1.02	15.37	0.11	0.78	0.22	0.17	0.33	8.98	11.20	12.77
Std. Dev.	2.12	0.00	1.54	0.07	0.74	0.36	0.12	2.64	4.20	6.42	6.20
Min	-0.40	-1.02	13.82	0.00	0.00	-0.06	0.00	0.00	4.03	6.53	8.41
Median	2.82	-1.02	14.83	0.09	0.56	0.15	0.15	0.00	8.49	10.14	11.59
Max	15.66	-1.02	21.51	0.65	5.08	4.36	0.96	37.54	64.67	90.90	90.96
						2008					
Obs	235	235	235	235	235	235	235	235	235	235	235
Mean	1.19	-7.05	15.35	0.13	1.80	0.64	0.18	0.28	9.66	11.92	13.67
Std. Dev.	1.36	0.00	1.51	0.09	1.60	0.70	0.13	2.09	5.02	6.69	6.54
Min	-3.32	-7.05	13.82	0.00	0.00	0.00	-0.01	0.00	3.51	3.63	6.72
Median	1.22	-7.05	14.88	0.11	1.39	0.38	0.16	0.01	9.08	11.28	13.11
Max	5.93	-7.05	21.50	0.69	10.61	4.15	0.97	28.56	72.92	99.74	99.91
						2009-2012					
Obs	944	944	944	944	944	944	944	944	944	944	944
Mean	4.01	-2.37	15.48	0.07	2.27	0.95	0.22	0.64	9.83	13.78	15.46
Std. Dev.	3.16	2.18	1.61	0.07	2.00	1.09	0.17	4.18	4.04	5.24	5.05
Min	-2.25	-5.26	13.82	0.00	0.00	-0.15	-1.01	0.00	-1.03	-1.44	-1.44
Median	3.75	-1.78	14.98	0.06	1.76	0.60	0.19	0.01	9.43	13.24	14.89
Max	36.70	0.75	21.58	0.62	19.63	9.38	0.99	52.72	67.63	97.16	97.29

Notes: This table shows the descriptive statistics of all dependent and independent variables for our selected BHCs, during the periods 2003-2012, 2003-2006, 2007, 2008, and 2009-2012. Detailed information on all shown variables can be found in Table 1. All descriptive results are expressed in percentage, except Observations (Obs), DD, and Size. Distance-to-Default (DD) is derived in terms of equations from (1) and (6).

Table 3 Correlation between All Dependent and Independent Variables for Our Selected BHCs

	Correlation Matrix										
	DD	**HPI**	**Size**	**STWF**	**NPLR**	**CR**	**NIN**	**OSBA**	**LEV**	**Tier I**	**TRBCR**
DD	1.000										
HPI	0.630	1.000									
Size	0.100	0.002	1.000								
STWF	-0.206	-0.018	0.257	1.000							
NPLR	-0.468	-0.448	-0.032	-0.005	1.000						
CR	-0.422	-0.363	0.039	-0.028	0.688	1.000					
NIN	0.250	0.059	0.525	0.047	-0.165	-0.106	1.000				
OSBA	-0.036	-0.025	0.441	0.213	-0.040	-0.016	0.266	1.000			
LEV	0.156	-0.085	-0.064	-0.145	-0.056	-0.067	0.311	-0.082	1.000		
Tier I	0.160	-0.069	-0.050	-0.029	-0.055	-0.087	0.342	-0.012	0.880	1.000	
TRBCR	0.164	-0.074	0.036	-0.020	-0.039	-0.061	0.383	0.019	0.877	0.987	1.000

Notes: This table shows the descriptive statistics of all dependent and independent variables for our selected BHCs during the period 2003-2012. Detailed information on all shown variables can be found in Table 1.

