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Value of latent risk and decision to hedge

Abstract

We present a novel approach to measure the systematic effect of latent information-based endogenous choices of firms and apply it to estimate the impact of bank holding companies' (BHCs') derivative trading decisions on their risk. To reduce the risk, a BHC can either restrict lending or hedge through derivatives. A BHC's choice depends on information that may be unobserved but potentially related to its systematic risks. Our methodology captures such effects induced by unobservable latent information. We find that derivative trading significantly increases a BHC's credit risk, and has no significant effect on its market risk, interest rate risk or unique risk.

Keywords: Central Bank Policy, Banks' Derivative Choice, Model Evaluation and Testing, Discrete Choice Model.
JEL Classification: E58, G21, C52, C25.

Introduction

This paper presents a novel methodology to measure the systematic effects of latent information-based endogenous choices of firms. We apply it to study an important quandary in the field of finance of whether hedging through derivative trading reduces risk[1]. Our empirical results show that bank holding companies (BHCs) that trade derivatives significantly increase their systematic credit risk, which is the factor risk (beta) of monthly BHC return with respect to monthly changes in the yield spread between Moody's AAA-rated and BAA-rated corporate bonds. Our estimation is based on an asset pricing model involving two other factors, monthly market return and monthly changes in 30-year U.S. Treasury Bond yields within a sample period, 1988-1997. We also find that derivative trading results in statistically insignificant changes in the other systematic risks, market and interest rate betas. The effect of derivative trading on the unsystematic risk is also statistically insignificant. Our tests control for important firm-specific attributes within an econometric model of latent information and endogenous choice by BHCs of whether or not to trade derivatives. These empirical results show that the motivation for derivative trading could be convenience and speculation, rather than risk reduction.

Our empirical results also indicate several useful conditions that enhance the likelihood of derivative usage by the BHCs[2]:

1. As the size of total loan portfolio increases, the probability of derivative usage rises. A larger loan portfolio perhaps increases the risk to be hedged by derivatives.

2. As the ratio of residential mortgages to total loans rises, the probability of derivative usage falls. Residential loans historically have lower degrees of default. BHCs having larger residential loans tend to feel more secure financially and so have little use of derivatives.

3. The derivative use decreases with the capital to assets ratio. A larger capital ratio makes the BHC less risky and so less dependent on derivative for hedging. Weaker BHCs with smaller capital ratios are more prone to use derivatives as the tendency to speculate rises.

4. The likelihood of derivative use increases with the one-year sensitivity GAP – the absolute difference between assets and liabilities that reprice within a year due to mark-to-market practice. The GAP measure shows the degree of vulnerability (with respect to profits and default) faced by a BHC due to interest rate moves either way. BHCs are more likely to use derivatives, the greater the degree of interest rate risk measured by GAP.

5. The probability of derivative usage falls as the ratio of non-performing loans (90+ days past due) to total loans rises. Basically BHCs with less non-performing loans need little use of derivatives for hedging.

A contribution of our study, compared to extant research in this area, is that we examine the effects of derivatives not only on systematic, but also on unsystematic risks. The systematic risks we consider are due to the market, interest rate, and credit risk factors. We use a multifactor asset pricing framework to estimate the influence of each risk factor on monthly asset returns, with the squared residual from the model providing a measure of the unsystematic risk component. Ours is a general framework for econometric examination of endogeneity of choices by banking firms, as opposed to estimation of any specific theoretical model or testing specific predictions from any theory. For example, Froot and Stein

[1] For a lucid exposure, see, for example, Brealey and Myers (1996), or Hull (1998).

[2] BHCs might not act the same way as our empirical results suggest if their subsidiary banks were deregulated. Whether or not banks should be regulated cannot be inferred from these empirical results derived from data generated in the current regulatory environment. See Acharya (2007) for optimality of *safe banking policy*.

(1997) show how firms may manage risk by ex-ante capital structure policy or by capital budgeting and hedging policies. Traditional rationale for hedging is extensively presented in the extant literature (Stulz, 1984; Smith and Stulz, 1985; and Froot, Scharfstein and Stein, 1993). Geczy, Minton and Schrand (1997) discuss capital structure rationale for the use of currency derivatives. Managerial risk aversion and managerial compensation may lead to the usage of derivatives (Schrand and Unal, 1998). Derivative usage can thus be an important endogenous choice of firms based on fundamental motives. We analyze this endonegous choice econometrically[1].

