BANK FOR INTERNATIONAL SETTLEMENTS

BIS Working Papers
No 238

Bank size, credit and the sources of bank market risk

by Ryan Stever

Monetary and Economic Department

November 2007

Abstract

This study examines bank risk by investigating the equity and loan portfolio characteristics of publicly-traded bank holding companies. Unlike the pattern for non-financial firms, equity betas of large banks are two to five times greater than those of small banks. In explaining this, we note that regulation imposes an effective cap on banks' equity volatility. Because the portfolios of small banks are less diversified, this cap has a greater effect on small banks than large banks. But we reject the hypothesis that small banks lower their equity volatility through lower leverage. Instead, we find that the reduced ability of small banks to diversify forces them to either pick borrowers whose assets have relatively low credit risk or make loans that are backed by relatively more collateral.

JEL Classification Numbers: G14,G21,G32
Keywords: Bank size, beta, idiosyncratic, volatility

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Copies of publications are available from:

Bank for International Settlements
Press & Communications
CH-4002 Basel, Switzerland

E-mail: publications@bis.org

Fax: +41 61 280 9100 and +41 61 280 8100

This publication is available on the BIS website (www.bis.org).

ISSN 1020-0959 (print)

ISSN 1682-7678 (online)

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Introduction and overview

This paper investigates the relationship between firm size and equity returns for publicly traded commercial banks. The results reveal that regulation affects the lending and investment choices of small banks differently than it affects these choices for large banks. Banks' equity betas are positively related to size. The median equity beta for very small banks (those in the smallest decile of market capitalization of NYSE non-financial firms) is 0.4 while the median equity beta for very large banks (those in the largest decile) is 1.2. These differences are a consequence of differences in lending behavior. Small banks appear to make safer loans than large banks. As a result, individual loans at small banks exhibit less sensitivity to market movements (and other risk factors) than large bank loans. However, due to small banks' inability to diversify, the total equity volatility of large and small banks is the same.

The cross-sectional variation in banks' equity betas differs substantially from the corresponding cross-sectional variation for non-financial firms. Chan and Chen (1988) estimate a correlation of -0.988 between the log of market capitalization and equity beta for all non-financial firms. High equity betas for small firms are consistent with the argument of Berk (1995) that investors place a discount on firms with high systematic risk. Roll (1988) finds a negative correlation between the size of nonfinancial firms and their idiosyncratic equity volatility, but casts doubt on the notion that diversification accounts for this pattern. The small firm stock returns from Fama and French (1992) are much more volatile than are the large firm stock returns. The median monthly equity volatility for the smallest decile of firms is 15.8% while for the largest decile is 7.2%.

There are a number of potential explanations for the cross-sectional relationships between bank equity returns and size. One obvious explanation is that the banking industry is highly regulated and subject to any frictions that accompany this regulation. But apart from these frictions, lending at small and large banks may target different types of borrowers. For instance, Berger et al. (2005) found that large banks are better at evaluating 'hard' information loan applicants and 'small banks are better at evaluating 'soft' information loan applicants. By 'soft' information they mean "informationally difficult credits, such as firms that do not keep formal financial records." Petersen and Rajan (2002) find empirical evidence that small banks lend to more localized firms than do large banks. Stiroh (2006) presented evidence that banks that have a large share of their income from noninterest sources tend to have higher total equity volatility (to be discussed in later sections). However, none of these findings predict differences in the equity betas of small and large banks. One could imagine a story for some of these results that suggest differences in idiosyncratic volatility but it is difficult to make a connection to differences in equity betas. In fact, many studies implicitly assume that bank equity betas are invariant to size and use them as a measure of overall

1 Special thanks to Claudio Borio, Greg Duffee, Frank Packer, Jim Wilcox, and Haibin Zhu. Thanks also to Dwight Jaffee, Nigel Barradale, Ben Hermalin and Roger Craine for helpful comments. The opinions expressed in this paper are the author's own and do not necessarily reflect those of the Bank for International Settlements. Any remaining errors are mine alone.

2 Bank for International Settlements, Monetary and Economic Department, Centralbahnplatz 2, 4002, Basel, Switzerland, tel. +41-61-280 9615, fax +41-61-280 9100 email: ryan.stever@bis.org.

bank risk. Most recently Brooks et al. (1997) examine the mean and variance of bank equity betas as a means of gauging the risk of banks across different regulatory time periods. Their study was similar in spirit to previous studies by Allen and Wilhelm (1988), Aharony et al. (1988), Millon-Cornett and Tehranian (1989) and Dickens and Philippatos (1994).

This paper presents substantial circumstantial evidence that banks' response to regulation accounts for the equity-size relationships. One key indication is that there is little cross-sectional variation in total equity volatility. Data reveal that other industries exhibit a far greater degree of dispersion in stock return volatility. A plausible interpretation is that regulators effectively limit the exposure of equity holders (and hence subordinated claimholders such as depositors and the FDIC) to fluctuations in the value of each bank's assets. This paper demonstrates that idiosyncratic volatility accounts for a larger share of total equity volatility for small banks than for large banks, thus stocks of small banks must have lower equity betas than those of large banks.

Presumably, small banks could lower total equity volatility by taking on relatively less debt than large banks. Yet this paper presents evidence that leverage (equity capital ratio) does not vary by bank size. Thus capital structure differences do not explain the lack of variation in total equity volatility. In addition, leverage ratios that do not vary by size are consistent with the aim of regulatory capital requirements. Another alternative explanation for the invariability of bank equity volatility is that large banks lend to sectors of the economy that have high asset betas. However this paper presents evidence that variations in asset betas among lending sectors are not related to each bank's equity beta.

The explanation that best accounts for the observed size-equity relationships is that, on average, the individual assets held by small banks have less credit risk than those of large banks. The loan charge-off and delinquency rates at large banks are higher than small banks. Cross-sectional regressions reveal that higher charge-off ratios cause higher bank equity betas. In these regressions, after controlling for charge-offs and other variables, size is no longer significant in explaining a bank's equity beta. An open question that is discussed is whether small banks garner lower credit risk loans because they have superior knowledge of borrower risk or whether small banks simply demand more collateral for each loan.

The next section describes the data. Section III examines the relationship between bank size and equity returns. Section IV investigates why bank size and market beta move together. Section V concludes.

Data description

Previous studies of bank holding company stock returns focus on a small sample of bank holding companies. These samples typically consist of the largest and most easily identifiable banks. For instance Brooks et al. (1997) have a sample of "eighteen different depository institutions"; Bundt et al. (1992) look at "twenty-seven large bank holding companies traded on the NYSE or AMEX"; and Allen and Wilhelm (1988) have "38 Federal Reserve member banks, 19 savings and loans, and 16 nonmember banks" in their sample. This study makes use of an original dataset which maps the Federal Reserve Y9C bank holding company database to the CRSP tapes[3]. For every quarter from 1986:2 until 2003:4

[3] The creation of this dataset was largely done at the Federal Reserve Bank of San Francisco by Ryan Stever, Judy Peng and Jose A. Lopez. While every effort was made to make a complete mapping between the Y9C database and CRSP, we cannot be completely certain that every publicly-traded bank holding company was mapped. We do feel confident that the dataset is at the least representative of the universe of publicly-traded bank holding companies. All errors are mine alone.

a list of bank holding company names, their corresponding asset values and Y9C identifier is created from the Y9C database. This list is merged with a list from Compustat of every publicly-traded company name, their assets and cusip identifier. If a match is found by bank name and asset value the bank is included in the sample as a publicly-traded bank holding company. These quarterly lists are then merged with CRSP via cusip number using the CRSP-Compustat merged database. This yields a larger cross-sectional sample than previous studies whose samples normally contain fifty or less bank holding companies. The dataset in this study has at least 339 publicly-traded BHCs at each point in time. These range in size from American Bancorporation at $31 million in book assets (200 employees) to Citigroup at $1.26 trillion (over 280,000 employees). This range in publicly traded bank size is important in identifying and examining relationships between size and equity returns that previous studies may have missed.

In presenting evidence on bank stock return characteristics there are a number of measures that need to be estimated such as: equity beta, idiosyncratic volatility, size, and total stock return volatility. Total stock return volatility for bank i in year t is measured as the standard deviation of monthly stock returns from July of year t-3 to July of year t. Following common industry practice individual monthly bank stock returns are calculated from CRSP (Campbell, Lo, and MacKinlay; 1997).

Equity beta and Fama-French factor loadings are estimated for each bank i in year t by running two regressions. The first is monthly stock returns minus the risk free rate from July of year t-5 through July of year t on the market return over the risk free rate for the corresponding time period (the coefficient estimate of the market defines beta). The second regression is the same monthly stock returns on the Fama-French factors: the excess market returns, the high-minus-low portfolio and the small-minus-big portfolio[4].The market is defined as the CRSP value-weighted index of all NYSE, AMEX and NASDAQ firms. Idiosyncratic volatility in this study is defined as the standard deviation of the fitted errors from the Fama-French three factor regression. The standard deviation of the fitted errors from the CAPM regression was also used as a definition of idiosyncratic volatility, results are robust to either definition. It is required that each bank i, time t observation has at least 36 months of stock returns available.

While the CAPM (and Fama-French model) is a static model, a bank's equity beta may change through time. Even though equity betas estimated in each year have overlapping data samples, a new equity beta is required in each year in order to capture any time variation in a bank's systematic risk. This leads to a modeling difficulty – it is implicitly assumed that the last five years of data give an unbiased estimate of a bank's equity beta. This requires that the equity beta of the bank did not change over the last five years. Since equity betas are estimated every year, this leads to the assumption that equity beta is constant across all years. The method used in Green et al (2001) is followed by interpreting a bank's equity beta as changing slowly through time, and that while there will be a bias in estimating equity beta, this bias is minimal given the fact it is necessary to capture the dynamic aspects of equity beta through time.

An alternative approach would be to estimate equity beta based on observations for a single year using daily data. The problem with this approach is that the estimates of equity beta will vary significantly due to small sample estimation noise rather than due to changes in systematic risk. Increasing the length of time that is used in estimation has the advantage of less noise but the disadvantage of obscuring variation due to changes in systematic risk.