Table 4 Univariate Regression Results for the Determinants of the Selected BHCs' Distance-to-Default

	2003-2012									
Constant	**HPI**	**Size**	**STWF**	**NPLR**	**CR**	**NIN**	**OSBA**	**LEV**	**Tier I**	**TRBCR**
4.48	0.37									
[0.000]***	[0.000]***	-	-	-	-	-	-	-	-	-
1.53		0.22								
[0.032]**	-	[0.000]***	-	-	-	-	-	-	-	-
5.75			-8.83							
[0.000]***	-	-	[0.000]***	-	-	-	-	-	-	-
6.25				-0.97						
[0.000]***	-	-	-	[0.000]***	-	-	-	-	-	-
5.87					-1.72					
[0.000]***	-	-	-	-	[0.000]***	-	-	-	-	-
3.71						5.879				
[0.000]***	-	-	-	-	-	[0.000]***	-	-	-	-
4.95							-0.04			
[0.000]***	-	-	-	-	-	-	[0.082]*	-	-	-
3.71								0.13		
[0.000]***	-	-	-	-	-	-	-	[0.000]***	-	-
3.76									0.093	
[0.000]***	-	-	-	-	-	-	-	-	[0.000]***	-
3.52										0.099
[0.000]***	-	-	-	-	-	-	-	-	-	[0.000]***

Notes: This table shows the univariate regression results for the determinants of the selected BHCs' DD during the period from 2003 to 2012. The variable construction can be found in Table 1. The year effect is controlled in the regressions. *, ** and *** imply statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 5 Multivariate Regression Results for the Determinants of the Selected BHCs' DD during the Period 2003-2012

Variable	2003-2012					
	DD	DD	DD	DD	DD	DD
	(1)	(2)	(3)	(4)	(5)	(6)
HPI	0.158	0.168	0.163	0.156	0.167	0.162
	[0.000]***	[0.000]***	[0.000]***	[0.000]***	[0.000]***	[0.000]***
Size	0.252	0.263	0.237	0.391	0.409	0.378
	[0.000]***	[0.000]***	[0.000]***	[0.000]***	[0.000]***	[0.000]***
STWF	-7.497	-8.369	-8.285	-7.240	-8.188	-8.093
	[0.000]***	[0.000]***	[0.000]***	[0.000]***	[0.000]***	[0.000]***
NPLR	-0.268	-0.267	-0.270	-0.293	-0.291	-0.294
	[0.000]***	[0.000]***	[0.000]***	[0.000]***	[0.000]***	[0.000]***
CR	-0.619	-0.595	-0.603	-0.648	-0.620	-0.630
	[0.000]***	[0.000]***	[0.000]***	[0.000]***	[0.000]***	[0.000]***
NIN	1.543	1.489	1.489			
	[0.000]***	[0.000]***	[0.000]***			
OSBA				-0.071	-0.080	-0.079
				[0.000]***	[0.000]***	[0.000]***
LEV	0.109			0.124		
	[0.000]***			[0.000]***		
Tier I		0.075			0.088	
		[0.000]***			[0.000]***	
TRBCR			0.078			0.091
			[0.000]***			[0.000]***
_cons	2.498	2.401	2.638	0.622	0.397	0.691
	[0.000]***	[0.000]***	[0.000]***	[0.243]	[0.460]	[0.192]
N	2288	2288	2288	2288	2288	2288
Fixed Year	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.633	0.633	0.633	0.634	0.635	0.635
R^2 - Adjusted	0.631	0.630	0.631	0.632	0.632	0.633
F	261.54	260.75	261.14	262.83	263.29	263.57
Prob F	[0.000]***	[0.000]***	[0.000]***	[0.000]***	[0.000]***	[0.000]***

Notes: This table shows the multivariate regression results for the determinants of the selected BHCs' DD during the period from 2003 to 2012. The variable construction can be found in Table 1. The Housing Price Index (HPI), size (Size), short-term wholesale funding (STWF), the non-performing loan ratio (NPLR), and the measure of credit risk (CR) are the five control variables, the latter three of which show BHC risk characteristics. The non-interest income ratio (NIN) and the off-balance-sheet activity risk ratio (OBSA) are the two alternative measures of BHC activity diversification. The Tier I risk-based capital ratio (Tier I), Total risk-based capital ratio (TRBCR), and Tier I leverage ratio (LEV) are the three alternative measures of capital requirements. The year effect is controlled in the regressions. *, ** and *** imply statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 6 Multivariate Regression Results for the Determinants of the Selected BHCs' DD during the Period 2003-2006