We address the endogeneity of derivatives use within an econometric model that measures the value of unobservable latent risk information used by a BHC to decide whether to hedge using derivatives. In particular, our model posits that a BHC chooses to use derivatives if the private (latent) evaluation of its risk crosses a threshold; otherwise, it elects not to use derivatives. The outcome from this decision rule depends on BHC-specific attributes and on the realization of an unobservable latent variable. The model measures the systematic risk shifts induced by a new policy regime, such as the initiation and continuance of hedging through derivative trades, resulting from an endogenous decision making process. These systematic risk shifts imply changes in the expected rates of return of a BHC, but they are very different from information effects measured by event study methodologies based on the release of latent information as in Acharya (1988, 1993), and Ekbo, Maksimovic and Williams (1990), Puri (1996), Haushalter (1997)[2]. The information effect or the abnormal expected rate of return in an event study is the change in the market model intercept coefficient effected by an event. Our methodology measures the shifts in the slope coefficients (market beta, interest rate beta and credit risk beta) induced by a latent variable-based choice process. It is perhaps possible to construct a far more sophisticated econometric model based on our approach than we have done, but in the interest of robustness of results we have used as simple a structure as needed to present our methodology. We use an untruncated panel data of 123 BHCs, over the period of 1988-1997, comprising both derivative users and non-users.

[1] We do not distinguish between various derivatives based, for example, on currency (Sinkey and Carter, 1993) or commodity.

[2] These methodologies correct potential inconsistencies in the dummy variable approach that presumes the decision process as exogenous, when in fact this decision is endogenous. See, however, Prabhala (1997) for equilibrium conditions of consistency of the standard event study methodology.

The explosive growth in financial derivatives[3] trading, along with several well-publicized derivatives-related debacles (e.g., Orange County, Barrings Bank, Gibson Greeting and Long-Term Capital Management) and the current banking turmoil associated with pervasive use of credit derivatives, has prompted concerns from federal regulators and policymakers about the potential impact of derivative trading on the safety and soundness of the U.S. banking system. A key concern is that banks, acting for themselves or for their clients, may use derivative instruments to increase risk exposure (speculate) rather than to reduce risk exposure (hedge). In response to these concerns, regulators and policy makers have mandated enhanced disclosures about how firms use derivatives in their risk-management practices, and about the effect of derivatives on specific aspects of risk such as interest rate risk and foreign exchange risk[4].

Derivative instruments offer BHCs a relatively low-cost mechanism to hedge many of the risks federal regulators evaluate during both on-site and off-site examinations. Finance theory argues that hedging can increase firm value by reducing expected taxes, expected costs of financial distress, or other agency costs[5]. Theories on financial intermediation (Diamond, 1984) also suggest that banks can reduce their costs of monitoring borrowers by diversifying their portfolio of assets, which includes loans and investment securities[6]. One way to achieve such diversification is to invest in a large number of independent projects (i.e., loans and securities). This approach, however, likely restricts banks to a limited quantity of assets, thereby reducing scale efficiencies,

[3] The notional value of derivatives contracts held by all insured commercial BHCs increased from $6.8 trillion at the end of 1990 to $25.4 trillion at year-end 1997. Although the number of institutions reporting derivatives use declined during the period (from 587 to 468), the dollar volume of assets of the derivative-using banks increased from $2.3 trillion to $3.9 trillion, representing roughly 80% of all commercial bank assets at the end of 1997. The Office of Comptroller of Currency reports that the number of banks using derivatives has reached a high of 836 as of December 2005.

[4] In December 1995, for example, the Securities and Exchange Commission proposed that derivatives disclosures include the impact of the derivatives portfolio on the maturity mismatch of an institution's on-balance sheet portfolio. In a similar move, the Financial Accounting Standards Board (FASB) encouraged quantitative disclosures in Statement of Financial Accounting Standards (SFAS) No. 119, "Disclosures about Derivative Financial Instruments and Fair Value of Financial Instruments". The standard encouraged disclosure of information about the risk of other financial instruments (besides derivatives) or non-financial assets or liabilities to which derivative financial instruments are related by risk management strategy. Such disclosures effectively indicate the net amount at risk with respect to the firm's portfolio. The FASB stated (SFAS No. 119, paragraph 12) that this type of quantitative information is more useful and "less likely to be of context or otherwise misunderstood".

[5] See Nance et al. (1993) for a good overview of these theories.

[6] Baltensperger (1980) also reviews several of these theories.

especially at institutions that specialize in particular types of credit or whose customer base is geographically concentrated. Diversification can also be achieved through the use of derivative securities. It is well known that derivatives offer firms the effective mechanisms for controlling risks and cash flows, thereby enhancing the availability of funds to pursue value-enhancing investment opportunities (and avoiding the under-investment dilemma outlined in Meyers and Majulif (1983). Banking firms may include derivatives in packages of financial products offered to clients (Kane and Malkiel, 1967; Wigler, 1991; and Sinkey and Carter, 1996) or trade directly. The result of all such derivative uses is a portfolio of banking assets and derivative products aimed at diversifying risk and enhancing return.