4 Fama and French's Benchmark factors were downloaded from http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html#Research.

Different sample periods (10 years to 1 year) were used and the results are robust to the frequency chosen.

The bank i, year t stock market data are combined with bank i, December of year t balance sheet and loan data from the Y9C database. Loan variables are scaled by total loans and any other assets are scaled by total assets. Book-to-market is defined as book equity capital (from the Y9C data) divided by market capitalization. An economy wide price-to-earnings ratio is used in some of the time-series regressions discussed later. This price-to-earnings ratio is defined as a 10 year rolling average of all publicly-traded firms' price-to-earnings ratios and is taken from Robert Schiller's website[5].

This study also requires data on loan charge-off and delinquency rates. Data on loan default rates is taken from the Federal Reserve's quarterly release "Charge-Off and Delinquency Rates on Loans and Leases at Commercial Banks". Unfortunately this release does not give a complete break down of delinquency rates by size of commercial bank. This release divides delinquency / charge-off rates into two size categories – 100 Largest Banks and All Other (Small). Within each of these size categories delinquency / charge off rates are reported for 10 different loan categories: all real estate, residential real estate, commercial real estate, all consumer, credit cards, other consumer, leases, commercial and industrial (C&I), agricultural, and total.

Calculating individual bank loan delinquency rates from the Federal Reserve Y9 database is not a straight-forward process. Banks do not directly report delinquent loans. A bank first makes allowances for loan losses, and then once a loan is deemed delinquent, the loan is 'charge-offed' from the allowances category. Finally a portion of the loan may be recovered. The bank can add back recovered loans to their allowance for loan losses. The Federal Reserve's quarterly release does not reveal how their delinquency rate is calculated. They do, however, report a description of how charge-off rates are calculated without referring specifically to any variables in the Y9C database. The following is taken from the Federal Reserve Board website…

> Charge-off rates for any category of loan are defined as the flow of a bank's net charge-offs (gross charge-offs minus recoveries) during a quarter divided by the average level of its loans outstanding over that quarter. Charged-off loans are reported on schedule RI-B and the average levels of loans on schedule RC-K.

Thus charge-off rates as a fraction of total loans are calculated for each BHC in each year as charge-offs (reported as item BHCK4635 in the Y9 database) minus recoveries (BHCK4605) divided by total loans/leases (BHCK2122).

Although this study refers to 'large' and 'small' banks as distinct groups there is no dividing line which defines a bank as large or small. The relationship between bank size and equity beta is examined as continuous rather than discrete. Following Chan and Chen (1988) and Fama and French (1992) size in year t is measured as the log of market capitalization for bank i on July 31 of year t. In order to form size portfolios and present summary statistics by bank size, each year the sample is divided into 10 size deciles. Deciles are created by sorting the NYSE banks by market capitalization and estimating decile breakpoints based on this sample. All banks (including those in AMEX and NASDAQ) are then allocated into each of these deciles based on these breakpoints. Estimating the breakpoints using NYSE banks avoids swamping all of the size deciles with small banks (the number of small banks is far greater than the number of large banks). For purposes of comparing this study with previous studies, the size breakpoints are also estimated by sorting all NYSE non-financial firms by

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5 http://aida.econ.yale.edu/~shiller/data.htm has downloadable stock market data used in Schiller's book "Irrational Exuberance".

market capitalization. Table I presents summary statistics of the bank holding company sample from year 2000 based on both definitions of the size deciles. Table I reveals that when using NYSE non-financial firm breakpoints there are 11, 14 and 19 banks in the largest three deciles while using NYSE bank only breakpoints there are 7, 9 and 8. Since the NYSE non-financial firm breakpoints result in a more balanced grouping (and therefore more reliable estimates for the larger deciles) further results in this paper are reported using these breakpoints. However all results are robust to either definition.

Bank equity characteristics

This section describes the relationship between bank size and equity returns. First, differences between the equity betas and idiosyncratic volatility of large and small banks are documented and tested. Evidence is given that these differences are not caused by variation in equity capitalization. Second, evidence is given that due to regulatory pressure or other features of the banking industry, there is an implicit cap on the level of total equity volatility at banks regardless of size. Tests show that the standard deviation of monthly stock returns does not vary by size. A comparison of cross-sectional dispersion in the volatility of stock returns at banks and other industries reveals that banks have remarkably little variation in total equity volatility. Finally, it is shown that as a side effect of this environment, small banks have a much greater proportion of their equity volatility coming from an idiosyncratic component than from a systematic one.

Table II presents median bank equity return characteristics by size decile (smallest banks are in the first size decile, largest in the tenth size decile). For each variable the median is calculated for each decile from 1986 to 2003 and the median of these time series is reported. Equity beta, as estimated from the CAPM and the Fama-French three factor model, increases monotonically by size decile. The smallest size decile has an equity beta of 0.36 while the largest is 1.22. There is no specific pattern to total equity volatility. The fourth size decile has the smallest equity volatility at 7.19% while the first and tenth size deciles have equity volatility of 7.77% and 8.59% respectively. Idiosyncratic volatility falls with bank size. The group with the most idiosyncratic volatility is the first size decile. Size deciles seven through ten have the smallest idiosyncratic volatility.

These relationships are made more formal by calculating cross-sectional (unequal variance) difference of mean test statistics between large and small banks. For the purpose of these tests, large banks are defined as those in size deciles 7, 8, 9, and 10 while small banks are defined those in size deciles 1,2,3, and 4. For the first series of tests, the null hypothesis is that the equity betas of small banks are greater than the equity betas of large banks. This null hypothesis is rejected every year. For the second series of tests, the null hypothesis is that the idiosyncratic volatility of large banks is greater than that of small banks'. The null is again rejected in each year. For the final cross-sectional test, the null hypothesis is that the total equity volatility of large banks is equal to that of small banks'. In all of the years except 1996 to 1998 and 2000 to 2003 the null is accepted. In 1996 to 1998 the equity volatility at large banks is significantly smaller than at small banks and in 2000 to 2003 the opposite is true. Table III reports the results of these tests.

What role does regulation play in these relationships? The fact that equity volatility does not vary by bank size is one piece of evidence that regulation reduces the cross-sectional dispersion of this variable. It is not the goal of this study to argue the absolute effectiveness of regulation or the ultimate goal of supervision. Regulatory bodies are not the only party to exert pressure on banks to maintain a minimum level of safety or soundness; deposit holders, share owners and deposit insurers are likely to have similar interests. However, it is clear that the intention of regulation is to set forth 'minimum ratios of capital to risk weighted assets' and if banks do not meet these requirements then 'both informal and formal supervisory and enforcement' action may be taken[6].

If regulation were perfectly effective, then a bank that dips below a threshold default probability would meet with supervisory action (see the Federal Reserve's Bank Holding Company Supervision Manual for the frequency and type of rating each bank receives). In this scenario, banks choose an acceptable combination of asset risk and equity capital. Regulation, however, is not perfectly effective. Indeed, capital requirements have been criticized for not accurately aligning regulatory capital with the risk of banks' assets. While regulation is not perfect, few would argue that regulation isn't somewhat effective at keeping most banks above a minimum default probability or credit rating. Of course one possibility is that minimum requirements may not bind as some banks may hold excess capital. However, (in the sample in this study) there is remarkably little cross-sectional variation in bank equity capital ratios and most stay within a relatively tight range (even across time).

If regulation requires banks to hold capital to balance the risk of their assets, and most banks have similar capital ratios, then there are only a few possibilities for the equity volatility and leverage characteristics of the cross section of banks. The first possibility is that regulation is somewhat effective and binding. If this is true, because bank capital holdings are relatively constant, the cross sectional dispersion of equity volatility would be small (the findings of this paper). The second possibility is that regulation is not at all effective and banks are limited to a threshold credit rating by depositors and other interested parties. This explanation fits perfectly with the findings of this paper as well (all that is important for the arguments in this study are that banks are 'pressured' to maintain a minimum threshold of safety and soundness, the pressure may come from sources other than regulation). Another possibility is that regulation is not effective and there is little pressure on banks to maintain safety standards. In this case it would be merely coincidental that all banks hold similar capital ratios and have similar levels of equity volatility. Finally, maintaining a minimum level of credit risk (and thus implicitly limiting equity volatility) may be an artifact of a combination of regulatory, depositor and market forces. While this study does not attempt to distinguish among these scenarios, as long as there is some truth to the latter scenario, the arguments in this paper are relevant.

As stated, if banks' equity volatilities – either explicitly or implicitly – are restricted, then one implication would be that the cross sectional dispersion in equity volatility should be smaller than that for unregulated firms. In order to test this hypothesis the standard deviation of monthly stock returns is calculated for all non-financial firms in the CRSP database (in the exact same manner as it was calculated for the banking industry). Firms are then divided into industry groups based on SIC code[7]. Levene F-Tests for equality of variance between banking and other industries are conducted on the time series (1986 to 2002) of cross sectional equity volatilities (testing for similar dispersion of equity volatility in each industry). The banking industry has significantly less cross-sectional dispersion of equity volatility than any of the other industries. Indeed the mean dispersion from 1986 through 2005 in the banking industry is 2.66% while all the other industries have a mean standard deviation of equity volatility of at least 8.32%. For the retail trade industry, the industry closest in size to the banking industry (5,007 firm-year observations versus 4,116 firm-observations respectively), the F-Statistic is 9.92 which rejects the null of equal variance in equity volatility

[6] Bank Holding Company Supervision Manual, The Federal Reserve Board, http://www.federalreserve.gov/Boarddocs/SupManual/bhc/200701/1000.pdf.

[7] The following industry definitions are used for all publicly traded companies: Mining – SIC code between 1000 and 1499, Construction – SIC code between 1500 and 1999, Manufacturing – SIC code between 2000 and 3999, Transportation/Communication – SIC code between 4000 and 4999, Retail Trade – SIC code between 5200 and 5999, Service – SIC code between 7000 and 8999, Mining – SIC code between 9000 and 9999.

at any significance level. Table IV reports annual dispersion in equity volatility by industry and the corresponding F-statistics testing the equality this dispersion with the banking industry.

