DIVERSIFICATION, SIZE, AND RISK AT BANK HOLDING COMPANIES

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Abstract

This paper shows that large BHCs are better diversified than small BHCs based on market measures of diversification. We find, however, that better diversification does not translate into reductions in overall risk. The risk reducing potential of diversification at large BHCs is offset by their lower capital ratios, larger C&I loan portfolios, and greater use of derivatives. Our results suggest that asset growth should enhance diversification but that the effects on risk will depend on the extent to which growth is accompanied by changes in portfolio attributes. Using data from 1980 to 1993, we find that BHC asset growth has, in fact, been accompanied by economically important reductions in risk.

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I. Introduction

Bank diversification takes on a variety of forms, most of which are commonly associated with asset size. Compared to small institutions, large banks have access to a wider variety of borrowers and a broader deposit base. Their loan originations and funding sources are likely to span larger geographical markets. The commercial and industrial (C&I) loan portfolios of large banks will generally represent a greater mix of industries than those of small banks, both because large banks are likely to have expertise in a wider variety of borrower industries and because they are more active than small institutions in the secondary market for C&I loans. Furthermore, large banks will in general have more sophisticated risk management systems than small institutions. It seems noncontroversial then that large banks have better diversification opportunities than small banks. But diversification is not the only determinant of risk, and certain activities and characteristics typically associated with large banking institutions may be inherently risky.

This paper focuses on the empirical relationships between bank size, diversification, and risk. We begin by constructing a conceptually sound measure of overall bank holding company (BHC) diversification and establishing a strong positive correlation between that measure and asset size. We measure diversification using the R^2 statistic from an equity return-generating regression, or "market model." This application is not novel to the finance literature but has been overlooked in the banking literature. In our opinion, it is superior to diversification measures derived from the balance sheet because the balance sheet lacks information on key aspects of diversification such as industrial or regional loan concentrations. Moreover, a measure based on equity returns reflects all types of diversification within the holding company, including diversification associated with each of the bank and nonbank subsidiaries and diversification across those subsidiaries.

Using total stock return variability to measure risk, we illustrate that the positive correlation between size and diversification does *not* translate into a negative correlation between size and risk. We explore this result further by decomposing total risk into its two components: systematic risk and firm-specific risk. Our analysis indicates that asset size is negatively related to firm-specific risk but positively related to systematic risk. This result is puzzling since a fundamental implication of portfolio theory is that only non-systematic risks are affected by the scale of a portfolio. If a large BHC can be characterized simply as a collection of smaller BHCs, portfolio theory predicts that larger BHCs will have less firm-specific risk than smaller BHCs but similar systematic risk. Our findings confirm that BHC size and firm-specific risk are negatively related but contradict the prediction that BHC size and systematic risk are unrelated. These results highlight the importance of differences in the activities of larger and smaller BHCs.

The final section of this paper explores the relationship between size, systematic risk, and firm-specific risk *controlling* for activities and characteristics related to BHC size. We find that certain characteristics and activities, particularly capitalization and C&I lending, can help explain the unconditional positive correlation between BHC size and systematic risk. In contrast, the negative relationship between BHC size and firm-specific risk becomes stronger when we control for activities and characteristics related to BHC size.

Our analysis has several interesting policy implications. The first relates to the safety and soundness of the banking system. While BHC size is positively related to diversification, that relationship comes about because larger institutions have lower firm-specific risk *and* because larger institutions have greater systematic risk. From the standpoint of the safety and soundness of the banking system, this is somewhat disconcerting. Reductions in firm-specific risk are certainly advantageous, but their advantages are primarily realized by individual institutions. The safety and soundness of the banking system depends more on levels of systematic risk, which we find to be positively correlated with BHC size. Our results also have implications for merger policy. The negative relationship between BHC size and firm-specific risk lends empirical support to the notion that growth enhances diversification. The associated risk reduction will depend on the extent to which that growth is accompanied by changes in an institution's activities and portfolio characteristics. We find that over the past decade, BHC asset growth has been accompanied by economically important reductions in risk.

The next section motivates the use of the market model R^2 as a measure of BHC diversification and presents R^2 statistics for a sample of BHCs using three alternative return-generating models. In section III, we explore the unconditional relationships between BHC size, diversification, and risk. Section IV presents a multiple regression analysis relating risk and diversification to BHC size, controlling for activities related to size. We also estimate a fixed effects model that addresses changes in BHC size over time. Section V concludes.

II. Measuring Diversification

Barnea and Logue (1973) first used the market model R^2 to measure the industrial diversification of conglomerate corporations.[1] They adopted the market model R^2 statistic as a measure of industrial diversification because it reflects the degree to which a given conglomerate "mirrors the diversity of the economy and the relative importance attaching to each segment of the firm's activities within the context of the whole economy." We argue that the concept of R^2 as a measure of diversification has broader applicability. In particular, it provides a convenient summary measure of overall diversification for BHCs that does not suffer from the deficiencies of measures derived from the balance sheet, which lack information on key aspects of diversification such as industrial or regional loan concentrations.[2]

The market model for a BHC is an ordinary least squares (OLS) regression relating the BHC's stock return to the return on a stock market index:

$$R_{bt} = \hat{\alpha} + \hat{\beta} R_{mt} + \hat{e}_t \tag{1}$$

In equation (1), the market index serves as a proxy for systematic factors common to the returns on most stocks. Since the residual vector is uncorrelated with the vector of market returns, the following

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[1] Barnea and Logue's approach has been adopted in several subsequent works calling for measures of conglomerate diversification. See, for example, Amihud and Lev (1981) and Amihud, Kamin, and Ronen (1983).

[2] Roll (1988) explores the relationship between R^2 and size for firms in a wide range of industries.

variance decomposition holds:

$$\sigma^2(R_b) = \hat{\beta}^2\sigma^2(R_m) + \sigma^2(\hat{\epsilon}) \tag{2}$$

The left-hand side of equation (2) represents the return variability, or "total risk," associated with the given BHC's equity. Equation (2) decomposes that return variability into two parts: $\hat{\beta}^2\sigma^2(R_m)$ represents the estimated return variability stemming from systematic factors; $\sigma^2(\hat{\epsilon})$ represents the estimated return variability specific to the given BHC. Following conventional terminology we will refer to the two risk components as "systematic risk" and "firm-specific risk," respectively. We use the R^2 statistic (the ratio of systematic risk to total risk) as a measure of overall BHC diversification.

Alternative Return-Generating Models

The one-factor model depicted in (1) uses a stock market index as a proxy for systematic factors common to most stock returns. With BHCs, we may consider some additional systematic factors not adequately captured by the stock market index. For instance, variables related to interest rate risk and credit risk may provide additional explanatory power over that provided by stock market returns.