While regulators are aware of the potential risk-reducing benefits of derivatives, they are also aware of the potential dangers of speculative derivatives activities. In response to concerns about exacerbating risk exposure through derivative transactions, regulators have levied explicit capital charges on banks that use derivative instruments, with these charges independent of whether the instruments are used for hedging or speculative purposes. To the extent that the marginal costs of such capital charges outweigh the marginal benefits of hedging with derivatives, these capital charges may discourage institutions from effectively controlling risk. As a step toward determining whether regulatory concerns about derivatives activities (and whether risk-based capital charges) are warranted, we empirically examine whether banks that use derivatives are riskier than those that do not[1].

[1] The standard two-step method used in extant research on banks' use of derivatives assumes that the choice is exogenous. But banks make consciously (endogenously) make choices on derivative use. Previously reported disparate empirical results may be because of not modeling for the endogenous nature of derivatives use. The standard two-step procedure is inherently inconsistent and, hence, results based on it can be unreliable. Other recent studies have directly examined the determinants of derivatives trading within a truncated sample of banking firms that have used derivatives. For example, Sinkey and Carter (1994), and Gunther and Siems (1995) use a Tobit model to find a significant negative relationship between balance sheet measures of interest rate risk and the extent of derivatives usage by banks. They argue that this finding is consistent with the idea that banks use derivatives as a substitute for on-balance sheet sources of interest rate risk or, in other words, to increase risk. Simons (1995) uses a similar approach to find no significant relationship between balance sheet measures of interest rate risk and derivative use. These studies do not focus on the relationship between market-based measures of systematic risks and derivatives activities. Neither do they employ the available full (untruncated) sample of banking firms that trade derivatives and that do not. It seems artificial to create a truncated sample (only derivative users) from a full available sample of untruncated data (derivative users and non-users) to apply a limited dependent variable model meant for naturally truncated or censored data. In any case, simulation results in Acharya (1993) show that coefficient estimates from limited dependent variable models can be very unreliable. As a result, no concrete conclusions about the market's perception or pricing of derivatives activities can be formulated based on the results of these works.

The remainder of this paper is arranged as follows. The next section presents the methodology for measuring the value of latent risk and the decision to hedge. Section 3 discusses the sample selection and data used in this study. Section 4 reports the results, followed by our conclusion.

1. Methodology to measure the value of latent risk

We specify a multi-factor asset pricing model based on market risk, interest rate risk, and credit risk and time-varying systematic risks (betas):

$$R_{bt} = \alpha_b + \tilde{\beta}_{Mbt} R_{Mt} + \tilde{\beta}_{Ibt} R_{It} + \tilde{\beta}_{Cbt} R_{Ct} + \epsilon_{bt}, \quad (1)$$

$$\tilde{\beta}_{Mbt} = \beta_{Mb} + \eta_{Mbt}, \quad (2)$$

$$\tilde{\beta}_{Ibt} = \beta_{Ib} + \eta_{Ibt}, \quad (3)$$

$$\tilde{\beta}_{Cbt} = \beta_{Cb} + \eta_{Cbt}, \quad (4)$$

where R_{bt} is the *excess* monthly rate of return on assets (we separately estimate the model using equity returns in place of asset returns) of a BHC, *b*, with the excess return defined as the dividend-included rate less the risk-free rate; R_{Mt} is the excess rate of return on the market as proxied by the monthly return to the S&P 500 index less the risk-free rate[2]; R_{It} is the change in the monthly interest rate, proxied by the yield on the constant maturity 30-year Treasury bonds[3]; and R_{Ct} is the yield spread between Moody's BAA-rated and AAA-rated corporate bonds at the end of month *t*[4]. In the model, $\eta_{jbt}, j = M, I, C$ are specified as mean-zero random variables that are potentially correlated with a BHC's latent information employed to decide whether or not to trade derivative securities for hedging. We later specify an econometric model for the endogenous decision-making process. We assume that η_{jbt} is uncorrelated with either ε_{bt} or the factor risks in the model, i.e., $Cov(\eta_{jbt}, R_{kt}) = 0 = Cov(\eta_{jbt}, \varepsilon_{bt})$, $j = M, I, C$, and $k = M, I, C$.

To examine the effects of derivatives use on the overall risk and diversification, we use the asset

[2] The risk free rate is proxied by the 3-month U.S. Treasury bill rate.

[3] The inclusion of an interest rate risk measure is based on prior studies' evidence that the market prices interest rate risk (Flannery and James, 1984; Sweeney and Warga, 1986; and Yourougou, 1990). These studies generally find a statistically significant (negative) coefficient on the interest rate factor, suggesting that stock returns are sensitive to interest rate risk. I include a measure of credit risk based on prior studies (such as Ferson and Harvey, 1991) which find a statistically significant relation between returns and proxies for default risk.