This evidence suggests that regulation imposes restrictions on the equity volatility of banks. If there is a cap on equity volatility and small banks are less diversified than large banks then it follows that they will be forced to deal with superfluous idiosyncratic volatility. It remains to be shown that the portfolios of small banks are less diversified than the portfolios of large banks. There are two ways in which large banks are able to reduce idiosyncratic volatility more than small banks (see the appendix for an explanation). First, due to their larger size, large banks may hold a greater number of loans. Second, they may have at their disposal a greater diversity of potential borrowers.

In considering the universe of potential borrowers, small banks are unable to lend to the subset of large firms. For one, regulators (state and federal) enforce lending limits that state that banks may not make loans in total to any single borrower greater than ten percent of bank equity capital and surplus. Since the size of some larger firms' loans would surely exceed these levels, small banks would not be able to meet the demand for funds from these firms. In addition there are other laws which essentially prohibit small banks from lending to large firms[8]. Empirical evidence that small banks do not lend to large firms is available from the Federal Reserve's Survey of Terms of Business Lending[9]. As Rosen (2006) details, only 10% of small bank loans in the first quarter of 2006 had face value over one million dollars whereas for large banks this figure was 55%. In the past, the numbers are even more skewed, in the first quarter of 1982 these large loans made up only 3% of all small bank loans. Thus, in as much as large firms only borrow over one million dollars at a time, small banks do not have the same access to the large firm loan market as large banks.

Historically, the Survey of Terms of Business Lending suggests that large banks lend to both large firms and small firms. Thus it appears that large banks have a deeper pool of borrowers to which they may lend, and thus a larger universe than small banks in which to diversify. The simple model in Appendix A reveals that as a result, large banks can lower their total idiosyncratic volatility more than small banks because they have both a larger number of loans and more groups of firms to which they can lend.

An empirical implication of large banks' superior loan diversity is that a portfolio of large bank equity returns should not exhibit a reduction in idiosyncratic volatility over one large bank's idiosyncratic volatility as much as a portfolio of small bank equity returns would exhibit a reduction in idiosyncratic volatility over one small bank. In other words if small banks have a greater proportion idiosyncratic volatility then a portfolio of small banks should eliminate the added idiosyncratic volatility and result in less total volatility. If large banks are fully diversified then a portfolio of large banks should have roughly the same idiosyncratic volatility as a single large bank. This implication is tested by forming annual size portfolios using the size deciles described earlier. Monthly stock returns for each annual size portfolio are calculated by taking the equally-weighted mean stock return of an equal number of banks (chosen randomly) from each size decile. Regressions of 5 years of monthly portfolio returns on the three Fama-French factors are run for each annual size portfolio. As with individual banks, the idiosyncratic volatility for each annual size portfolio is measured as the standard deviation of the fitted error terms from these Fama-French regressions. Since the sample spans 1986 to 2003 and each year has 10 different size portfolios, in total 180 portfolio regressions are run. Table V reports the mean estimates of these regressions. One obvious

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8 For example see California State Law on lending limits at http://www.leginfo.ca.gov/cgi-bin/displaycode?section=fin&group=01001-02000&file=1220-1239.

9 http://www.federalreserve.gov/releases/e2/.

fact is that the small bank size portfolios exhibit less idiosyncratic volatility than the large bank size portfolios. The mean root mean squared error from the Fama-French regressions is 2.4% for the smallest decile and 3.8% for the largest decile. Total volatility also increases by bank portfolio size from a low of 3.74% for the smallest size decile to a high of 6.96% for the largest size decile. Recall that prior to portfolio formation, idiosyncratic volatility decreased with size and total volatility was constant across size. The results in Table V give strong evidence that small banks hold portfolios with a higher proportion of idiosyncratic volatility than do large banks. Table V reveals that when small banks diversify their loan portfolios the resulting total volatility is less than when large banks fully diversify.

This section described in detail differences between equity beta and idiosyncratic volatility at large and small banks. Beta is positively correlated with bank size. Idiosyncratic risk is negatively correlated with bank size. Table I shows us that equity capital does not vary by bank size, thus these relationships are not driven by differences in equity capitalization at large and small banks. Support was given for implications of an implicit cap on total equity volatility. Tests show that the total equity volatility does not vary by bank size. A comparison of cross-sectional dispersion in the volatility of stock returns at banks and other industries show that banks have remarkably little variation in total equity volatility. Evidence was given that of this volatility, small banks have a higher proportion coming from idiosyncratic volatility than large banks.

The correlation of bank size and equity beta

This section addresses the correlation of bank size and equity beta in the banking industry. Simple models (see Appendix A and B) reveal that there are four possible reasons for why the equity beta of small banks is smaller than that of large banks. The empirical results to follow demonstrate that after controlling for these reasons, as expected size is no longer correlated with equity beta. As a preview, it is found that while the sectoral breakdown of a bank's loan portfolio does explain changes in equity beta, the primary reason small banks have smaller equity betas is because they tend to make less leveraged loans than large banks.

In theory, one explanation for the equity beta-size relationship, is that large banks may hold less equity capital (more leveraged) than small banks. As indicated before, there is little evidence to suggest that this is the case. In regressions of equity beta on controls and equity capital, equity capital is insignificant. A second explanation is that large and small banks may make similar types of loans with similar lending terms (such as collateral, information, etc.) but that small non-financial firms simply have smaller asset betas than large non-financial firms. If this is the case and small banks lend exclusively to small firms, then even if all other aspects of each loan are identical, small banks will have a smaller equity beta than large banks. However, evidence suggests that small non-financial firms do not have smaller asset betas. Third, large banks may lend to different sectors than small banks. For instance, small banks may make relatively more credit card loans than small banks. If credit card borrowers have lower asset betas than other borrowers then it follows those small banks who make credit card loans will have smaller equity betas. This hypothesis is tested by regressing bank equity betas on loan portfolio characteristics and bank size. If size is insignificant in this regression, then the size phenomena is explainable by the fact that banks of different size lend to different sectors. Fourth, small banks may lend to similar sectors and asset types as large banks, but they make loans with lower credit risk. They may require more collateral per loan or have superior information on borrower risk. Support for this hypothesis is found by examining loan charge-off and delinquency rates at large and small banks. Small banks charge-off less and have less delinquent loans than large banks. This is especially true for types of loans in which the bank can require more collateral. Finally a test is run to determine whether a bank's loan charge-off ratio outperforms size as a predictor of equity beta. This cross-sectional regression sets average bank beta as the dependent variable and the average of loan portfolio characteristics, average size and average loan charge-offs as the explanatory variables. Average loan charge-offs is significant and size is not giving strong evidence that small banks make loans of similar types but with less credit risk than large banks' loans.

The first relationship to examine is leverage, asset beta and equity beta. In general, the value of a firm is just the aggregate value of each of the firm's investments. It then follows that equity beta should reflect a weighted average beta of each of the firm's projects and the firm's debt. This is most easily seen by considering a firm's assets as a portfolio of debt and equity. One can then solve for the beta of the firm's equity and find:

$$\beta_E = \frac{\beta_A - \left(\frac{D}{D+E}\right)\beta_D}{\frac{E}{D+E}} \qquad (1)$$

where βE is the beta of the firm's equity, βA is the beta of the firm's assets, D is the value of the firm's debt and E is the value of the firm's equity. While this formula may be helpful for most firms, for banks it is difficult to interpret. Banks are, by the nature of their business, highly leveraged. Even if leverage is important in determining equity beta, the relationship is made even more obscure by the fact that a bank's capital structure is highly governed and monitored by the regulations established by the Basel Committee on Banking Supervision which the U.S. adopted as their capital requirements in 1989. Thus there is little fluctuation in the capital structure of most publicly traded banks. Referring back to Table I we can see that capital structure does not vary systematically by bank size.

Equation 1 reveals that asset beta (banks' assets typically consist of loans) will also be a factor in determining a bank's equity beta. Thus if large banks select loan portfolios that consist of assets that tend to have higher asset betas than those loans selected by small banks, cateris parabis large banks would have higher equity betas. Thus the second hypothesis to test is: after controlling for leverage and the systematic differences in the types of assets to which small and large banks lend (respectively), there is no systematic relationship between a bank's size and equity beta. If this hypothesis is rejected, then even after controlling for portfolio selection and leverage of the bank, size is still related to equity beta. Thus both hypotheses – that leverage fully explains the equity beta-size relationship and sector lending explains this relationship - are rejected if in the following regression size is significant:

$$\begin{aligned}\beta_{i,t} &= b_{0t} + b_{1t}(size_{it}) + b_{2t}(equity\ capital_{it}) + \bar{b}_{3t}(loans\ held\ in\ each\ category_{it}) \\ &\quad + b_{4t}(assets\ in\ each\ class_{it}) + b_{5t}(controls) + \varepsilon_{it}\end{aligned} \qquad (2)$$

This regression is run for every year of the sample and as a panel. The loan categories used are: commercial real estate (not collateralized by real estate); construction and land development; real estate secured by farmland; other depository institutions; real estate secured by nonfarm, nonresidential properties; finance agricultural production; commercial and industrial; credit card; foreign governments and other official institutions; and 'other'. Each of the loan categories is divided by bank total assets in order avoid capturing size effects and only capture changes in equity beta due to relative differences in lending. In addition to loans, a bank's assets consist of investments and cash. Indeed, Stiroh (2006) finds that differences in the total equity volatility of large and small banks are driven by differences in interest versus noninterest income. As an example, consider a bank who hedges against the risk of interest rates falling. The bank purchases an inverse floater option to hedge against this risk. Thus, if large banks hold more of these types of derivative contracts, this would affect the equity beta of large banks and not small banks. Thus, it is necessary to control for any of these trading contracts on the balance sheet. The FR Y9-C has information on individual bank holdings of derivatives in interest rate, foreign exchange, equity security and commodity and other contracts. The net exposure in each of these contracts is included in the annual regressions. In order to control for other investments, a bank's total trading assets, trading liabilities, noninterest and interst income and maturity GAP[10] (as reported in the Y9-C) scaled by total assets are also included as controls in the regression. Table VI summarizes equity beta's hypothesized explanatory variables.