We estimate a second return-generating model by adding three regressors. *Yield* is the change in the three-month Treasury Bill rate, where that rate is defined as the bond equivalent yield. Positive values of *yield* represent increases in short term rates.[3] *Term* is the change in the spread between 30-year and three-month Treasury rates with positive values representing a steepening of the yield curve.[4] *Credit quality spread* is the change in the spread between rates on Moody's Baa-rated corporate bonds and 30-year Treasury Bonds. Positive values represent an increase in the premium charged for credit risk.[5] Our multi-factor model is thus defined as:

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[3] Specifically, $Yield_t$ = three-month $rate_t$ - three-month $rate_{t-1}$.

[4] Specifically, $Term_t$=(30-year rate - three-month rate)$_t$ - (30-year rate - three-month rate)$_{t-1}$.

[5] Specifically, *credit quality spread*$_t$ = (Baa rate-30-year rate)$_t$ - (Baa rate-30-year rate)$_{t-1}$.

$$R_{bt} = \hat{\alpha} + \hat{\beta}_1 R_{mt} + \hat{\beta}_2 Yield_t + \hat{\beta}_3 Term_t + \hat{\beta}_4 Credit\ Quality\ Spread_t + \hat{\epsilon}_t \tag{3}$$

While the multi-factor market model is certainly richer than the simple market model, it may still exclude some relevant systematic factors. To address this concern, we also estimate a third return-generating model. This model differs in concept from those expressed in (1) and (3). Rather than estimating a regression based on a set of economically interpretable independent variables, we apply factor analysis to our sample of BHC stock returns and endogenously derive a set of five vectors whose linear combination best explains the returns of our sample of stocks. Though these five vectors are not interpretable economically, they can be considered systematic factors common to the returns of the BHCs in our sample.[6] The factor analysis approach has the advantage that systematic risk is not constrained to be a function of observable economic variables. Consequently, this third approach provides a check on the robustness of results derived from return-generating models that may have omitted variables.

The R^2 derived from factor analysis (the fraction of return variability explained by the five endogenously derived factors) has a somewhat different interpretation from those derived using the market model or multi-factor model. This R^2 measures the extent to which a particular BHC's stock tracks those systematic elements common to the BHC stocks in our sample, as opposed to economy-wide systematic factors. One advantage of this approach is that risks systematic to banks, including regulatory risks such as changes in capital requirements or deposit insurance premia, will now contribute to the *systematic* component of risk, whereas in the earlier models such risks would likely be absorbed by the *firm-specific* component. On the other hand, if most BHCs in our sample have a common risk, such as large exposure to problems in the commercial real estate sector, a BHC with that exposure may appear to be *more* diversified than one lacking that exposure.

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[6] We have also estimated a six-factor decomposition of BHC stock returns and found nearly identical results to those generated using the five-factor model.

We estimate each of the three return-generating models using data from the Center for Research in Securities Prices (CRSP). We identified over 150 publicly traded BHCs by referring to the 1985 Bank Compustat database. Our analysis is based on those BHCs that traded for at least 30 weeks in a given calendar year between 1980-1993 and for which we could retrieve both CRSP return data and data from Y-9C reports describing BHC characteristics.[7] As Column (1) of Table 1 indicates, our sample size ranges from 80 in 1993 to 133 in 1986. This variability arises because several of the BHCs in our sample did not have traded equity in every year between 1980 and 1993. In the case of mergers, we dropped acquired companies from the sample after the date of acquisition. Acquirers remain in the sample.

We constructed weekly (Friday-to-Friday) BHC stock returns using daily CRSP return data.[8] Columns (2) and (3) of Table 1 provide return summary statistics by year. The lowest mean weekly-return of -0.85 percent occurred in 1990, amidst growing concern regarding bank asset quality. The mean weekly-return for 1987, the year of the stock market "crash," is also low, at -0.36 percent. The highest mean weekly-return of 0.89 percent occurred in 1991, as the economy pulled out of its recent recession. Return standard deviations tend to rise over most of the sample period, illustrating an increasing trend in overall bank risk.[9]

Table 1 also presents the median R^2 for each yearly sample, based on the market model, multi-

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[7] Compustat and CRSP both use "cusip" numbers as company identifiers. However, the only identifier common to Compustat and the Y-9C is the company's name. Our sample includes only those BHCs for which the match between the name provided by Compustat and that appearing on the Y-9C was unambiguous.

[8] Daily returns are adjusted by CRSP to account for dividend payouts and stock splits. In cases where Friday was a holiday and no stocks were traded, we used the Thursday-to-Friday or Friday-to-Thursday returns instead. In cases where the return was not available for a given stock on a given Friday, that stock's weekly return was coded as missing.

[9] Neuberger (1993) reports a similar pattern for his sample of 84 large BHCs.

factor model, and factor analysis approaches (Columns (4), (5), and (6), respectively).[10] We estimate these models by year to account for the possibility that the estimated parameters change over time.[11] In the multi-factor model, *yield*, *term*, and *credit quality spread* are each measured on a Friday-to-Friday basis, to maintain consistency with our weekly return variables. In both the market model and multi-factor model, R_{mt} is measured using the weekly return on an *equally*-weighted portfolio of stocks trading on the NYSE or AMEX. Since we are particularly interested in the relationship between the market model R^2 and asset size we use an equally-weighted index rather than a value-weighted index.[12]

Column (4) reports the median market model R^2s, which range from 2.5 percent in 1993 to 36.2 percent in 1987. A relatively high median R^2 is observed in 1987 because the "crash" of October 1987 resulted in a large degree of explained variance (systematic risk) for most stocks. Adding the interest rate and credit risk variables to the return-generating model increases the median R^2s for each year by about 5 to 10 percentage points (column (5)). The median R^2 for 1987 continues to exceed those for other years.[13]

We attribute the low R^2s from both the market and multi-factor models in 1992 and 1993 to recent changes in the regulatory environment, including full implementation of risk-based capital standards and increases in deposit insurance premia. These events represent risks particular to banks; i.e., risks that will not be captured by the systematic factor(s) underlying the market model and multi-factor model. Note that the R^2 derived using factor analysis (column (6)) remains high in 1992-1993, since it reflects systematic factors common to the BHCs in our sample. In general, the factor analysis

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[10] We do not report estimates for the multi-factor model in 1980-1982 because the data used to construct the credit quality spread variable were unavailable for those years.

[11] Using a switching regression model, Kane and Unal (1988) find that the parameters of return-generating models for depository institutions changed significantly in 1979 and 1982.

[12] A market model estimated using a value-weighted index will *induce* some degree of correlation between R^2 and asset size.