Variable	2003-2006					
	DD	DD	DD	DD	DD	DD
	(1)	(2)	(3)	(4)	(5)	(6)
HPI	0.214	0.169	0.162	0.243	0.195	0.185
	[0.023]**	[0.071]*	[0.083]*	[0.007]***	[0.031]**	[0.041]**
Size	0.742	0.758	0.726	0.871	0.888	0.848
	[0.000]***	[0.000]***	[0.000]***	[0.000]***	[0.000]***	[0.000]***
STWF	-13.024	-14.584	-14.427	-12.870	-14.532	-14.350
	[0.000]***	[0.000]***	[0.000]***	[0.000]***	[0.000]***	[0.000]***
NPLR	-0.774	-0.743	-0.765	-0.844	-0.808	-0.827
	[0.001]***	[0.001]***	[0.001]***	[0.000]***	[0.000]***	[0.000]***
CR	-1.396	-1.212	-1.238	-1.326	-1.132	-1.165
	[0.000]***	[0.001]***	[0.001]***	[0.000]***	[0.001]***	[0.001]***
NIN	1.024	0.995	0.905			
	[0.184]	[0.206]	[0.249]			
OSBA				-0.123	-0.125	-0.124
				[0.000]***	[0.000]***	[0.000]***
LEV	0.149			0.159		
	[0.000]***			[0.000]***		
Tier I		0.088			0.095	
		[0.000]***			[0.000]***	
TRBCR			0.094			0.100
			[0.000]***			[0.000]***
_cons	-4.712	-4.302	-3.993	-6.686	-6.269	-5.843
	[0.000]***	[0.000]***	[0.000]***	[0.000]***	[0.000]***	[0.000]***
N	879	879	879	879	879	879
Fixed Year	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.369	0.365	0.367	0.377	0.373	0.376
R^2 - Adjusted	0.363	0.358	0.360	0.371	0.367	0.369
F	56.47	55.38	55.98	58.51	57.51	58.13
Prob F	[0.000]***	[0.000]***	[0.000]***	[0.000]***	[0.000]***	[0.000]***

Notes: This table shows the multivariate regression results for the determinants of the selected BHCs' DD during the period from 2003 to 2006. The variable construction can be found in Table 1. The Housing Price Index (HPI), size (Size), short-term wholesale funding (STWF), the non-performing loan ratio (NPLR), and the measure of credit risk (CR) are the five control variables, the latter three of which show BHC risk characteristics. The non-interest income ratio (NIN) and the off-balance-sheet activity risk ratio (OBSA) are the two alternative measures of BHC activity diversification. Tier I risk-based capital ratio (Tier I), Total risk-based capital ratio (TRBCR), and Tier I leverage ratio (LEV) are the three alternative measures of capital requirements. The year effect is controlled in the regressions. *, ** and *** imply statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 7 Multivariate Regression Results for the Determinants of the Selected BHCs' DD during the Period 2007-2008

Variable	2007-2008					
	DD	DD	DD	DD	DD	DD
	(1)	(2)	(3)	(4)	(5)	(6)
HPI	0.227	0.228	0.228	0.216	0.219	0.219
	[0.000]***	[0.000]***	[0.000]***	[0.000]***	[0.000]***	[0.000]***
Size	-0.109	-0.091	-0.105	0.033	0.041	0.022
	[0.054]*	[0.116]	[0.062]*	[0.531]	[0.440]	[0.676]
STWF	-3.289	-3.421	-3.394	-3.853	-4.019	-4.008
	[0.000]***	[0.000]***	[0.000]***	[0.000]***	[0.000]***	[0.000]***
NPLR	-0.402	-0.398	-0.399	-0.474	-0.447	-0.453
	[0.000]***	[0.000]***	[0.000]***	[0.000]***	[0.000]***	[0.000]***
CR	-0.462	-0.459	-0.464	-0.413	-0.420	-0.427
	[0.004]***	[0.004]***	[0.004]***	[0.012]**	[0.010]***	[0.009]***
NIN	3.330	2.945	3.098			
	[0.000]***	[0.000]***	[0.000]***			
OSBA				-0.015	-0.018	-0.019
				[0.652]	[0.578]	[0.565]
LEV	0.020			0.057		
	[0.258]			[0.000]***		
Tier I		0.023			0.050	
		[0.089]*			[0.000]***	
TRBCR			0.019			0.048
			[0.170]			[0.000]***
_cons	5.137	4.866	5.067	3.286	3.125	3.357
	[0.000]***	[0.000]***	[0.000]***	[0.000]***	[0.000]***	[0.000]***
N	465	465	465	465	465	465
Fixed Year	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.475	0.476	0.475	0.453	0.462	0.460
R^2 - Adjusted	0.467	0.468	0.467	0.445	0.454	0.451
F	58.97	59.41	59.14	54.15	56.09	55.50
Prob F	[0.000]***	[0.000]***	[0.000]***	[0.000]***	[0.000]***	[0.000]***