As mentioned previously, Stiroh (2006) finds that noninterest income and bank revenue sources are important factors in determining equity volatility. This study finds that these variables are also significant in determining a bank's equity beta. However these variables do not fully account for the correlation of equity beta and size as size is significant after controlling for these factors. Given the timing and breadth of the cross section of the data panel, this should not come as a surprise. Certainly there are likely to be significant differences between noninterest income sources for the largest decile of banks and the smallest decile of banks. The largest banks certainly have operations outside of the traditional commercial banking services (investment banking, underwriting, etc) while small banks do not. However, the finding in this study is that equity beta tends to fall monotonically with bank size (that is, equity beta is not just large for the 'largest' of banks and small for the 'smallest' of banks). It does not seem likely that banks near the median size would be involved in activities (including off-balance sheet) available to the very large banks. Thus the share of their income that is from noninterest sources is likely (and empirically is) similar to small banks, yet their equity betas are larger than those of small banks. Indeed, a similar reason that noninterest income is unlikely to fully explain the equity beta-size relationship, long before commercial banks had the diversity of opportunities to earn noninterest income the correlation of equity beta and size was present (prior to the repeal of interstate banking laws and the Glass-Steagall Act).

Due to the size constraints the year by year regression results are suppressed. In each year size is significant. The smallest size t-statistic is 4.76 in 1996. In 1989 through 1997 equity capital is negative and significant but in the other years it is either insignificant or positive and significant (1993 and 2003). Thus large banks do not have large equity betas because they hold less equity capital. Maturity GAP is positive and significant in all of the regressions meaning banks more exposed to interest fluctuations have higher equity betas. Consistent with the findings of Stiroh (2006), trading assets and noninterest income are positive and typically significant (as expected). Some of the loan categories are significant and with the expected signs (for example commercial real estate loans is typically positive and significant). The regressions suggest that while a bank's loan portfolio composition is a factor in determining a bank's equity beta, it is not the only factor as size is still significant in each of the regressions.

As a robustness check, the same hypotheses are tested by running the same regressions on the above explanatory variables except this time not including size in the regression. The errors are then calculated from this regression and regressed on each bank's corresponding size. If the size coefficient is significant both hypotheses are rejected. This second test is superfluous and is included only to demonstrate the robustness of the results. Although not reported in a table the null hypotheses are again rejected in the alternative test. The size t-statistics in these tests are again all greater than four.

Due to the changes in the FR Y9-C a single panel regression for our entire 18 year sample is not feasible (1986-2003). The data on derivative contract holdings and loans to other financial

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[10] Following Flannery and James (1984) maturity GAP is defined as the absolute value of assets that mature or re-price within a year minus liabilities that mature or re-price within a year divided by the total assets of the BHC.

institutions are not available until 1996. The data on construction and land development, real estate secured by farmland, real estate secured by nonfarmland, nonresidential properties, credit card, and 'other' loans are not available until 1991. Thus three different time periods are used: a) 1996-2003 b) 1991-2003 and c) 1986-2003. In order to control for macroeconomic conditions that may affect equity beta, the risk-free rate, the volatility of the risk-free rate and an economy wide price to earnings ratio are included in the panel regression. The volatility of the risk-free rate is measured as the standard deviation of the monthly risk-free rate over the 12 months within a given year t. The economy wide price to earnings ratio is a ten year rolling average of all publicly-traded firms price to earnings ratio taken from Robert Schiller's website.

Table VII reports the results from the panel regressions. T-statistics are estimated using Rogers standard errors and allow clustering of errors by individual bank holding companies (Petersen, 2005). Size has a t-statistic of 16.66 – thus the null hypotheses are rejected. The risk-free rate causes banks to have high betas as evidenced by the positive coefficient on the risk-free rate and a t-statistic of 27.02. As one would expect, a more volatile risk-free rate also causes banks to have higher equity betas. Finally when the economy wide price to earnings ratio falls, the dependent variable tends to fall as well.

Finally Table VIII reports the panel regression test results when size is excluded from the initial regression. As a reminder the residuals from the panel regression are regressed on bank size for a more stringent test. Table VIII reveals that in the panel regression with all of the available variables (Sample A) the t-statistic on size is still significant at over the 99% significance level for the t-distribution.

In equation 1 the asset beta of banks is an important factor in determining a bank's equity beta. It has been shown that while equity beta is a function of the sectoral composition of a bank's loans, there are other factors that drive the relationship with size. An alternative hypothesis involving asset beta is the possibility that asset betas of large non-financial firms are higher than those of small non-financial firms. If small banks are only able to lend to small firms and if small firms have relatively low asset betas, then small banks would also have less asset betas (and thus lower equity betas than large banks). A priori there is no reason to believe that this is the case. In order to test this hypothesis quarterly data from 1976 to 2002 is gathered from compustat on all non-financial firms' outstanding debt and market capitalization. For each quarter j, year t and non-financial firm i the standard deviation of monthly stock returns is estimated using data from CRSP from quarter j, year t-3 to quarter j, year t. Then using the data on book value of debt, monthly equity volatility, the risk-free rate and market capitalization the total market value of each firm is estimated using the Merton model[11].

After the quarterly series of market value of assets have been estimated for every non-financial firm in Compustat from 1976:1 to 2002:4, a return on assets series is defined as: ri,A = (market value assets)t /(market value assets)t-1 -1, (t = the end of quarter date). The following regression is run for each firm using data from 1976:1 to 2002:4.

$$r_{A,i,t} = \alpha_i + \beta_{A,i}(r_{m,t} - r_{f,t}) + \eta_{i,t} \qquad (3)$$

where rm and rf are the market and risk-free rates (as defined previously) and ηi is mean zero noise.

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[11] Merton (1974) uses a firm's data on book debt, market equity value, market equity volatility and the risk-free rate to solve for the market value of the firm's assets and asset volatility. This involves solving two simultaneous equations that are isomorphic to the Black and Scholes option pricing model with market capitalization equal to the option price, book debt equal to the strike price and the risk-free rate equal to the risk-free rate. The most familiar use of Merton's model is the first step in calculating Moodys-KMV's expected default frequency for each firm.

Each non-financial firm's market capitalization (for the purpose of portfolio formation) is defined as mean market capitalization over all the firm's quarterly observations. The sample is divided into size deciles using this measure of size. Again deciles are estimated using NYSE only firms to estimate breakpoints. For each size decile, the mean and standard deviation of asset beta are calculated and presented in Table IX. The mean asset beta for the smallest decile of non-financial firms is 1.13 and .83 for the largest decile. While these results are approximations to actual asset betas it does appear that asset beta is actually negatively correlated with firm size. Thus differences in non-financial firms' asset betas do not appear to cause small banks to have lower asset betas (and therefore lower equity betas) than large banks. Recall the reason for estimating non-financial firm asset betas was to investigate the possibility that small bank borrowers may have higher asset betas. If this is true then this would at least be a partial explanation to why small banks have 'small' equity betas. In fact given the results from Table IX one would expect that small banks would have higher equity betas than large banks.

Equation 1 detailed three ways a bank could lower their equity beta: hold more equity capital; lend to low asset beta sectors or lend to firms with low asset betas. There is no evidence that small banks use any of these methods to achieve a low equity beta. In order to gain a more thorough understanding of a bank's equity beta it is necessary to consider each loan the bank holds - the beta of the returns to a loan will be a function of the terms and size of the loan, as well as the borrower's asset beta.

For example, consider Bank X and Bank Y. The Widget LLC is an all-equity firm that wishes to change it's debt to equity ratio. Widget's equity is currently worth $100 million. They go to both Bank X and Bank Y in search of a loan. Bank X is willing to offer Widget LLC a loan that has a face value equal to $30 million while Bank Y is only willing to offer Widget LLC a loan that has a face value of $20 million. The loan Bank X is willing to make will have a higher beta (and more idiosyncratic volatility) than the loan Bank Y would make. Thus if Bank X makes all of their loans in this manner, cateris parabis Bank X's equity would have a higher beta than Bank Y.

Galai and Masulis (1976, see Appendix B) formalize this relationship with a model that combines the option pricing model of Merton with the CAPM. Their results demonstrate that besides the asset beta of the borrower (loan sector), face value (or collateral or strike price) is the only other unambiguous parameter that determines the beta of a loan. This leads to the hypothesis that small banks have lower equity betas than large banks due to cross-sectional variation in loan default risk (less collateral per loan).

As an example of how collateralization affects the beta of an individual loan consider a firm with a standard deviation of asset growth equal to 40% per year and asset value worth $100 million. If a bank offers this firm a five year loan of $40 million, the bank's resulting beta on this loan (assuming the bank has a 10% capitalization level) is 1. Now if the same bank were to offer this firm a five year loan of only $29 million the bank's resulting beta would now be .6.

What are the implications of the null hypothesis that large banks make loans at lower collateralization levels than small banks? This hypothesis can be interpreted in a number of different ways. Collateral may mean a more thorough knowledge of the borrower's ability to repay or promised assets recovered by the bank in the event of a default. The most obvious way to test the hypothesis would be to gather individual loan data from small and large banks. This data would ideally identify the assets underlying the loan, the value of those assets, the loan amount and the status at expiration of the loan (default, recovery, etc.). This type of data, however, is not available.

One implication of the null is that, other things being equal, default rates will be higher at large banks than small banks. If large banks lend more aggressively and extend more credit than small banks, on average their loans should have a lower success rate. The first test of this hypothesis is to calculate mean delinquency and charge-off rates for each of the loan / size categories and then calculate a difference of means t-statistic. If the t-statistic is significant the null hypothesis is rejected and the conclusion is that large banks make riskier loans than small banks.