[13] Coefficient estimates from the multi-factor return-generating model are available from the authors.

approach results in higher R^2s and greater stability of R^2s over time.

III. Diversification, Size, and Risk

Use of the market model R^2 as a diversification index facilitates a straightforward investigation of the relationship between BHC size and diversification. Table 2 reports the correlation between asset size and the R^2s estimated using each of the return-generating models described above. Asset size is measured as of the beginning of each year in order to avoid a potential simultaneity problem.[14] Since we look only at publicly traded BHCs, our sample asset size distribution is not representative of all BHCs. It does provide ample size variation, however. In 1993, the asset sizes of the BHCs in our sample ranged from $340 million to $214 billion, with a median of $10 billion. Taken as a group, these BHCs held close to half of all banking assets in the U.S.

In Table 2, columns (1), (3), and (5) report the Pearson correlation coefficient between the log of total assets and each of the three R^2 statistics for each year. Columns (2), (4), and (6) report the Spearman correlation coefficient. Both correlation coefficients are positive and highly significant for almost every year in our sample period regardless of which return-generating model was used to derive R^2. We conclude that the positive relationship between BHC size and diversification is both strong and robust.[15]

Some interesting differences emerge when comparing the correlation coefficients based on the market model R^2 with those based on the factor analysis R^2. When either of the two market models are used, correlation coefficients for 1988 and 1992 are somewhat lower than those calculated for other

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[14] For instance, abnormally strong performance by a set of BHC stocks may lead to a spurious negative correlation between asset size and the market model R^2 if that strong performance promotes asset growth.

[15] Roll (1988) compares firm size to the R^2s from a market model and a five-factor analysis, using the stocks of all companies traded on the New York and American Stock Exchanges from September, 1982 through August, 1987. He finds a positive relationship between firm size and the market model R^2 but finds "a much less perceptible positive relation" when comparing firm size with the R^2 from the five-factor analysis.

years and coefficients for 1993 are not significantly different from zero. When we use factor analysis to estimate a return-generating model, however, 1988, 1992, and 1993 correlation coefficients rise to levels comparable to those of the other years in the sample period. We attribute differences in results derived from the alternative return-generating models to events that had systematic effects on BHC stock returns but are not reflected in our multi-factor model. Possibilities for 1988 include the S&L crisis, the full impact of which may not have been felt until that year; BHC-specific events from 1992 and 1993 include changes in the regulatory environment for banks, such as the implementation of risk-based capital requirements and risk-based deposit insurance, and rising deposit insurance premia.

These findings leave unanswered an important question: Does the enhanced diversification of large BHCs result in lower overall risk? Columns (7) and (8) of Table 2 present the Pearson and Spearman correlation coefficients between asset size and total stock return variability (i.e. return variance) over the 1980-1993 period. In each year between 1980 and 1991, these two correlation coefficients were either positive or not statistically significant, suggesting that large BHCs did *not* exhibit lower total risk than small BHCs. Between 1980 and 1984 we estimate positive and significant correlation coefficients between size and total risk.[16] Between 1985 and 1991 there is no relationship between size and risk. Only in 1992 and 1993 do we estimate a negative relationship. Overall, there is little evidence that asset size is associated with lower BHC risk.[17]

Table 3 presents the correlation coefficients between asset size and the two components of total risk. As shown in Panel A, there is a negative relationship between firm-specific risk and BHC size,

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[16] Along similar lines, Samolyk (1994) finds that very large banks (asset greater than $10 billion) had return on assets exhibiting greater variability than other banks between 1984 and 1992. These institutions also had substantially higher levels of non-performing assets over this period.

[17] Demsetz and Strahan (1995) consider the impact of recent regulatory reforms on changes in the size/risk relationship since 1991.

particularly after 1984.[18] Panel B shows, however, that large BHCs consistently hold more systematic risk than small BHCs in every year throughout the sample, with the exception of 1992 and 1993. This relationship holds for the Spearman correlation across all three return-generating models. The Pearson correlation displays a similar pattern, although these results are less robust. Between 1984 and 1991, then, large BHCs exhibited smaller firm-specific risk but greater systematic risk than small BHCs. These offsetting relationships are consistent with the positive relationship between size and diversification and the generally insignificant difference between the total risk of smaller and larger institutions.

The results of Table 3 have two interesting implications. First, they suggest that from the standpoint of the safety and soundness of the banking system, large size may not be as desirable a characteristic as we may have believed. While larger BHCs appear more diversified than smaller BHCs, they also appear to have higher levels of systematic risk. This sensitivity to systematic shocks induces correlation among the returns of large BHCs. Consequently, adverse events could lead simultaneously to poor performance on the part of many large BHCs.

Our results also suggest that a large BHC should *not* be characterized simply as a collection of smaller BHCs. If large banking institutions were nothing more than scaled-up versions of smaller institutions, then portfolio theory would imply that large institutions hold less firm-specific risk than smaller institutions, but similar levels of systematic risk. Our findings confirm the predicted negative relationship between BHC size and firm-specific risk but run counter to the prediction that there is no relationship between BHC size and systematic risk, suggesting that there are important differences between the characteristics and activities of large and small BHCs.[19] It may be that the heightened

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[18] This result is consistent over time, though most of the yearly correlation coefficients are not statistically significant.

[19] Boyd and Gertler (1993) provide some examples, including differences in the C&I lending, core deposits, and capital-to-assets ratios of banks of different sizes. They discuss the role of these characteristics in explaining differences in two accounting measures of bank performance: net loan charge-offs and net income to assets.

systematic risk associated with larger BHCs is a natural and necessary byproduct of certain large-BHC activities valuable to the financial system. We explore this hypothesis in the next section.

IV. Bank Activities, Diversification, and Risk

This section explores differences in the characteristics and activities of large and small BHCs in order to explain the unconditional correlations between BHC size and the components of risk. Our framework of analysis is a multiple regression in which systematic or firm-specific risk is a function of BHC size and a series of variables describing BHC characteristics and activities. In particular, we estimate the following regressions:

$$Ln(systematic\ risk)_{t,i} = \alpha_t^s + \beta_1^s Ln(Assets)_{t-1,i} + \beta_2^s Ln((E/A)^2)_{t-1,i} + \gamma^{s\prime} Z_{t-1,i} + e_{t,i}^s \qquad (4)$$

$$Ln(firm\text{-}specific\ risk)_{t,i} = \alpha_t^f + \beta_1^f Ln(Assets)_{t-1,i} + \beta_2^f Ln((E/A)^2)_{t-1,i} + \gamma^{f\prime} Z_{t-1,i} + e_{t,i}^f \qquad (5)$$

where E/A equals the BHC's equity capital-asset ratio; γ^s and γ^f are $\boldsymbol{kx1}$ vectors of parameters; and $Z_{t-1,i}$ is a vector of BHC characteristics and activities, dated as of the beginning of the period over which the diversification index is measured.[20] This timing convention ensures that the direction of causality flows from the set of variables in $\boldsymbol{Z}$ to the dependent variables. We estimate each equation using pooled time series/cross-section data from 1987 to 1993 and include a set of time fixed-effects to control for changes in risk common to all BHC stocks in our sample.[21]

The purpose of these regressions is to determine how BHC size is related to the components of risk, controlling for the characteristics and activities included in $\boldsymbol{Z}$. We are particularly interested in whether the coefficient on size remains positive and significant in the systematic risk regression, equation

[20] The derivation of the specification relating the log of risk to the log of total assets and the log of $(E/A)^2$ is available from the authors.