[4] See Smith et al. (1990) for a good discussion of using this framework in identifying and measuring interest rate risk. Folger et al. (1986) provide support for using an interest rate factor in explaining the equity returns of financial institution.

return the dependent variable in (1). For this purpose, equity returns will be misleading. From the point of view of regulators monitoring derivative trades within a BHC, the risk of equityholders is not as important as the safety and soundness of debtholders. Observe that high leverage at even well-diversified institutions can translate into high volatility of stock returns. Given the highly leveraged nature of the commercial banking sector, focusing on asset returns is more appropriate for studying the effect of derivatives on safety and soundness banks and BHCs. Since market values of assets are not available, we calculate asset returns as the weighted-average of the BHC's stock return and debt return, with the weights reflecting the capital structure of the firm. Our measure of asset returns is expected to capture changes in the market values of assets. We thus define the asset return of BHC, *b*, for month *t* as:

$$AR_{bt} \equiv c_{bt} + (1 - c_{bt})DR_{bt},$$

where c_{bt} is the ratio of equity capital to total assets for the BHC at the end of month *t*; SR_{bt} is the stock return of BHC *b* for month *t*; and DR_{bt} is the debt return of BHC *b* for month *t*. R_{bt} is equal to AR_{bt} is less the risk-less rate of interest for the end of month *t*. We compute monthly stock returns as the natural log of the ratio of the current month-end stock price plus dividend to previous month-end stock price, while the debt return for each BHC is proxied by the yield on 30-year constant maturity U.S. Treasury bonds. Using the long-term Treasury bond yield to proxy for a BHC's cost of debt is not unreasonable, since the majority of a banking firm's funds are in the form of federally insured, i.e., risk-free deposits.

The coefficient on the interest rate term, $\tilde{\beta}_{Ibt}$, measures the sensitivity of the BHC's asset return to changes in interest rates, after controlling for changes in the return on the market and general credit conditions in the economy. This coefficient can essentially be interpreted as a measure of a BHC's interest rate risk exposure. More precisely, $\tilde{\beta}_{Ibt}$ is an estimate of the duration of the BHC's assets[1]. A negative interest rate beta implies that the value of the BHC's assets tends to decrease when interest rates rise, while a positive beta implies the opposite. The sign and magnitude of the interest rate beta provide an indication of the direction and extent of the repricing mismatches inherent in a BHC's on- and off-balance sheet positions. A negative beta is consistent with the conventional idea that banking firms fund long-term assets with relatively shorter-term deposits, thereby exposing net interest earnings and net asset values to rising interest rates.

1.1. Latent risk. Our main purpose is to study whether systematic risks ($\tilde{\beta}_{jbt}$, *j = M, I, C*) are affected by a BHC's use or non-use of derivatives in a given period. We now turn to a model of a firm's endogenous choice behavior based on latent information not available to the market. Note that the decision to first use derivative trades for hedging is an event that is rarely announced by BHCs. The precise timing of the event is rarely documented. Thus, the standard announcement effect, if any, due to the first derivative use is not easily measurable. Furthermore, when a firm continues to use derivative securities, the one-time event (the initial decision) will have little systematic effect on the firm's performance.

Given that derivatives use is not a required activity of BHCs, it would seem that the decision to engage in derivatives trading is endogenous and probably the result of some optimization by management of the BHC. This reasoning argues for the use of a choice-theoretic model, which takes into consideration the fact that the use of derivatives is observed conditional on their expected use producing a positive outcome in the optimization. A BHC's decision to continue using derivative securities is based on information not generally available to the market. That is, the management may know information about the riskiness of the institution's asset portfolio that is known by (or cannot be easily reported to) the market. The variance-covariance matrix of a BHC's portfolio of loans, for example, may be known only to management. Proprietary trading positions may also influence a BHC's decision-making process about whether to use derivative securities. Although the decision process leading to the choice to use derivative securities is likely based on information unobservable by the market, it is not unreasonable to assume that the market can anticipate the nature of this process and make at least an inference about the unobservable information. The idea is to model the unobserved information as a latent random variable whose realization at a point in time determines whether or not derivatives are used. Specifically, we let a random variable, $\tilde{Y}_{bt}$, denote the net latent risk: the difference between the

[1] The duration of an asset with a current price *P* is $D = -\frac{1}{P}\frac{dP}{dy}$, where *dP* denotes the change in the price *P* of the asset due to a small change *dy* in the interest rate, *y*. Thus, theoretically, $\frac{dP}{dy} = -Ddy$, or the rate of return on the asset over a small time *dt* is negatively related to the change in the interest rate with the coefficient of relationship equal to the asset's duration.

risk of not using derivatives and the risk of using derivative securities by BHC *b* at time *t*. We posit that BHC *b* will choose to use derivatives whenever $\tilde{Y}_{bt}$ crosses a specified threshold. We normalize the problem so that for any BHC, this threshold is zero, i.e., $\tilde{Y}_{bt}$ represents the difference between the net risk of not using derivatives and the threshold for BHC *b*.