Table X reports the average loan default rates for the 100 largest and small commercial banks. Table XI reports average charge-off rates for the same bank categories. Delinquency rates at large banks are higher than those at small banks. For all the loans and leases banks make, the largest 100 have on average a .7% higher delinquency rate and a .3% higher charge-off rate per quater. Total charge-off rates at large banks are .28% greater than at small banks. Small banks charge off .47% less commercial real estate loans per quarter and .36% less ‘other consumer’ loans than large banks. The only categories for which small banks do not have lower delinquency/charge-off rates is credit card loans, leases and C&I loans. Difference of mean t-tests for each of the loan categories reveals that large banks never have a significantly lower charge-off rate than small banks. The fact that credit card loans, leases and C&I loans are the only loans for which small and large banks have similar delinquency rates adds further (albeit informal) evidence to the fact that small banks require more collateral per loan. Small banks cannot require more collateral for credit card loans since these loans inherently have zero collateral backing them. In addition, information on the risk of individual consumers is unlikely to vary from bank to bank. Thus when small banks do not have the ability to require more capital there is no difference between lending at small and large banks. For leases, the law dictates that the bank must retain ownership of the asset so that in this case the small bank loses the ability to change the collateral backing the loan. It is not surprising then that similar delinquency rates are observed for leases. The difference of mean results in Table XII reveal that the hypothesis that large and small banks have the same loan charge-off rates is rejected. Similarly, Table XIII reports the difference of means tests for loan delinquency rates. These results support the rejection of the null hypothesis.

Finally in order to show a more robust relationship between size, equity beta and loan delinquency rates a regression is run of equity beta on loan delinquency rate, size and bank portfolio characteristics. If the coefficient on loan delinquency rate is significant, the null hypothesis that large and small banks lend at the same collateralization rates is rejected. There is a timing problem with this regression in the sense that it is unclear when equity beta will adjust to past, present or future charge-offs. That is, when do markets incorporate the risk of a loan into the equity characteristics of the bank. Since it is impossible to know the average duration of each bank’s loan portfolio and when the risk of loans unfolds, it is impossible to know the appropriate time scale for this regression. In addition there are cyclical components to charge-offs. There may be time periods when small banks have high loan delinquency rates but large banks do not. This will result in running an erroneous regression. The solution to these problems is to take the time average of equity beta, charge-offs and all of the other bank control variables and estimate the regression using these variables. Since the hypothesis is a cross-sectional hypothesis, this regression will give us an unbiased estimate of the relationship between equity beta, size and charge-offs. The null-hypothesis is again that banks, regardless of size, make loans of similar credit risk. Under the null hypothesis, large and small banks will have similar loan charge-off ratios. When we regress mean equity beta on average loan charge-offs as a ratio of total loans, average bank assets, and other explanatory variables (used previously) the coefficient of loan charge-offs will be zero under the null. The regression to test the hypothesis is:

$$\begin{aligned}\overline{\beta_i} &= b_0 + b_1(\overline{size_i}) + b_2(\overline{equity\ capital_i}) + b_3(\overline{loans\ held\ in\ each\ category_i}) \\ &+ b_4(\overline{assets\ in\ each\ class_i}) + b_5(\overline{controls}) + b_6(\overline{chargeoffs_i}) + \varepsilon_i\end{aligned} \quad (4)$$

The mean of each of the variables in the regression is taken from 1994 to 2003 (this is the longest time period for which all of the explanatory variables are available). It is required that each bank have at least four years of continuous observations. Standard errors are Huber-White robust. Table XIV presents the results of this regression. The null hypothesis is rejected as the total charge-offs t-statistic is 4.21. In addition the coefficient on size is positive but no longer significant (this is not the case if charge-offs is left out of the regression). Thus the factor that drives large banks to have higher equity betas is riskier loans within each loan type. This regression also reveals (once again) that equity capital is not a factor in determining a bank's equity beta. The coefficient is negative but is not significantly different from zero.

Conclusion

This paper has presented strong circumstantial evidence that regulators (and/or shareholders) place a limit on the total volatility of each bank's assets regardless of size. Small banks have more risk inherent in their loan portfolio because they cannot diversify away idiosyncratic volatility as well as large bank. This inability to diversify comes about a number of different ways – for example; less total loans held, less diversity in borrower type (they do not have access to large borrowers) and geographic restrictions (small banks tend to be more localized). Because their total equity volatility is limited by regulation they must find a way to eliminate the superfluous idiosyncratic volatility (which large banks do not have). Small banks do not accomplish this through equity capitalization or by lending to different sectors in the economy. While the type of loans (credit card, commercial, etc.) has been shown to affect a bank's equity beta, after controlling for loan sector, size is still significant. Further, evidence suggests small bank borrowers do not have higher asset betas than large bank borrowers. This was shown by constructing asset betas for all non-financial firms and finding that small non-financial firms (likely small bank borrowers) do not have higher asset betas. Small banks, however, do make loans with less credit risk than large banks. This has the effect of reducing idiosyncratic volatility (as desired) and also reducing the beta of each loan (and thus the equity beta of small banks). These results suggest a possible explanation for the co-existence of large and small banks. Small banks are able to secure loans with lower credit risk (either due to their superior knowledge of borrower risk or borrower preference for small banks) but at the cost of less diversity in their loan portfolio. Further research needs to be done to determine not only how small banks secure less risky loans but also what role this plays in the equilibrium co-existence of large and small banks.

References

Aharony, Joseph, Saunders, Anthony and Itzhak Swary, "The Effects of DIDMCA on Bank Stockholders' Returns and Risk," *Journal of Banking and Finance* 12 (1988): 317-331.

Akhavein, Jalal D., Allen N. Berger, and David B. Humphrey, "The Effects of Megamergers on Efficiency and Prices: Evidence from a Bank Profit Function," *Review of Industrial Organization* 12 (1997).

Allen, Paul R., and William J. Wilhelm, "The Impact of the 1980 Depository Institutions Deregulation and Monetary Control Act on Market Value and Risk: Evidence from the Capital Markets," *Journal of Money, Credit and Banking* 20:3 (August 1988): 364-380.

Berger, Allen N., "The Profit-Structure Relationship in Banking," *Journal of Money, and Banking*, 27 (May 1995a): 404-31.

Berger, Allen N., Diana Hancock, and David B. Humphrey, "Bank Efficiency Derived from the Profit Function," *Journal of Banking and Finance* 17 (April 1993): 317-47.

Berger, Allen N., and Timothy H. Hannan, "Using Measure of Firm Efficiency to Distinguish among Alternative Explanations of the Structure-Performance Relationship," *Managerial Finance*, (1996).

Berger, Allen N., and David B. Humphrey, "Megamergers in Banking and the Use of Cost Efficiency as an Antitrust Defense," *Antitrust Bulletin* 37 (Fall 1992): 541-600.

Berger, Allen N., David B. Humphrey, and Lawrence B. Pulley, "Do Consumers Pay for One-Stop Banking? Evidence from an Alternative Revenue Function," Working Paper, Department of Finance, Florida State University, Tallahassee, FL (November 1995).

Berger, Allen N., Nathan H. Miller, Raghram G. Rajan, and Jeremy C. Stein, "Does Function Follow Organizational Form? Evidence from the Lending Practices of Large and Small Banks," *Journal of Financial Economics* 76:2 (May 2005): 237-269.

Berk, Jonathan, "A Critique of Size Related Anomalies," *Review of Financial Studies* 8 (1995): 275-286.

Bliss, Robert and Mark J. Flannery, "Market Discipline in the Governance of U.S. Bank Holding Companies: Monitoring vs. Influencing," NBER Working Paper 2001.

Brooks, Robert D., Faff, Robert W., and Yew Kee Ho, "A New Test of the Relationship Between Regulatory Change in Financial Markets and the Stability of Beta Risk of Depository Institutions," *Journal of Banking and Finance* 21 (1997): 197-219.

Bundt, Thomas P., Cosimano, Thomas F. and John A Halloran, "DIDMCA and Bank Market Risk: Theory and Evidence," *Journal of Banking and Finance* 16 (1992): 1197-1193.

Campbell, J., Lo, A. and A. McKinlay, *The Econometrics of Financial Markets* (1997), Princeton University Press, Princeton, NJ.

Chan, K.C., and N. Chen. "An Unconditional Asset Pricing Test and the Role of Firm Size as an Instrumental Variable for Risk," *Journal of Finance* 43 (June 1988): 309-325.

DeJong, Douglas and Daniel W. Collins. "Explanations for the Instability of Equity Beta: Risk-Free Rate Changes and Leverage Effects," *Journal of Financial and Quantitative Analysis* 20:1 (March 1985): 73-94.

Diamond, Douglas W., "Financial Intermediation and Delegated Monitoring," *Review of Economic Studies* 51 (July 1984): 393-414.

Diamond, Douglas W., "Monitoring and Reputation: The Choice between Bank Loans and Directly Placed Debt," *Journal of Political Economy*, 99 (August 1991): 689-721.

Dickens, Ross and George Philippatos, “The Impact of Market Contestability on the Systematic Risk of US Bank Stocks,” *Applied Financial Economics*, 4 (5, October 1994): 315-322.

Fama, Eugene F., and Kenneth R. French, “The Cross-Section of Expected Stock Returns,” *Journal of Finance* 47 (June 1992): 427-465.

Flannery, M. J. and C. M. James, 1984, “Marker Evidence on Effective Maturity of Bank Assets and Liabilities,” *Journal of Money, Credit and Banking* 16, 435-445.

Galai, Dan and Ronald W. Masulis, “The Option Pricing Model and the Risk Factor of Stock,” *Journal of Financial Economics* 3 (1976): 53-81.

Green, Edward J., Jose A. Lopez and Zhenyu Wang, “The Federal Reserve Banks’ Imputed Cost of Equity Capital,” Working Paper, Federal Reserve Bank of San Francisco, San Francisco, CA (July 2001).

Grossman, Sanford and Oliver D. Hart, “The Costs and Benefits of Ownership: A Theory of Vertical and Lateral Integration,” *Journal of Political Economy* 94 (August 1986): 691-719.

Hannan, Timothy H., “Bank Commercial Loan Market and the Role of Market Structure: Evidence from Surveys of Commercial Lending,” *Journal of Banking and Finance*, 15 (February 1991): 133-149.

Krainer, John and Jose A. Lopez, “Incorporating Equity Market Information into Supervisory Monitorning Models,” Working Paper, Federal Reserve Bank of San Francisco, San Francisco, CA (June 2002).