[21] We begin this analysis in 1987 because the data reported to regulators, particularly for off-balance sheet activities, increased significantly after 1986. Also, we include only the pooled regressions since preliminary analysis of the individual cross-sectional regressions corresponding to these equations suggest little evidence that the parameters changed over the sample period.

(4). That is, we are interested in the extent to which the elements of *Z* help explain the unconditional positive correlation between size and systematic risk illustrated above. If we consider a BHC to be a portfolio of assets, liabilities, and off-balance sheet instruments, then increases in scale should lead to reductions in firm-specific risk but not systematic risk. Thus, to the extent that *Z* captures all relevant attributes, portfolio theory predicts that $\beta^s = 0$. Also, by controlling for BHC characteristics and activities, we can estimate the partial effect of size on firm-specific risk, β^f. To the extent that the smallest BHCs in our sample have not exhausted the bulk of the risk reducing potential of diversification, portfolio theory predicts that $\beta^f < 0$.

BHC Characteristics and Activities

The *Z* vector in equations (4) and (5) includes variables describing each BHC's assets, liabilities, subsidiary diversification and off-balance sheet positions, to the extent that meaningful measures of these characteristics are available from the Y-9C report. This sub-section describes each variable. The last sub-sections describe and interpret our empirical findings.

Asset Composition. We measure asset composition by including the ratio of commercial and industrial (C&I) loans to assets, real estate loans to assets, consumer loans to assets, agricultural loans to assets and trading-account assets to total assets. We also include an index of loan concentration to control for the dispersion in lending across the following categories: real estate loans, C&I loans, consumer loans, agricultural loans and other loans. Our index is modelled after the Herfindahl-Hirschman index (HHI), commonly used in analyses of market concentration for antitrust purposes. As applied to the case at hand, the HHI equals the sum of the squared share of each loan category relative to total loans. Increases in this index represent increases in specialization in a given loan category.

Liability Composition. We include the ratio of total deposits to total assets as a measure of the contribution of the banking subsidiaries to the total business of the BHC. Also, as a crude description of the attributes of the funding of the bank portion of the holding company, we include the ratio of non-interest bearing deposits to total deposits. The non-interest bearing deposits variable includes demand deposits, non-interest bearing passbook savings accounts, and non-interest bearing time deposit accounts. We also include the ratio of deposits from foreign sources to total deposits as a measure of geographical diversification outside the U.S.[22]

Subsidiary Diversification. Beginning in 1987 the Federal Reserve Board began allowing BHCs to hold subsidiaries engaged in limited underwriting under Section 20 of the Glass-Steagall Act of 1933. These "Section 20 subsidiaries" are granted permission to underwrite corporate and government securities such as commercial paper, corporate debt and equity, and municipal bonds. Proponents of universal banking have argued that diversification associated with combining commercial and investment banking functions in a single financial services holding company could contribute to stability of the financial system. To test the hypothesis that investment banking activities significantly enhance BHC diversification and reduce risk, we include an indicator variable equal to one for BHCs with Section 20 subsidiaries. Since Section 20 subsidiary powers were significantly increased between 1987 and 1990, we include this variable only in a separate estimation of equations (4) and (5) based on data from 1991 to 1993.

We also differentiate between BHCs operating broadly throughout the nation from those operating only within one region by including an indicator variable equal to one for BHCs with commercial bank subsidiaries located in more than one census region. While the secondary loan market permits BHCs to hold loans originated in many regions, BHCs operating more widely throughout the country may have increased protection against regional downturns.[23]

Off-Balance Sheet Activities. Two variables are included to measure each BHC's use of derivative instruments: (1) the ratio of the notional principal on interest rate swaps to total assets; and (2)

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[22] Recent research shows that geographical diversification can be more effective than industrial diversification in reducing risk. See Heston and Rouwenhorst (1994).

[23] Levonian (1994) shows that bank accounting profits across states exhibit low correlations, suggesting that banks operating in many states may be able to reduce risk through diversification.

the ratio of the notional principal on foreign exchange futures to total assets. We use the notional principal amounts of these derivatives to reflect the scale of derivatives activities, while acknowledging that they do not represent either the marked-to-market value or the risks associated with the contracts. No better measures of derivatives activities were available throughout the sample period.[24]

We also include the ratio of non-interest income to net interest income as a measure of each BHC's reliance on off-balance sheet activities. Boyd and Gertler (1994) show that the ratio of non-interest income to net interest income may be interpreted as the ratio of the present value of the BHC's off-balance sheet contracts to the present value of its on-balance sheet assets. This interpretation holds under two assumptions: (1) the average returns to off- and on-balance sheet assets are equal; and, (2) non-interest expenses are allocated to off- and on-balance sheet assets in proportion to their value.

Capital. The **Z** vector controls for differences in the characteristics and activities of BHCs which influence risk through their effects on variabilities of asset, liability and off-balance sheet returns. We also include the log of the square of the equity capital-asset ratio (based on book values) to control for the effects of leverage on the levels of both systematic and firm-specific risk.[25] Since a given fluctuation in asset value translates into larger variation in the value of equity at more highly leveraged firms, we expect to find a negative relationship between the equity capital-asset ratio and both firm-specific and systematic risk.

Trading Frequency. Since the variables in **Z** may not fully account for the underlying variances of the BHC's assets, liabilities, and off-balance sheet positions, we also include a measure of the frequency with which each BHC's stock is traded. Trading frequency proxies for the rate of arrival of new information about the economic value of a BHC's stock, which is presumably correlated with the

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[24] Since collection of data on foreign exchange swaps began only in the third quarter of 1990, we do not include a measure of foreign exchange swap activity in the regression analysis.

[25] A simple model of bank diversification that motivates the use of this particular functional form is available from the authors.

underlying variances of the BHC's assets, liabilities and off-balance sheet positions. We measure trading frequency using the variable *turnover,* defined as total trading volume divided by the average shares outstanding over the year in which stock return variability is measured. Data on both volume and shares outstanding are from CRSP.