From the market's perspective, $\tilde{Y}_{bt}$ is an unobservable, latent random variable whose realization determines a BHC's choice about derivatives use. Although the market may not observe the information, $\tilde{Y}_{bt}$, that supports the BHC's decision to engage in derivatives activities, it can observe, at time *t-1*, K number of firm-specific characteristics, $x_{bt-1} \equiv (x_{b0t-1}, x_{b1t-1},...., x_{bKt-1})$ that help it assess the likelihood of this BHC using derivatives in period *t*.

We model the latent variable, $\tilde{Y}_{bt}$, as a function of observable BHC attributes and private information:

$$\tilde{Y}_{bt} = \tilde{Q}x_{bt-1} + \xi_{bt}, \tag{5}$$

where $\tilde{\theta}' x_{bt-1}$ is the market's expectation of $\tilde{Y}_{bt}$, conditional on prior publicly available information x_{bt-1}, with $\tilde{\theta}$ as the vector of coefficients; and $\tilde{\xi}_{bt}$ is the private latent information, i.e., the component of $\tilde{Y}_{bt}$ that is not observable by the market.

We define the terms in the above equation as:

$$Y_{bt} = \frac{\tilde{Y}_{bt}}{\sigma_{\tilde{\xi}}},\ Q = \frac{\tilde{Q}}{\sigma_{\tilde{\xi}}},\ \xi_{bt} = \frac{\tilde{\xi}_{bt}}{\sigma_{\tilde{\xi}}}, \tag{6}$$

where $\sigma_{\tilde{\xi}}$ is the standard deviation of $\tilde{\xi}_{bt}$[1]. Substituting these values into equation (5) yields:

$$Y_{bt} = \theta' x_{bt-1} + \varepsilon_{bt}. \tag{7}$$

The error term, $\tilde{\xi}_{bt}$, represents the latent information. Note that the inference that the market draws from this latent information is limited by the observability of a dummy variable, I_{bt}^U, which equals one whenever derivatives are used and zero otherwise. Given (6), the market can infer that:

$$I_{bt}^U = \begin{cases} 1, \text{whenever } Y_{bt} > 0, \\ 0, \text{otherwise.} \end{cases} \tag{8}$$

Consistent with the semi-strong form of market efficiency, BHC asset returns are related to the set of conditioning information; this set includes data on the market return (R_{Mt}), interest rate movements (R_{It}), and credit risk (R_{Ct}), as well as the BHC-specific characteristics x_{bt-1}. A BHC's expected return conditional on derivative use, R_{bt}^U, and on derivative non-use, R_{bt}^N, is well defined (letting $I_{bt}^N = 1 - I_{bt}^U$):

$$R_{bt}^k \equiv E[R_{bt} | R_{Mt}, R_{It}, R_{Ct}, x_{bt-1}, I_{bt}^k = 1], k = U, N. \tag{9}$$

We can then write the realized returns as:

$$R_{bt} = \sum_{k=N,U} R_{bt}^k I_{bt}^k + \zeta_{bt}, \tag{10}$$

where ζ_{bt} is orthogonal to the information set $\Psi_t \equiv \{(R_{MT}, R_{It}, R_{Ct}, x_{bt-1}), I_{bt}^k\}$.

To determine the expression for conditional expected asset returns, R_{bt}^U and R_{bt}^N, by using the specifications (1) and (7), we need to specify the relationship between the latent information ξ_{bt} in (7) and η_{jbt}, *j* = *M*, *I*, *C* in (2)-(4). Observe that the latent information ξ_{bt} will likely co-vary with the asset return error ε_{bt} if it is the basis of announcement of an event in time period (*t,t-1*) as in Acharya (1988, 1993). While we can easily incorporate information effect due to one-time events, our specific case is about systematic effects, if any, induced by continuance of a policy regime like trading derivative securities over the sample period[2]. We thus assume, for our application, that $Cov(\xi_{bt}, \varepsilon_{bt}) = 0$. Using (1), we can evaluate the conditional mean expected returns $R_{bt}^k, k = U, N$,

$$R_{bt}^k = \alpha_b + \sum_{j=M,I,C} E[\tilde{\beta}_{jbt} R_{jt} | \Psi_t, I_{bt}^k = 1] \tag{11}$$

$$= \alpha_b + \sum_{j=M,I,C} R_{jt} E[\tilde{\beta}_{jbt} | \Psi_t, I_{bt}^k = 1] \tag{12}$$

[1] Redefining these variables in this fashion loses no generality, and is performed because $\sigma_{\tilde{\xi}}$ and $\tilde{\theta}$ are not separately identifiable. The probit model can be used to identify only the ratio, $\tilde{\theta} / \sigma_{\tilde{\xi}}$. One can alternatively use the logit model with no loss of generality.