Notes: This table shows the multivariate regression results for the determinants of the selected BHCs' DD during the period from 2007 to 2008. The variable construction can be found in Table 1. The Housing Price Index (HPI), size (Size), short-term wholesale funding (STWF), non-performing loan ratio (NPLR), and the measure of credit risk (CR) are the five control variables, the latter three of which show BHC risk characteristics. The non-interest income ratio (NIN) and the off-balance-sheet activity risk ratio (OBSA) are the two alternative measures of BHC activity diversification. The Tier I risk-based capital ratio (Tier I), Total risk-based capital ratio (TRBCR), and Tier I leverage ratio (LEV) are the three alternative measures of capital requirements. The year effect is controlled in the regressions. *, ** and *** imply statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 8 Multivariate Regression Results for the Determinants of the Selected BHCs' DD during the Period 2009-2012

Variable	2009-2012					
	DD	DD	DD	DD	DD	DD
	(1)	(2)	(3)	(4)	(5)	(6)
HPI	0.684	0.670	0.673	0.681	0.665	0.668
	[0.000]***	[0.000]***	[0.000]***	[0.000]***	[0.000]***	[0.000]***
Size	0.070	0.075	0.043	0.188	0.211	0.180
	[0.194]	[0.167]	[0.423]	[0.000]***	[0.000]***	[0.000]***
STWF	-4.912	-6.036	-5.947	-4.288	-5.325	-5.243
	[0.000]***	[0.000]***	[0.000]***	[0.000]***	[0.000]***	[0.000]***
NPLR	-0.248	-0.252	-0.255	-0.264	-0.269	-0.273
	[0.000]***	[0.000]***	[0.000]***	[0.000]***	[0.000]***	[0.000]***
CR	-0.600	-0.548	-0.562	-0.630	-0.577	-0.593
	[0.000]***	[0.000]***	[0.000]***	[0.000]***	[0.000]***	[0.000]***
NIN	1.105	1.163	1.232			
	[0.043]**	[0.032]**	[0.023]**			
OSBA				-0.054	-0.067	-0.067
				[0.006]***	[0.001]***	[0.001]***
LEV	0.142			0.150		
	[0.000]***			[0.000]***		
Tier I		0.114			0.123	
		[0.000]***			[0.000]***	
TRBCR			0.114			0.124
			[0.000]***			[0.000]***
_cons	4.482	4.273	4.568	2.863	2.333	2.617
	[0.000]***	[0.000]***	[0.000]***	[0.000]***	[0.004]***	[0.001]***
N	944	944	944	944	944	944
Fixed Year	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.547	0.548	0.547	0.549	0.552	0.550
R^2 - Adjusted	0.543	0.544	0.543	0.544	0.548	0.546
F	125.31	126.00	125.42	126.16	127.82	127.03
Prob F	[0.000]***	[0.000]***	[0.000]***	[0.000]***	[0.000]***	[0.000]***

Notes: This table shows the multivariate regression results for the determinants of the selected BHCs' DD during the period from 2009 to 2012. The variable construction can be found in Table 1. The Housing Price Index (HPI), size (Size), short-term wholesale funding (STWF), the non-performing loan ratio (NPLR), and the measure of credit risk (CR) are the five control variables, the latter three of which show BHC risk characteristics. The non-interest income ratio (NIN) and the off-balance-sheet activity risk ratio (OBSA) are the two alternative measures of BHC activity diversification. Tier I risk-based capital ratio (Tier I), Total risk-based capital ratio (TRBCR), and Tier I leverage ratio (LEV) are the three alternative measures of capital requirement. The year effect is controlled in the regressions. *, ** and *** imply statistical significance at the 10%, 5%, and 1% levels, respectively.