Empirical Results

Table 4 contains simple summary statistics for all of the independent variables included in equations (4) and (5). Since we are interested in explaining the correlation of size and risk based on differences in portfolio attributes of large and small BHCs, Table 4 also presents the Pearson correlation of the log of asset size with each of the other variables included in equations (4) and (5). As shown, large BHCs engage more heavily in C&I lending, hold more assets in the trading account, hold more foreign deposits, and hold more derivative instruments than small BHCs. More large BHCs operate across multiple census regions than small BHCs. Small BHCs are more likely to be dominated by their banking subsidiaries than large BHCs, as measured by the ratio of deposits to total liabilities. Table 4 also shows that large BHCs tend to have smaller capital ratios than small BHCs.[26]

Table 5 presents the results from estimating equations (4) and (5). Columns (1) and (2) present the estimated coefficients and t-statistics when the dependent variable is systematic risk; columns (3) and (4) present the estimated coefficients and t-statistics when the dependent variable is firm-specific risk. Columns (1) and (3) include the regression results with only the size variable (along with time fixed effects), while columns (2) and (4) contain the results including size along with the control variables. We present the results using the factor analysis model to divide risk into systematic and firm-specific components; similar results were obtained using the multi-factor return-generating model.

The results in Table 5 show quite clearly that size affects risk according to the predictions of portfolio theory, once the attributes of the BHCs' portfolios have been held constant. The coefficient on

[26] Boyd and Runkle (1993) also find that large banks have smaller capital ratios than small banks.

size in the firm-specific risk regressions is negative and statistically significant at the one percent level in both specifications including the control variables. By contrast, the positive, unconditional relationship between size and systematic risk becomes insignificant when the BHC characteristics and activities are included in the regression.[27]

Comparing the results of columns (1) and (3) with those of columns (2) and (4), it is evident that controlling for a BHC's activities leads to an increase in the magnitude of the negative size coefficient in the firm-specific risk regression and a decrease in the magnitude of the positive size coefficient in the systematic risk regression. The size coefficient falls from 0.17 to 0.07 in the systematic risk regression and falls from -0.14 to -0.25 in the firm-specific risk regression. The coefficient on size is biased upward when the control variables are omitted because, on average, the activities and characteristics of large BHCs increase both firm-specific and systematic risk, offsetting the potential for risk reduction associated with increased diversification.

These results explain the observed unconditional correlations between size and the components of risk. As noted above, portfolio theory suggests that increases in scale will reduce non-systematic risk, holding constant portfolio attributes. Consistent with this theory, we find that large BHCs hold less firm-specific risk than small BHCs, controlling for assets, liabilities and off-balance sheet activities available from the Y-9C Report. In fact, the results indicate that large BHCs achieve economically important reductions in risk through diversification. For instance, doubling the size of a BHC while holding its portfolio attributes fixed would lead to a reduction in firm-specific risk of about 25 percent. Portfolio theory also implies that increases in scale should have no direct impact on systematic risk, again holding constant portfolio attributes. Consistent with this prediction, we find no correlation between size and systematic risk when we control for the attributes of the BHC's portfolio.

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[27] Rosenberg and Perry (1981) reach similar conclusions using data from 1969 to 1977. They find that asset size is a good predictor of the market beta but that the relationship between size and systematic risk can be explained by other variables in their model.

Comparing Table 4 (the correlation of the regressors with log size) with Table 5 (the regression results), it becomes clear why large BHCs exhibit more systematic risk than small BHCs. First, the stock returns of large BHCs exhibit greater trading frequency, as measured by the variable *turnover*, which is positively correlated with measured stock price variance, both systematic and firm-specific. Perhaps more interesting, large BHCs engage in more C&I lending, are more active in derivatives and hold less capital than small BHCs. Table 5 shows that C&I lending, derivatives holdings (as measured by FX futures) and low capital ratios all are positively associated with systematic risk. The unconditional positive correlation between BHC size and systematic risk results from these large-BHC activities. Table 5 also shows that C&I lending and low capital ratios are positively related to firm-specific risk.[28] As a consequence, the effect of size on firm-specific risk is understated when these variables are omitted from the regression.

It is worth noting, however, that not all of the attributes of large BHCs are positively related to risk. For example, large BHCs are more likely to operate in more than one census region. In 1987, for example, 72 percent of BHCs in the top quartile of the size distribution operated across census regions while only 12 percent of BHCs in the smallest quartile operated across census regions.

Table 6 presents the regression results using data from 1991-1993 and including the Section 20 subsidiary indicator. These results provide no support for the idea that universal banking will lead to reductions in risk through diversification. In fact, we estimate that both systematic risk and firm-specific risk are about 25 percent higher at BHCs holding Section 20 subsidiaries. The coefficients are statistically significant at the 10 percent level in both models. It is important to emphasize, however, that these results may not apply to universal bank holding companies which could emerge following major Glass-Steagall reform. Currently, a BHC must receive explicit approval from the Federal Reserve

[28] Samolyk (1994) finds that banks with a higher proportion of C&I loans relative to total assets have higher levels of nonperforming assets and net charge-offs, providing further evidence from accounting information that this category of loans is high risk relative to other kinds of bank lending.

Board to set up a Section 20 subsidiary and can generate no more than 10 percent of its gross revenues from that subsidiary. Whether similar results would hold in a different regulatory environment remains an open question. However, these results do raise questions about the validity of the argument that universal banks could reap significant risk reduction from diversification.

The other results in Table 6, which are based on the 1991-1993 period, are quite consistent with the results estimated over the whole 1987-1993 sample period. In particular, we continue to find a positive and significant relationship between size and systematic risk when portfolio characteristics are omitted but no relationship between size and systematic risk when portfolio attributes are included in the regression. The negative relationship between size and firm-specific risk also becomes stronger (more negative) when these portfolio controls are included in the model.

BHC Growth and Risk

Because of data limitations, the regressions reported in Table 5 are based only on the last seven years of our sample period. In this section, we estimate an alternative specification capable of accommodating data from 1983 to 1993 (when the multi-factor model is used to decompose risk) or from 1980 to 1993 (when factor analysis is used to decompose risk). In particular, we pool data across time and regress the log of systematic or firm-specific risk on log of total assets, a set of time fixed effects and a set of firm fixed effects. Because the $\boldsymbol{Z}$ vector, the equity capital-assets ratio, and the *turnover* variable are not included in this specification, the size coefficients quantify the *total* derivative of each risk component with respect to BHC size. Since the model includes firm fixed effects, however, the estimate of this total derivative is driven solely by within-firm variation over time; the asset size coefficient reflects both the direct effect of asset growth (either by expansion or acquisition) and the indirect effect of portfolio changes associated with asset growth.