[2] We tested for event announcement effects using our data and found no significant abnormal expected return conditional on either derivative use, {I_{bt}^U=1}, or non-use, {I_{bt}^N=1}. That is, $E(\varepsilon_{bt} | I_{bt}^U = 1)$ and $E(\varepsilon_{bt} | I_{bt}^N = 1)$ are not statistically significant and so we avoid complicating our notations for measuring *bt* potential announcement effects within our model.

$$= \alpha_b + \sum_{j=M,I,C} R_{jt}[\beta_{jb} + E(\eta_{jbt} | \Psi_t, I^k_{bt} = 1)]. \quad (13)$$

As long as the latent information ξ_{bt} is correlated with the error in the systematic risks η_{jbt}, $E(\eta_{jbt} | \Psi_t, I^k_{bt} = 1)$ will be non-zero. We call $E(\eta_{jbt} | \Psi_t, I^k_{bt} = 1)$ the *latent systematic risk* and the systematic stock price effect associated with it the *value of latent risk*. To determine the latent systematic risks, we specify a simple cross-sectional relationship between η_{jbt} and ξ_{bt} as follows:

$$\eta_{jbt} = \delta_j \xi_{bt}, \quad j = M, I, C, \quad (14)$$

where $\delta_j = Cov(\xi_{bt}, \eta_{jbt})$. The above relationship is obtained because the variance of the latent information ξ_{bt} equals 1, following its standardization earlier, and η_{jbt} is a mean-zero random variable.

In light of the inference process outlined in (8) and specification (14), the latent systematic risks $E(\eta_{jbt} | \Psi_t, I^k_{bt} = 1)$ can now be evaluated as (for *j* = *M, I, C*)

$$E(\eta_{jbt} | \Psi_t, I^U_{bt} = 1) = \delta_j E(\eta_{jbt} | \Psi_t, \varepsilon_{bt} > -\theta' x_{bt-1}) = \frac{\delta_j n(\theta' x_{bt-1})}{N(\theta' x_{bt-1})} \equiv \delta_j z^U_{bt}(\theta), \quad (15)$$

$$E(\eta_{jbt} | \Psi_t, I^N_{bt} = 1) = \delta_j E(\eta_{jbt} | \Psi_t, \varepsilon_{bt} \le -\theta' x_{bt-1}) = \frac{\delta_j n(\theta' x_{bt-1})}{1 - N(\theta' x_{bt-1})} \equiv \delta_j z^N_{bt}(\theta), \quad (16)$$

where *n*(.) and *N*(.) are the standard normal density and cumulative density functions, respectively. The ratios on the right-hand side of the above equations, $z^U_{bt}(\theta)$ and $z^N_{bt}(\theta)$, are inverse Mills ratios[1].

Now, substituting for the values of the latent systematic risks from (15)-(16) in (13) and then (10), we obtain the following econometric model:

$$R_{bt} = \alpha_b + \sum_{j=M,I,C} \left[\beta_{jb} + \delta_j (z^U_{bt}(\theta) I^U_{bt} + z^N_{bt}(\theta) I^N_{bt})\right] R_{jt} + \zeta_{bt}, \quad (17)$$

with a vector of coefficients $[\alpha_b, (\beta_{Mb}, \beta_{Ib}, \beta_{Cb}), b = 1, 2, ..., H, \delta_M, \delta_I, \delta_C, \theta]$, for H number of BHCs. Thus, despite not observing the latent information, ξ_{bt}, on which the BHC conditions its decision to use derivative securities, market participants can assess the systematic effect of the latent information contingent on the indicator variable, $I^k_{bt}, k = U, N,$ and the BHC specific information, x_{bt-1}, using the inference rule in equation (8), and estimate these effects using (17). Notice that the conditional means used to evaluate the systematic latent risks $z^U_{bt}(\theta)$ and $z^N_{bt}(\theta)$ are functions of the probability of derivatives usage, $N(\theta' x_{bt-1})$. Given, x_{bt-1}, the market can compute this probability. We interpret the conditional means of the latent information (latent systematic risks) as measuring the extent of relevant information released by derivatives use or non-use. The value of this information for market participants is given by the effect on expected asset returns of this latent information through the changes in the systematic risks, as reflected in the coefficient in equations (15) and (16).