Merton, Robert C., 1974, “On the Pricing of Corporate Debt: The Risk Structure of Interest Rates,” *Journal of Finance* 29, 449-470.

Millon-Cornett, Marcia H., and Hassan Tehranian, “Stock Market Reactions to the Depository Institutions Deregulation and Monetory Control Act of 1980,” *Journal of Banking and Finance* 13 (1989): 81-100.

Petersen, Mitchell A., 2005, “Estimating Standard Errors in Finance Panel Data Sets: Comparing Approaches,” NBER and Kellogg School of Management Working Paper.

Petersen, Mitchell A., and Raghuram G. Rajan, “The Effect of Credit Market Competition on Lending Relationships,” *Quarterly Journal of Economics*, 110 (May 1995).

Petersen, Mitchell A., and Raghuram G. Rajan, “Does Distance Still Matter? The Information Revolution in Small Business Lending,” *Journal of Finance* 57 (December 2002), 2533-2570.

Rhoades, Stephen A., “Market Share as a Source of Market Power: Implications and Some Evidence,” *Journal of Economics and Business* 37 (1985): 343-63.

Roll, Richard, “R-Squared,” *Journal of Finance* 43 (July 1988): 541-566.

Rosen, Richard, Discussant of “Financial Innovations, Idiosyncratic Risk, and the Joint Evolution of Real and Financial Volatilities,” *Federal Reserve Bank of San Francisco Conference, 17 November, 2006*, http://www.frbsf.org/economics/conferences/0611/index.html.

Stein, Jeremy C., “Information Production and Capital Allocation: Decentralized versus Hierarchical Firms,” *Journal of Finance*

57 (October 2002): 1891-1920**.**

Stiroh, K., “A Portfolio View on Banking with Interest and Noninterest Activities,” *Jounral of Money, Credit and Banking*, 38 (August 2006): 1351-1361.

Stiroh, K., “New Evidence on the Determinants of Bank Risk,” *Journal of Financial Services Research*, 30 (2006): 237-263.

Tables

Table I

Sample Summary Statistics by Size Decile

Table 1 reports the median of various variables for year 2000 by size decile for all of the publicly-traded bank holding companies in our sample. Following Fama-French (1993) size deciles are created using only the banks/non-financial firms listed on the NYSE. Size decile bins are created in two ways: using all non-financial firms (thus replicating Fama-French size decile bins) and using only bank holding companies. Equity capital is equity capital reported in the Federal Reserve Y9-C database divided by total assets. Loans to assets is total loans reported in the Y9-C divided by total assets. Assets and market capitalization are reported in millions of dollars.

	Using Only Banks for Size Decile Markers					Using All Firms for Size Decile Markers				
Size Decile	# of BHCs	Equity Capital	Loans to Assets	Assets	Market Cap	# of BHCs	Equity Capital	Loans to Assets	Assets	Market Cap
1	222	8.34%	0.681	$537	$59	136	8.44%	0.687	$378	$37
2	41	8.27%	0.661	$2,011	$315	62	8.44%	0.674	$939	$99
3	21	8.06%	0.625	$4,537	$590	40	8.04%	0.655	$1,593	$213
4	19	8.36%	0.673	$6,743	$1,124	25	8.27%	0.661	$2,270	$358
5	9	7.44%	0.681	$7,201	$1,495	17	7.96%	0.599	$4,341	$542
6	13	8.96%	0.705	$12,108	$2,029	13	8.36%	0.689	$5,454	$862
7	10	8.15%	0.712	$30,428	$3,870	22	8.10%	0.677	$8,594	$1,378
8	7	8.49%	0.721	$43,407	$7,020	11	9.13%	0.715	$15,401	$2,073
9	9	8.21%	0.533	$60,896	$17,064	14	8.15%	0.703	$32,550	$4,343
10	8	7.70%	0.564	$243,764	$51,379	19	7.98%	0.578	$81,530	$21,748

Table II

Characteristics of Stock Returns by Size Decile

Figure 1 reports the median of annual estimates by size decile for all publicly-traded bank holding companies in the sample from 1986 through 2003. Size deciles are created using only the banks/ non-financial firms listed on the NYSE. These decile bins are created in two ways: using all non-financial firms (thus replicating Fama-French size decile bins) and using only bank holding companies. Standard deviation of equity return is the standard deviation of monthly stock returns. Beta is the estimated coefficient from annual regressions of the last 5 years of individual bank stock excess returns on the CRSP value-weighted index return. The Fama-French factors are the coefficient estimates from annual regressions of the last 5 years of individual bank stock excess returns on the three Fama-French factors and the FF residual standard deviation is the root mean squared error from this regression. Rm-Rf is the CRSP value-weighted index return minus the risk-free rate. HML is the Fama-French portfolio long 'high' book-to-market firms, short 'low' book-to-market firms. SMB is the Fama-French portfolio 'long' small firms, 'short' big firms.

	Using Only Banks for Size Decile Markers						Using All Firms for Size Decile Markers					
			Fama-French Factors						Fama-French Factors			
Size Decile	Std. Dev of Equity Return	Beta	Rm-Rf	HML	SMB	FF Residual Std. Dev	Std. Dev of Equity Return	Beta	Rm-Rf	HML	SMB	FF Residual Std. Dev
1	7.77%	**0.39**	**0.61**	0.66	0.38	7.39%	8.03%	**0.36**	**0.55**	0.62	0.34	7.72%
2	7.66%	**0.59**	**0.80**	0.69	0.50	6.87%	7.44%	**0.36**	**0.60**	0.70	0.39	7.07%
3	7.30%	**0.66**	**0.84**	0.68	0.49	6.44%	7.84%	**0.55**	**0.76**	0.73	0.46	7.31%
4	7.19%	**0.80**	**1.01**	0.67	0.41	5.96%	7.66%	**0.63**	**0.81**	0.64	0.51	6.80%
5	7.37%	**0.87**	**1.08**	0.73	0.32	6.13%	7.30%	**0.63**	**0.78**	0.72	0.54	6.50%
6	7.54%	**0.93**	**1.16**	0.79	0.31	5.94%	7.27%	**0.72**	**0.90**	0.69	0.53	6.26%
7	7.45%	**0.99**	**1.21**	0.64	0.21	5.69%	7.39%	**0.89**	**1.08**	0.67	0.32	6.09%
8	7.89%	**1.15**	**1.37**	0.67	0.04	5.97%	7.46%	**0.95**	**1.17**	0.78	0.31	5.85%
9	7.98%	**1.14**	**1.33**	0.67	-0.04	5.92%	8.00%	**1.05**	**1.30**	0.71	0.14	5.97%
10	8.59%	**1.25**	**1.49**	0.78	-0.21	6.06%	8.31%	**1.22**	**1.46**	0.73	-0.26	5.99%

Table III

Risk and BHC Size

Table III presents the results of annual difference of mean t-tests comparing equity characteristics of large and small banks. Large banks are defined as those banks in year t that have market capitalization greater than 60% of all non-financial firms' market capitalization while small banks are defined as those banks that have market capitalization less than 40% of all non-financial firms market capitalization. For each year/bank observation: systematic risk or beta is measured by a regression of 5 years of monthly excess stock returns on market (CRSP value-weighted index) excess returns, idiosyncratic risk is defined as the standard deviation of the residual from a regression of 5 years of monthly excess stock returns on the standard three Fama-French factors (excess market returns, HML and SMB); and total risk is measured by the standard deviation of 3 years of individual monthly stock returns. The systematic risk, idiosyncratic risk, and total risk columns reports the cross-sectional difference of mean t-statistic for each of these measures.

			Systematic Risk	Idiosyncratic Risk	Total Risk
Year	# of Small BHCs	# of Large BHCs	H_0: $\beta_{Large}<\beta_{Small}$ T-Stat	H_0: $\sigma_{\varepsilon,Large}<\sigma_{\varepsilon,Small}$ T-Stat	H_0: $\sigma_{Large}=\sigma_{Small}$ T-Stat
1986	91	31	7.57	-4.40	-0.05
1987	88	32	7.87	-4.36	-0.36
1988	88	32	7.01	-4.14	-1.01
1989	96	32	7.51	-3.01	0.18
1990	105	35	8.38	-3.19	0.58
1991	96	34	6.55	-2.79	-0.24
1992	96	31	10.41	-2.46	0.00
1993	86	33	10.26	-3.04	-0.63
1994	231	39	13.79	-3.39	-0.19
1995	244	37	12.27	-4.51	-0.92
1996	269	39	10.44	-6.53	-3.53
1997	261	38	8.91	-7.52	-3.89
1998	259	36	11.34	-8.31	-2.30
1999	269	36	13.46	-4.42	0.29
2000	303	34	9.42	-2.49	3.39
2001	235	26	7.77	-2.74	2.97
2002	307	30	7.41	-2.87	3.02
2003	309	29	6.47	-2.14	3.60

Table IV

Risk Dispersion in Various Industries

Table IV compares the cross-sectional monthly standard deviation of equity volatility in the banking industry to six other commonly studied industries. Industry assignments were made by SIC code. Equity volatility for each firm was measured as the standard deviation of monthly stock returns over year t, t-1 and t-2. For each industy / year the cross-sectional standard deviation of the monthly stock return standard deviation is reported in the corresponindg industry column / year row. The F-Statistic reported is a time-series difference of standard deviations test of the banking industry versus the industry in the corresponding column. *Df banking* denotes the number of observations in the banking industry whilie *df industry* denotes the number of observations in the comparable industry.