We expect the size coefficient to be negative when the dependent variable measures firm-specific risk, since both the unconditional and conditional relationships between asset size and firm-specific risk were negative and significant. Our prior on the size coefficient in the systematic risk regression is less clear. To the extent that non-size characteristics and activities are stable over time, we would expect to observe an insignificant size coefficient. However, if changes in asset size over the sample period are accompanied by changes in non-size characteristics and activities, we may observe either a positive or negative size coefficient.

Results based on a risk decomposition derived using the multi-factor model are presented in the top half of Table 7. Those based on a risk decomposition derived using factor analysis are presented in the bottom half of Table 7. In both cases, the size coefficient is negative and significant when the dependent variable measures firm-specific risk, as expected. When the dependent variable measures systematic risk, we observe mixed results. Asset growth is associated with significant declines in systematic risk when the risk decomposition is based on the multi-factor model and insignificant changes in systematic risk when the risk decomposition is based on factor analysis. Taken as a whole, the results in Table 7 confirm that asset growth, either through acquisition or simple expansion, led to risk reduction for the BHCs in our sample. Coupled with our earlier results, this suggests that asset growth of BHCs in our sample was *not* accompanied by significant risk-enhancing changes in portfolio composition.

V. Conclusions

This paper provides strong evidence of a link between size and diversification at large, publicly-traded bank holding companies. The correlation between the R^2 from three return-generating models and the log of total assets is consistently positive and significant from 1980 to 1993. This result is important but not surprising, since it is generally accepted that large banks have better opportunities to diversify. We show, however, that the positive relationship between BHC size and diversification does *not* result in a negative relationship between BHC size and total risk during most of the sample period. This second result has important implications for the policymaker, who must fully understand the risks that particular institutions introduce into the banking system. Our results suggest that larger BHCs exhibit less firm-specific risk than smaller BHCs but greater systematic risk. These relationships are approximately offsetting, so that larger BHCs and smaller BHCs exhibit similar total risk.

The positive relationship between BHC size and systematic risk may be troublesome from the standpoint of the safety and soundness of the banking system as a whole. Systematic risk is particularly undesirable since it increases the likelihood that many BHCs will simultaneously face difficulties in a given economic environment. Our results suggest that the positive correlation between BHC size and systematic risk is in large part due to the differences in the characteristics and activities of large and small BHCs. Specifically, large BHCs hold more C&I loans, hold more derivative instruments, and operate with lower capital ratios than small BHCs. Each of these characteristics and activities tends to be associated with increases in systematic risk. Despite their riskier portfolios, however, large BHCs do not exhibit greater overall risk than small BHCs because of the effects of diversification. In fact, our results show that increases in size may lead to large reductions in firm-specific risk, provided these increases in size are not accompanied by risk-enhancing changes in portfolio composition.

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Table 1

Summary Statistics for BHC Returns and Return-Generating Model R^2 Statistics

		Weekly Returns		Median R^2		
	N	Mean[a]	Standard Deviation[b]	Market Model	Multi-Factor Model	Factor Analysis
	(1)	(2)	(3)	(4)	(5)	(6)
1980	118	0.35%	3.49%	21.1%		48.4%
1981	118	0.41%	3.14%	12.3%		36.1%
1982	119	0.29%	3.75%	21.2%		41.0%
1983	129	0.62%	3.31%	8.3%	14.5%	33.3%
1984	131	0.25%	2.96%	11.9%	17.9%	37.0%
1985	132	0.70%	3.28%	10.3%	16.0%	35.3%
1986	133	0.11%	4.10%	21.0%	26.2%	44.9%
1987	129	-0.36%	4.90%	36.2%	44.5%	55.6%
1988	119	0.17%	3.92%	10.4%	18.2%	35.7%
1989	111	0.28%	3.71%	11.2%	16.5%	33.7%
1990	105	-0.85%	5.54%	21.2%	25.7%	48.2%
1991	98	0.89%	5.51%	22.1%	27.9%	44.2%
1992	89	0.74%	4.12%	6.8%	12.7%	41.0%
1993	80	0.06%	3.60%	2.5%	10.6%	46.6%

[a] Annual means, averaged over the BHCs in our sample.

[b] Annual standard deviations, averaged over the BHCs in our sample.

Table 2

Pearson and Spearman Correlation of BHC Size with R^2 and with Overall Stock Return Variance[c]

	Market Model R^2		Multi-Factor Model R^2		Factor Analysis R^2		Overall Stock Return Variance	
	Pearson	Spearman	Pearson	Spearman	Pearson	Spearman	Pearson	Spearman
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1980	0.13	0.24*			0.44**	0.48**	0.20*	0.33**
1981	0.39**	0.46**			0.61**	0.59**	0.18	0.29**
1982	0.33**	0.38**			0.42**	0.35**	0.45**	0.49**
1983	0.64**	0.57**	0.60**	0.54**	0.55**	0.48**	0.24**	0.24*
1984	0.56**	0.57**	0.57**	0.51**	0.59**	0.53**	0.45**	0.43**
1985	0.59**	0.56**	0.57**	0.53**	0.46**	0.40**	-0.01	0.09
1986	0.65**	0.64**	0.62**	0.61**	0.63**	0.56**	0.03	-0.02
1987	0.31**	0.35**	0.30**	0.32**	0.44**	0.47**	0.05	0.10
1988	0.25*	0.28**	0.18	0.19	0.42**	0.40**	-0.07	-0.04
1989	0.67**	0.68**	0.62**	0.60**	0.54**	0.56**	-0.13	0.01
1990	0.42**	0.48**	0.32**	0.37**	0.49**	0.53**	-0.03	0.20*
1991	0.55**	0.50**	0.46**	0.39**	0.51**	0.48**	-0.03	0.12
1992	0.26**	0.27**	0.28**	0.31**	0.65**	0.63**	-0.30**	-0.21*
1993	-0.13	-0.15	-0.01	-0.03	0.69**	0.67**	-0.35**	-0.14

[c] The Pearson correlation is computed using the log of total assets as of the end of the prior year and R^2 or total stock return variance over the current year. Values marked "**" are statistically significant at the 1% level; those marked "*" are significant at the 5% level.