The latent variable model permits the market to update the probability of derivatives use and to estimate the systematic latent risks as functions of BHC-specific characteristics, x_{bt-1}, presumed to influence the derivatives choice. One of our main purposes is to test whether the expected market required rate of return for BHCs that use derivative trading, R^U_{bt}, is greater than that for the non-user, R^N_{bt}. If R^U_{bt} > R^N_{bt}, the users' risk-adjusted cost of capital will be interpreted to be higher than that of the non-users. By using (15) and (16) in (9), we obtain the following:

$$R^U_{bt} - R^N_{bt} = \sum_{j=M,I,C} \delta_j [z^U_{bt}(Q) - z^N_{bt}(Q)] R_{jt}, \quad (18)$$

which is the cost of capital differential between users and non-users of derivatives. Observe that $z^U_{bt}(\theta)$ - $z^N_{bt}(\theta)$ > 0, which means that we need to simply test whether $\delta_j > 0$ to infer if the systematic risk associated with factor *j* has increased and the corresponding cost of capital has risen for the users as compared to that for the non-users. A positive δ_j will indicate that the users' systematic risk of factor *j* is higher than that for the non-user. This model can be used to test for changes in the systematic risks and risk-adjusted costs of capital associated with other corporate policy shifts. For example, whether or not firms experience systematic changes in their risks and costs of capital after mergers and acquisitions can be studied.

1.1.1. Shifts in Systematic and idiosyncratic кisks. As discussed earlier, theories of financial intermediation suggest that BHCs can reduce agency costs by diversifying their portfolios. A measure of the

[1] See Johnson and Kotz (1970) for the derivation of this expression.

degree of diversification is the idiosyncratic risk, which is $\sigma_{\zeta b} = \sqrt{Var(\zeta_{bt})}$. To reduce $\sigma_{\zeta b}$, a BHC has to increase the size of its loan portfolio (assets) by lending to many independent projects. The possibility of lending to projects that generate independent returns is limited for most BHCs. To reduce their risks, BHCs may have to resort to low-risk lending like home mortgages or engage in derivative-based hedging. Theoretically, derivative securities offer BHCs with a concentration of risky assets, like commercial real-estate loans, a vehicle to reduce their risk. By controlling for asset size and other BHC-specific attributes, we can test if $\sigma_{\zeta b}$ is lower for derivative users than for non-users. Similar to the specification for the systematic risks in (2)-(4), we specify $\sigma_{\zeta b}$ as follows:

$$2\ln(\sigma_{\zeta b}) = \gamma_0 + \tilde{\gamma}_{bt}, \quad (19)$$

where the error $\tilde{\gamma}_{bt}$ may be potentially correlated with the BHC's latent information ξ_{bt}. We specify the natural log of $\sigma_{\zeta b}$ to accommodate for the possibility of negative errors in $\tilde{\gamma}_{bt}$. To test whether $E\{\ln(\sigma_{\zeta b}) \mid I_{bt}^U = 1\} > E\{\ln(\sigma_{\zeta b}) \mid I_{bt}^N = 1\}$, we proceed with steps similar to those for the systematic risk to obtain:

$$E(\ln(\sigma_{\zeta b}) \mid I_{bt}^U = 1) - E(\ln(\sigma_{\zeta b}) \mid I_{bt}^N = 1) = \delta_\sigma [z_{bt}^U(Q) - z_{bt}^N(Q)], \quad (20)$$

where $\delta_\sigma = Cov(\tilde{\gamma}_{bt}, \xi_{bt})$. A test of whether the idiosyncratic risk rises due to derivative use is simply a test of whether $\delta_\sigma > 0$ in the following:

$$2\ln(\sigma_{\zeta b}) = \gamma_0 + \delta_\sigma [z_{bt}^U(Q) I_{bt}^U - z_{bt}^N(Q) I_{bt}^N] + \kappa_{bt}, \quad (21)$$

where κ_{bt} is an error. The above model is similar to the model derived for the asset return. We take the log of the squared residuals from (17) as a proxy for the dependent variable in (21). We see no better proxy and admit it to be rough.

There seems to be no a priori reason for whether BHCs will necessarily use derivatives to mitigate or exacerbate their risk exposures; therefore, we do not predict whether derivatives use is risk-increasing or risk-reducing. We test the more general hypothesis that the coefficient relating to a given component of systematic risk and idiosyncratic risk differs between users and non-users. Formally, we specify the following null and alternative hypotheses.

Risk Null Hypothesis and Alternative hypothesis

Systematic Market Risk $\delta_M = 0$ $\delta_M \neq 0$.

Systematic Interest Rate Risk $\delta_I = 0$ $\delta_I \neq 0$.

Systematic Credit Risk $\delta_C = 0$ $\delta_C \neq 0$.

Idiosyncratic Risk $\delta_\sigma = 0$ $\delta_\sigma \neq 0$.