Year	Banking	Construction	Manufacturing	Mining	Retail Trade	Services	Transportation
1986	1.77%	6.95%	7.61%	9.34%	5.34%	7.92%	6.21%
1987	1.82%	6.78%	7.79%	13.09%	6.19%	8.46%	6.53%
1988	2.11%	4.86%	6.41%	11.17%	6.70%	7.41%	7.25%
1989	2.03%	6.09%	6.76%	7.90%	7.34%	9.80%	6.69%
1990	1.81%	4.92%	8.61%	9.73%	7.60%	10.58%	6.50%
1991	3.29%	9.13%	11.03%	9.63%	8.35%	11.12%	9.63%
1992	4.27%	16.33%	15.95%	11.42%	8.41%	12.39%	9.95%
1993	4.38%	10.19%	14.86%	13.17%	7.52%	10.79%	11.89%
1994	4.29%	10.58%	7.90%	11.20%	7.40%	8.18%	10.76%
1995	4.03%	11.40%	8.01%	8.07%	6.90%	8.70%	7.45%
1996	3.09%	5.99%	10.42%	9.38%	7.10%	10.06%	7.68%
1997	2.57%	6.34%	10.03%	9.84%	6.76%	10.16%	8.12%
1998	1.65%	11.40%	8.01%	10.65%	6.27%	9.07%	8.12%
1999	1.76%	12.95%	10.33%	10.61%	14.24%	13.18%	11.76%
2000	1.96%	9.85%	14.14%	8.63%	15.60%	15.66%	13.38%
2001	2.04%	16.11%	15.03%	7.21%	10.69%	16.01%	10.49%
2002	2.38%	9.01%	10.69%	6.55%	8.99%	12.41%	11.37%
F-Statistic		**12.37**	**14.22**	**12.54**	**9.92**	**17.37**	**10.99**
df banking		4,116	4,116	4,116	4,116	4,116	4,116
df industry		1,040	34,228	4,921	5,007	12,297	6,723

Table V

BHC Size Portfolio Risk Characteristics

Table V reports the mean of annual estimates from two seperate regressions of portfolio returns on excess market returns and the Fama-French factors. Each year bank size portfolios are created using size buckets from all non-financial firms. Size for all non-financial firms is measured with market capitalization and decile markers are estimated using only firms on the NYSE. Each bank is placed into the size bucket with the corresponding market capitalization decile boundaries. Monthly stock return series for each size portfolio are then formed by taking the mean monthly stock return over all banks within each size bucket. For each year the size portfolios have a time-series of monthly returns for which the standard deviation of returns is calculated, a beta is estimated by regressing excess returns on the market excess return and a regression using the Fama-French factors is also run. Below is the mean (across time) of each of these estimates for each size bucket.

Size Portfolio	Std Dev of Portfolio Return	Portfolio Beta	Fama-French Factors			FF Residual Std. Dev
			Rm-Rf	HML	SMB	
1	3.74%	0.58	0.70	0.75	0.70	2.40%
2	4.28%	0.71	0.84	0.77	0.61	2.20%
3	4.33%	0.73	0.87	0.78	0.52	2.28%
4	4.95%	0.82	1.00	0.73	0.47	2.70%
5	5.40%	0.89	1.11	0.73	0.41	3.02%
6	5.80%	0.97	1.19	0.81	0.36	3.12%
7	5.88%	0.99	1.20	0.67	0.25	3.17%
8	6.47%	1.14	1.40	0.72	0.11	3.82%
9	6.83%	1.20	1.41	0.68	0.06	3.82%
10	6.96%	1.28	1.48	0.81	-0.26	3.81%

Table VI

Variable Definitions

Table VI reports the variables used in the regressions of beta on bank holding company characteristics. Each of these variables is taken from the Federal Reserve's Y9C database on bank holding companies. The estimated annual betas for each bank (time t beta is estimated using the time t-5 to t excess bank and market returns) are then linked to these time t items from the Y9C database. In the regressions the loan variables are scaled by total loans and any other assets are scaled by total assets.

Variable Name	Definition	Variable Name	Definition
Size	Log of Market Capitalization	Other	Other types of loans
Construction	Construction and land development loans	IR Derivatives	Total notional amount of interest rate derivatives held
Farm	Real estate loans secured by farm land	FE Derivatives	Total notional amount of foreign exchange derivatives held
Bank	Loans to depository institutions	EQ Derivatives	Total notional amount of equity derivatives held
Real Estate	Loans secured by non-farm real estate	Equity Capital	Total equity capital
Farm Production	Loans to finance agricultural production and other loans to farmers	Leverage	Subordinated notes and debentures
U.S. C&I	Commercial and industrial loans to U.S. addresses	Maturity GAP	Assets that mature in 1 year minus liabilities that mature in 1 year
Foreign C&I	Commercial and industrial loans to non U.S. addresses	Trading Assets	Total trading assets
Credit Card	Credit card and related plan loans	Trading Liabilities	Total trading liabilities
Noninterest Income	Noninterest income, main sources	Other Noninterest	Other noninterest income
Foreign	Loans to foreign goverments and official institutions	Commercial Real Estate	Commercial Real Estate loans (not collateralized by real estate)

Table VII

Full Sample Regression Results

Table VII reports the results of the panel regressions of beta on bank variables taken from the Federal Reserve's Y9C database and various macroeconomic control variables. Sample A is all publicly traded bank observations from 1986 through 2003, Sample B is all publicly traded bank observations from 1994 through 2003 and Sample C is all publicly traded bank observations from 1996 to 2003. To be included in the sample each bank must have at least 3 years of monthly stock return data. Beta is estimated for each bank each year by regressing the last 5 years of monthly excess stock returns on the excess market return (the market is the CRSP value-weighted index). The risk-free rate is taken from Ken French's website on risk-free rates. Economy P/E is a rolling 10 year average all publicly-traded firms' price-to-earning ratio taken from Robert Schiller's website on stock price data. The volatility of the risk-free rate is the annual standard deviation of the monthly risk-free rate. For each variable row 1 reports the coefficient estimate and row 2 reports the corresponding T-statistic.

Variable	Sample A	Sample B	Sample C
Intercept	-0.29	-0.59	-1.30
	0.14	0.14	0.07
Size	0.09	0.10	0.13
	16.66	19.30	32.58
Commercial Real Estate Financing	0.68	0.59	1.35
	1.82	1.72	2.08
Real Estate	-0.47	-0.39	
	-4.64	-3.88	
Farm Real Estate	-1.48	-2.00	
	-3.48	-5.22	
Bank	-1.64		
	-2.32		
Nonres. Real Estate	-0.31	-0.36	
	-5.37	-6.03	
Farm Production	-0.96	-0.65	-1.43
	-2.79	-1.97	-6.09
C&I	-0.46	-0.45	-0.05
	-4.23	-4.15	-1.19
Other Noninterest	1.19	-1.65	-0.34
	0.67	-0.94	-0.25
Noninterest Income	0.66	0.63	2.92
	1.23	1.12	8.89
Credit Card	0.32	0.42	
	2.11	2.85	
Other Consumer	-1.10	-1.09	
	-9.05	-9.25	
Foreign	-1.98	-0.84	0.38
	-0.65	-0.33	0.66
Int. Rate Contracts	0.44		
	2.38		
FE Contracts	-0.02		
	-0.02		

Continued on Next Page

Equity Contracts	0.06		
	0.05		
Equity Capital	0.30	0.16	0.21
	1.88	0.95	1.25
Debentures	-0.10	-0.31	0.50
	-0.15	-0.42	0.89
Maturity GAP	0.12	0.17	0.28
	3.47	5.05	9.35
Loans to Assets	-0.11	-0.05	-0.23
	-2.03	-0.98	-5.14
Trading Assets	1.15	0.81	
	2.71	2.25	
Trading Liabilities	-3.43	-1.97	
	-2.36	-2.70	
Risk Free Rate	0.10	0.09	0.07
	27.02	28.95	25.16
Book to Market	-0.11	-0.10	-0.06
	-8.24	-7.13	-5.47
Economy P/E	-0.01	-0.01	0.00
	-8.85	-8.60	-6.60
Volatility of Risk Free Rate	0.18	0.11	0.01
	6.85	5.50	0.29
Observations	2559	3236	4450
R-Squared	49.96%	46.49%	41.22%

Table VIII

Full Sample Test Results

Table VIII reports the results of the regression of the fitted errors from the panel regressions of beta on bank variables (not including size) taken from the Federal Reserve's Y9C database and various macroeconomic control variables on size. Sample A is all publicly traded bank observations from 1986 through 2003, Sample B is all publicly traded bank observations from 1994 through 2003 and Sample C is all publicly traded bank observations from 1996 to 2003. To be included in the sample each bank must have at least 3 years of monthly stock return data. The panel regressions are described in Table VII. Row 1 reports the estimated coefficients for the size and intercept variables and row 2 reports the corresponding t-statistic. Standard errors for the t-statistics are Rogers' robust standard errrors that allow for clustering by bank.

	Sample A			Sample B			Sample C		
	Intercept	Size	R-Squared	Intercept	Size	R-Squared	Intercept	Size	R-Squared
Estimate	-0.55	0.04	4.3%	-0.66	0.05	4.7%	-1.17	0.08	12.3%
T-Stat	-10.74	10.86		-12.64	13.03		-24.70	25.03	

Table IX

Nonfinancial Asset Betas

Table IX reports the mean and standard deviation of individual asset betas for each non-financial firm within the given size deciles. Size deciles are created by estimating breakpoints using only NYSE firms. Size is definied as the mean quarterly market capitalization of each firm from 1976 to 2002. Quarterly market asset values are estimated for each firm using the merton model (compustat provides the quarterly market cap, book debt and risk-free rate values and quarterly equity volatilities are estimated for each firm using the previous 3 years monthly stock return data). Each firm's time series of market value of assets is then used to estimate a quarterly return on assets series. Firm i's return on assets is then regressed on the CRSP value-weighted index minus the risk-free rate. The estimated coefficient on the market excess return is the firm's estimated asset beta.

	Size Decile									
	1	2	3	4	5	6	7	8	9	10
Number of Non-financial firms	9,401	4,200	3,594	3,471	3,290	3,354	3,621	3,922	4,109	4,577
Mean Asset Beta	1.13	1.09	1.08	1.03	0.99	0.94	0.85	0.85	0.80	0.83
Std. Dev. Asset Beta	0.95	0.92	0.97	0.90	0.87	0.79	0.59	0.68	0.68	0.76

Table X

Loan Delinquency Rates

Table X reports mean quarterly loan delinquency rates from 1985 to 2004 at large (100 largest) and small (all other) commercial banks. Delinquency rates are taken from the Federal Reserve's "Charge-Off and Delinquency Rates on Loans and Lease at Commercial Banks" quarterly release.