Table 3, Panel A

Pearson and Spearman Correlation of BHC Size with Firm-Specific Risk[d]

	N	Market Model		Multi-Factor Model		Return-Generating Model Based on Factor Analysis	
		Pearson	Spearman	Pearson	Spearman	Pearson	Spearman
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
1980	118	0.18	0.33**			-0.01	0.15
1981	118	0.12	0.23*			-0.02	0.08
1982	119	0.34**	0.39**			0.20*	0.30**
1983	129	0.11	0.14	0.09	0.12	-0.06	-0.01
1984	131	0.30**	0.29**	0.25**	0.26**	0.11	0.17
1985	132	-0.12	-0.05	-0.12	-0.07	-0.18	-0.16
1986	133	-0.10	-0.29**	-0.10	-0.28**	-0.18	-0.36**
1987	129	-0.01	-0.06	-0.01	-0.06	-0.08	-0.22*
1988	119	-0.07	-0.08	-0.07	-0.07	-0.08	-0.19
1989	111	-0.16	-0.13	-0.16	-0.13	-0.16	-0.14
1990	105	-0.07	0.10	-0.06	0.11	-0.08	-0.07
1991	98	-0.07	0.02	-0.07	0.04	-0.12	-0.03
1992	89	-0.31**	-0.23*	-0.31**	-0.24*	-0.35**	-0.47**
1993	80	-0.34**	-0.12	-0.35**	-0.11	-0.37**	-0.47**

[d]The Pearson correlation is computed using the log of total assets as of the end of the prior year and firm-specific risk (total residual variance from the three return-generating models) over the current year. Values marked "**" are statistically significant at the 1% level; those marked "*" are significant at the 5% level.

Table 3, Panel B

Pearson and Spearman Correlation of BHC Size with Systematic Risk[a]

	N	Market Model		Multi-Factor Model		Return-Generating Model Based on Factor Analysis	
		Pearson	Spearman	Pearson	Spearman	Pearson	Spearman
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
1980	118	0.15	0.34**			0.43**	0.51**
1981	118	0.33**	0.46**			0.47**	0.49**
1982	119	0.55**	0.59**			0.64**	0.61**
1983	129	0.62**	0.54**	0.53**	0.48**	0.54**	0.44**
1984	131	0.72**	0.66**	0.74**	0.64**	0.68**	0.64**
1985	132	0.54**	0.52**	0.49**	0.46**	0.36**	0.33**
1986	133	0.65**	0.65**	0.59**	0.59**	0.39**	0.44**
1987	129	0.21*	0.29**	0.18	0.26**	0.24*	0.38**
1988	119	0.06	0.23*	-0.06	0.05	0.02	0.26**
1989	111	0.40**	0.50**	0.02	0.35**	0.11	0.33**
1990	105	0.47**	0.54**	0.13	0.46**	0.10	0.42**
1991	98	0.26**	0.46**	0.15	0.31**	0.21*	0.27**
1992	89	0.03	0.05	-0.03	0.02	-0.06	0.12
1993	80	-0.23**	-0.26**	-0.33**	-0.17	-0.06	0.17

[a]The Pearson correlation is computed using the log of total assets as of the end of the prior year and systematic risk (total explained variance from the three return-generating models) over the current year. Values marked "**" are statistically significant at the 1% level; those marked "*" are significant at the 5% level.

Table 4
Summary Statistics for BHC Portfolio Attributes

	Mean (Standard Deviation)	Correlation with Log Size[f]
	(1)	(2)
Log Size	16.2946 (1.1568)	1
C&I Loans/Assets	0.1863 (0.0641)	0.29**
Real Estate Loans/Assets	0.2299 (0.0947)	-0.22**
Agricultural Loans/Assets	0.0046 (0.0062)	-0.02
Consumer Loans/Assets	0.1209 (0.0537)	0.01
Loan Concentration	0.3206 (0.0536)	-0.21**
Trading Assets/Assets	0.0124 (0.0346)	0.32**
Total Deposits/Assets	0.7595 (0.0944)	-0.50**
Non-interest Deposits/Deposits	0.2165 (0.0675)	-0.14**
Foreign Deposits/Deposits	0.0853 (0.1571)	0.57**
Multi-Census Indicator	0.5009 (0.5005)	0.48**
Notional Principal on Interest Rate Swaps/Assets	0.1842 (0.4768)	0.52**
Notional Principal on FX Futures/Assets	0.2974 (0.7842)	0.56**
Non-interest Income/Net Interest Income	0.6651 (3.7104)	0.01
Book Value of Capital/Assets	0.0619 (0.0138)	-0.24**
Stock Market Turnover	0.7049 (0.4856)	0.36**

[f]Correlations are based on pooled data over the 1987-1993 period. These correlations are adjusted for time fixed effects. That is, the table presents the correlations of the difference between the variable and the annual means of that variable using the pooled data. Values marked "**" are statistically significant at the 1% level; those marked "*" are significant at the 5% level.

Table 5

Regressions of Factor-Analysis Firm-Specific Risk and Systematic Risk on BHC Size, Characteristics and Activities. Pooled Data from 1987 to 1993, with Time Fixed Effects. T-statistics in parentheses; "" indicates statistical significance at the 1% level, "*" indicates statistical significance at the 5% level.**

Dependent Variable:	*Ln(Systematic Risk)*		*Ln(Firm-Specific Risk)*	
	Without Controls	With Controls	Without Controls	With Controls
	(1)	(2)	(3)	(4)
Log of Assets	0.171	0.067	-0.142	-0.248
	(6.06)**	(1.72)	(-4.33)**	(-5.74)**
C&I Loans/Assets		2.537		2.333
		(5.31)**		(4.43)**
Real Estate Loans/Assets		1.044		0.758
		(2.20)*		(1.45)
Agricultural Loans/Asset		1.102		12.388
		(0.23)		(2.38)*
Consumer Loans/Assets		0.523		-0.194
		(0.74)		(-0.25)
Loan Concentration		1.384		1.807
		(1.77)		(2.10)*
Trading Assets/Assets		-0.013		-1.282
		(-0.01)		(-0.82)
Total Deposits/Assets		-0.072		-0.374
		(-0.16)		(-0.74)
Non-interest D./Total D.		0.489		-0.431
		(1.00)		(-0.80)
Foreign D./Total D.		-0.510		-0.368
		(-1.34)		(-0.88)
Multi-Census Indicator		-0.212		-0.260
		(-3.33)**		(-3.71)**
Interest Rate Swaps/Assets		-0.029		0.043
		(-0.19)		(0.26)
FX Futures/Asset		0.170		0.063
		(2.03)*		(0.68)
Non-interest Income/Net Interest Income		0.009		0.016
		(1.21)		(2.00)*
Log (Capital/Assets Squared)		-0.644		-1.056
		(-8.88)**		(-13.20)**
Turnover		0.423		0.332
		(6.31)**		(4.50)**
N	551	551	551	551
R^2	35.70%	59.37%	14.16%	51.31%

Table 6

Regressions of Factor-Analysis Firm-Specific Risk and Systematic Risk on BHC Size, Characteristics and Activities. Pooled Data from 1991 to 1993, with Time Fixed Effects. T-statistics in parentheses; "" indicates statistical significance at the 1% level, "*" indicates statistical significance at the 5% level.**