	Mean Delinquency Rates(%)			*Mean Delinquency Rates(%)*	
Loan Category	**Large Banks**	**Small Banks**	*Loan Category*	**Large Banks**	**Small Banks**
All Loans	3.93	3.22	Credit Card	4.61	4.66
All Real Estate	4.35	3.03	Other Consumer	3.33	2.45
Residential Real Estate	2.37	2.27	Leases	1.56	1.85
Commercial Real Estate	5.61	3.02	C&I	3.50	3.59
All Consumer	3.90	3.04	Agricultural	5.34	3.00

Table XI

Loan Charge-Off Rates

Table XI reports mean quarterly loan charge-off rates from 1985 to 2004 at large (100 largest) and small (all other) commercial banks. Loan charge-off rates are taken from the Federal Reserve's "Charge-Off and Delinquency Rates on Loans and Lease at Commercial Banks" quarterly release.

	Mean Charge-Off Rates(%)			*Mean Charge-Off Rates(%)*	
Loan Category	**Large Banks**	**Small Banks**	*Loan Category*	**Large Banks**	**Small Banks**
All Loans	1.01	0.73	Credit Card	4.23	4.79
All Real Estate	0.49	0.29	Other Consumer	1.12	0.77
Residential Real Estate	0.18	0.12	Leases	0.49	0.70
Commercial Real Estate	0.79	0.32	C&I	0.91	0.93
All Consumer	2.39	1.75	Agricultural	0.72	0.73

Table XII

Difference of Means Tests - Loan Charge-Off Rates

Table XII reports the results of difference of means tests for large and small bank quarterly loan charge-off rates. Charge-off rates are taken from the Federal Reserve's "Charge-Off and Delinquency Rates on Loans and Lease at Commercial Banks" quarterly release. The sample of loancharge-off rates is from 1985:1 through 2004:2.

	Total Loans / Leases			All Consumer	
	Large	*Small*		*Large*	*Small*
Mean	1.0147	0.7318	Mean	2.3850	1.7467
Variance	0.2046	0.0642	Variance	0.2881	0.2654
df	77		df	77	
t Stat	7.2374		t Stat	19.4143	

	All C&I			Commercial Real Estate	
	Large	*Small*		*Large*	*Small*
Mean	0.9133	0.9282	Mean	0.7898	0.3222
Variance	0.3145	0.2369	Variance	1.4764	0.1504
df	77		df	53	
t Stat	-0.3688		t Stat	4.0551	

Table XIII

Difference of Means Tests - Loan Delinquency Rates

Table XIII reports the results of difference of means tests for large and small bank quarterly loan delinquency rates. Delinquency rates are taken from the Federal Reserve's "Charge-Off and Delinquency Rates on Loans and Lease at Commercial Banks" quarterly release. The sample of loan delinquency rates is from 1985:1 through 2004:2.

	Total Loans / Leases			All Consumer	
	Large	*Small*		*Large*	*Small*
Mean	3.9278	3.2188	Mean	3.9044	3.0389
Variance	3.1029	1.1454	Variance	0.2108	0.1067
df	77		df	69	
t Stat	7.2608		t Stat	9.3637	

	All C&I			Commercial Real Estate	
	Large	*Small*		*Large*	*Small*
Mean	3.4999	3.5873	Mean	5.6106	3.0231
Variance	3.1738	1.5301	Variance	29.3651	4.0261
df	69		df	53	
t Stat	0.7825		t Stat	5.5236	

Table XIV

Mean Cross-Sectional Regression Results

Table XIV reports the results of a cross-sectional regression of mean beta on the mean of the explanatory variables. For all banks in the sample from 1994 to 2003 beta is estimated using the past 5 years of stock return data and the corresponding return on the CRSP value-weighted index. These annual betas are matched to the corresponding explanatory variables from the Federal Reserve's Y9C database. Finally the mean beta and the mean of each of the explanatory variables is calculated for each bank. The results of the cross-sectional regression of mean beta on the mean of the explanatory variables is reported below. For each explanatory variable the coefficient estimate is reported in the first row and the corresponding T-statistic is reported in the second row (standard errors for the t-statistics are Huber-White robust standard errrors).

Variable	Estimate	Variable	Estimate
Intercept	1.69	Credit Card	0.076
	7.29		1.21
Size	0.32	Other Consumer	-1.10
	1.02		-3.92
Commercial Real Estate	0.60	Foreign	-1.46
	2.34		-0.49
Real Estate	-0.76	Equity Capital	-2.40
	-3.24		-2.30
Farm Real Estate	-2.24	Maturity GAP	0.38
	-2.32		4.21
Nonresidential Real Estate	-0.85	Other noninterest income	1.10
	-6.12		0.32
Noninterest income	2.76	Total Charge-Offs	8.44
	3.05		4.09
Farm Production	-0.90		
	-1.19		
Commerical and Industrial	-0.92	R-Squared	34.64%
	-3.50	F-Value	28.54

Appendix A

Consider a simplified model of a bank. The bank's only assets are N different loans. Each loan has returns that are systematic and idiosyncratic. Let the beta of loan i be denoted β_i and denote the market value of each loan at time t as $V_{i,t}$. Then it follows that the beta of the bank's total loan portfolio will be

$$\beta_p = \frac{\sum_{i=1}^{N} V_{i,t}\beta_i}{\sum_{i=1}^{N} V_{i,t}} \qquad (5)$$

and if the total return of the bank's assets are generated by the following process

$$R_{A,t} = \beta_P R_{M,t} + \varepsilon_I \qquad (6)$$

then the bank's total (asset) risk is then

$$\sigma_A = \beta_P \sigma_M + \sigma_I \qquad (7)$$

Now assume that the idiosyncratic component of each loan held by the bank is independent (a strong assumption and one that will be dropped), then the idiosyncratic component (εI) of the bank's loan portfolio has mean zero and variance

$$\sigma_I^2 = \frac{\sum_{i=1}^{N} V_{i.t}\sigma_i^2}{\left(\sum_{i=1}^{N} V_{i,t}\right)^2} \text{ and when } V_{i,t} = V_t \text{ for all i } \sigma_I^2 = \frac{\sigma_i^2}{N} \qquad (8)$$

Thus one way a bank can lower idiosyncratic volatility (and thus total volatility) is to simply increase the number of loans it holds.

Now consider the case where each loan again has the same value and all loans have a correlation to each other of ρ. Now the idiosyncratic risk of the bank's assets is given by

$$\sigma_I^2 = \frac{\sigma_i^2}{N} + \frac{N-1}{N}\rho\sigma_i^2 \approx \frac{\sigma_i^2}{N} + \rho\sigma_i^2 \qquad (9)$$

Finally keep the same assumptions as above except that there are two types of loans, A and B. Type A loans have correlations with each other of ρ, type B loans also have correlations with each other of ρ, but a single type A loan and single type B loan have correlation of ρA,B. Then the bank's idiosyncratic asset return is given by

$$\sigma_{I,P}^2 = \frac{\sigma_i^2}{N} + \frac{(N_A(N_A-1) + N_B(N_B-1))}{N^2}\rho\sigma_i^2 + 2\frac{N_A N_B}{N^2}\rho_{A,B}\sigma_i^2 \qquad (10)$$

$$\approx \frac{\sigma_i^2}{N} + \frac{N_A^2 + N_B^2}{N^2} \rho \sigma_i^2 + 2 \frac{N_A N_B}{N^2} \rho_{A,B} \sigma_i^2 \qquad (11)$$

$$= \frac{\sigma_i^2}{N} + \rho \sigma_i^2 + 2 \frac{N_A N_B}{N^2} (\rho_{A,B} - \rho) \sigma_i^2 \le \frac{\sigma_i^2}{N} + \rho \sigma_i^2 \quad \text{if } \rho_{A,B} \le \rho \qquad (12)$$

Thus if a bank can choose to make loans in either group or both the total idiosyncratic risk of the bank will be less whenever a bank has a greater diversity of borrowers.

Appendix B

Galai and Masuli list a set of assumptions for which the CAPM and the option pricing model can be derived. What is of importance here is not the absolute truth of these assumptions or of the individual models but the relationship between the two which highlight the dynamics of equity and debt betas, leverage, and other facets of corporate structure.

Galai and Masulis begin with a CAPM world in which Equation 1 holds. In this world the price of European-type call option via Black and Scholes (1973) is

$$E = VN(d_1) - De^{-r_f T} N(d_2) \qquad (13)$$

where E is the value of a European call option, V is the current value of the corresponding underlying asset, σ2 is the variance of the percentage returns of V, D is the exercise price, T is the time to expiration, rf is the risk-free rate of return and N(x) is the standard normal cumulative density function. d1 and d2 are as usual:

$$d_1 = \frac{\ln(V / D) + (r_f + .5\sigma^2)T}{\sigma\sqrt{T}} \qquad (14)$$

$$d_2 = d_1 - \sigma\sqrt{T} \qquad (15)$$

Now, as in Black and Scholes (1973), the equity of a firm is viewed as a European call option on the firm's assets with strike price equal to the face value of the firm's debt. Galai and Masulis then use this partial equilibrium value of the equity to find the equilibrium value of the firm using the CAPM. Galai and Masulis state,

> "Given the current market value of the firm V, Black-Scholes tells us the equilibrium value of the equity; however, this does not require that V be the equilibrium value of the firm…"

So finally assuming a constant systematic risk of the firm's underlying assets (βv), it is found in equilibrium that

$$\beta_E = N(d_1) \frac{V}{E} \beta_V \qquad (16)$$

$$\beta_D = N(d_1)\frac{V}{D}\beta_V \qquad (17)$$

From these relationships one finds that $\partial\beta_D/\partial V<0$, $\partial\beta_D/\partial D>0$ and $\partial\beta_D/\partial r_f<0$, while $\partial\beta_D/\partial\sigma^2$, $\partial\beta_D/\partial T$ can be either less than, equal to or greater than 0 respectively Thus a bank's only unambiguous parameter in setting each loan's beta is the strike price, or collateral value of each loan.