Dependent Variable:	*Ln(Systematic Risk)*		*Ln(Firm-Specific Risk)*	
	Without Controls	With Controls	Without Controls	With Controls
	(1)	(2)	(3)	(4)
Log of Assets	0.135	0.076	-0.215	-0.262
	(3.04)**	(1.32)	(-5.01)**	(-4.29)**
C&I Loans/Assets		3.930		2.764
		(5.18)**		(3.44)**
Real Estate Loans/Assets		1.308		1.445
		(1.68)*		(1.75)*
Agricultural Loans/Asset		4.281		12.913
		(0.57)		(1.62)
Consumer Loans/Assets		0.760		0.668
		(0.59)		(0.49)
Loan Concentration		-0.333		0.728
		(-0.23)		(0.47)
Trading Assets/Assets		-0.405		-1.168
		(-0.22)		(-0.61)
Total Deposits/Assets		0.959		0.063
		(1.10)		(0.07)
Non-interest D./Total D.		0.276		0.198
		(0.36)		(0.25)
Foreign D./Total D.		-0.247		0.337
		(-0.41)		(0.53)
Section 20 Subsidiary Indicator		0.266		0.256
		(1.87)*		(1.70)*
Multi-Census Indicator		-0.389		-0.323
		(-3.72)**		(-2.92)**
Interest Rate Swaps/Assets		0.169		0.104
		(0.82)		(0.48)
FX Futures/Asset		0.026		-0.028
		(0.25)		(-0.25)
Non-interest Income/Net Interest Income		0.042		0.033
		(1.10)		(0.83)
Log (Capital/Assets Squared)		-0.969		-1.022
		(-7.22)**		(-7.20)**
Turnover		0.408		0.233
		(3.82)**		(2.06)**
N	212	212	212	212
R^2	17.78%	62.15%	26.39%	59.68%

Table 7

Regressions of Firm-Specific Risk and Systematic Risk on BHC Size. Pooled Data from 1983 to 1993 for Multi-Factor return-generating model and 1980 to 1993 for Factor Analysis return-generating model, with Time and Firm Fixed Effects. T-statistics in parentheses; "" indicates statistical significance at the 1% level, "*" indicates statistical significance at the 5% level.**

	Log(Systematic Risk)	Log(Firm-Specific Risk)
	(1)	(2)
Multi-Factor Return-Generating Model		
Coefficient on Log(Size)	-0.200 (-2.08)*	-0.277 (-3.80)**
N	1256	1256
R^2	61.07%	51.21%
Factor Analysis Return-Generating Model		
Coefficient on Log(Size)	-0.057 (-0.88)	-0.133 (-2.17)*
N	1611	1611
R^2	56.31%	42.92%

Addendum: A Model of Bank Asset Risk and Diversification

This appendix describes a model of economies of scale in diversification based on asset risk. We use this model to motivate our choice of functional form in Equations (4) and (5). For this purpose, we assume that liabilities are non-stochastic and that the bank has no off-balance sheet positions.

Suppose bank i holds n assets.

The return on asset j held by bank i is generated as follows:

$$R_j = R_i^s + \epsilon_{i,j} \qquad j=1,\ldots,n$$

where R^s_i equals the systematic component of the return (to simplify notation, this is assumed to be the same for all assets held by bank i); $\epsilon_{i,j}$ is the diversifiable component of the return, assumed to be independent of R^s_i and independent of the other $\epsilon_{i,j}$. So, the return on bank i's assets equals the following:

$$R_i^a = R_i^s + \sum_{j=1}^{n} (w_{i,j}\, \epsilon_{i,j})$$

where $w_{i,j}$ = the portfolio weight for asset j at bank i.

The return on equity, then, may be written as follows:

$$R_i = (A/E)_i[R_i^s + \sum_{j=1}^{n} (w_{i,j}\, \epsilon_{i,j})] - (L/E)_i R_i^l$$

where A = total assets; L = total liabilities; E = total equity capital; and (R^l) = the return on the bank's liabilities (assumed to be non-stochastic).

Systematic risk may be written as follows:

$$\sigma_i^2(s) = (A/E)_i^2\ \sigma^2(R_i^s)$$

Assuming that the bank holds equal proportions of each of its assets ($w_{i,j} = 1/n$), firm-specific risk may be expressed as follows:

$$\sigma_i^2(f) = (A/E)_i^2 \sum_{j=1}^{n} ((1/n)^2 \sigma_{i,j}^2)$$

$$= (A/E)_i^2 \ \bar{\sigma}_i^2(f) \ / \ n$$

$$where \ \bar{\sigma}_i^2(f) \equiv \sum_{j=1}^{n} \sigma_{i,j}^2 \ / \ n$$

$$\sigma_{i,j}^2 \equiv the \ variance \ of \ \epsilon_{i,j}$$

We allow n (the number of assets with independent risks held by bank i) to vary with size, as follows:

$$n = \kappa(Assets)^{\alpha}$$

so that

$$\sigma_i^2(f) = (A/E)_i^2 \ \bar{\sigma}_i^2(f) \ / \ (\kappa(Assets)^{\alpha})$$

The parameter α describes the relationship between asset size and the number of assets with independent risks. If $\alpha = 0$, then large and small banks hold the same number of assets with diversifiable risks (i.e. large banks achieve no reduction in risk from diversification); if $0 < \alpha < 1$, large banks achieve reductions in risk from diversification but there are diminishing returns; if $\alpha >= 1$, large banks achieve reductions in risk from diversification and there are constant or increasing returns (this case seems implausible). This model motivates the log specification in equations (4) and (5), as follows:

$$Ln(\sigma_i^2(s)) = Ln(\sigma^2(R_i^s)) - Ln((E/A)_i^2)$$
$$Ln(\sigma_i^2(f)) = Ln(\bar{\sigma}_i^2(f)) - Ln((E/A)_i^2) - \alpha Ln(Assets_i) - Ln(\kappa)$$

Since $\sigma^2(R_i^s)$ and $\sigma^2_i(f)$ may vary with the configuration of each bank's portfolio, we include a set of portfolio characteristics (***Z***) in both the systematic and firm-specific risk regressions. These variables are included to permit unbiased estimation of α. Both regressions also include the log of the squared equity capital-asset ratio and the log of total assets, allowing us to test the hypothesis that $\alpha = 0$ when the dependent variable is systematic risk. This functional form will not fully reflect the relationship between risk and size if equity return variance is generated by risks associated with the bank's liabilities as well as its assets. However, this simplification is unlikely to introduce a significant bias whenever the bulk of a bank's risks stem from its assets.