For $j = M, I, C, \sigma$: if $\delta_j > 0[\delta_j < 0]$, derivative users are exposed to a higher [lower] risk than that of the non-users.

1.1.2. Estimation. We estimate the latent variables model (17) in two stages. At the first stage, we estimate a binary probit model of the BHC- and time-specific factors influencing the BHC's decision to use derivatives in period *t*. The qualitative dependent variable I_{bt}^U equals one if the BHC uses derivatives at time *t* and zero otherwise. The explanatory variables consist of a set of BHC attributes, x_{bt-1}, posited to explain derivatives use by financial firms[1]. Estimation of the probit model for the sample firms yields a set of coefficients, θ, describing the weights placed on each of the factors. The product of the weights and the factors is transformed to yield the inverse Mills ratios $z_{bt}^U(\theta)$ and $z_{bt}^N(\theta)$. Since the probit model yields a consistent estimator of θ, the corresponding values of $z_{bt}^U(\theta)$ and $z_{bt}^N(\theta)$ are consistent allowing us to estimate (17) and (21), consistently, by Slutsky's theorem. The two-step procedure specified here is consistent and the estimation is robust. The whole model can, however, be estimated in one step, though a convergence of nonlinear estimation may not be always possible in most computer packages.

Observe that we are not developing any theory on hedging or testing any of the extant theories. In particular, the econometric controls or attributes x_{bt-1} are not intended to test any specific theory. We have tried many possible BHC-specific attributes in estimation. We have retained only those attributes that are significant and that have generally interesting economic intuition with no connotation to any specific theoretical model. We thus have seven BHC attributes x_{bt-1} which explain derivatives use within a probit model:

SIZE: the size of loan portfolio measured by the natural log of the dollar value of all loans.

CAPITAL: the capital adequacy ratio measured by the capital-to-assets ratio.

CI: the ratio of commercial loans to total assets.

[1] See Sinkey and Carter (1994) for a good overview of the theories about the motivations for derivatives use in the banking industry.

RESLOAN: the ratio of residential real estate loans to total assets.

GAP: one-year gap defined by the difference between the dollar volumes of assets and liabilities that can reprice within a specified period because of their contractual maturity or repricing terms.

NONPERF: the ratio of non-performing loans (90+ days past due) to total loans.

RESERVE: the ratio of loan-loss reserves to total loans.

Our probit model is thus specified through these variables[1]. We now describe the variables and explain the reasons for including each. The BHC-specific variables are linked to three hypotheses regarding the use of derivatives by BHCs: the informational and scale-economies hypothesis, the moral hazard hypothesis, and the market-discipline hypothesis. Each hypothesis suggests a unique set of testable implications about BHCs' risk-taking behavior in general and about their choice to use derivative securities in particular. A summary of the variables and their expected associations with derivatives use is reported in following table under the three following hypothesis.

The *informational and scale-economies hypothesi*s suggests that large BHCs are more likely to engage in derivatives activities because they can better obtain the expertise to manage and monitor derivatives activity and because they are better able to diversify risk through their broader array of products, services, and geographic locations. We capture this determinant of derivative use by including the natural log of total loans (SIZE).

2. Motivations for the explanatory variables used in the probit regression

1. Moral hazard hypothesis: to exploit federal deposit insurance subsidies, BHCs either avoid using derivatives and hedging risk or engage in derivatives activities to speculate.

2. Market-discipline hypothesis: BHCs use derivatives to hedge risks and avoid explicit risk premium charges (incremental costs of capital) imposed by the capital markets.

3. Informational and scale-economies hypothesis: large BHCs are more likely to use derivatives.

The moral hazard hypothesis argues that mis-priced deposit insurance encourages banking firms to engage in risk taking activities. The idea here is that BHCs will attempt to exploit FDIC subsidies either by not using derivative securities and avoid hedging certain risks leading to greater risk of BHC failure, or by using derivative securities to take additional risks (i.e., speculate). Offsetting the moral hazard hypothesis is the market discipline hypothesis which argues that external monitoring by BHC creditors and equity-holders may encourage riskier BHCs to hedge. Stakeholders may demand higher risk premiums from BHCs that engage in riskier activities. Hedging with derivatives may allow BHCs to offset the explicit charge demanded from the capital markets. In short, while both moral hazard and market-discipline may suggest an increased use in derivative contracts, the former argues that these contracts will be used to increase risk while the latter argues they will be used to mitigate risks.

The remaining six variables are included to capture moral hazard and market discipline effects. The ratio of total capital to total assets (CAPITAL) provides an immediate gauge of the proximity of the banking firm to failure, with low capital ratios assumed to reflect riskier institutions. The lower the CAPITAL is, the greater the temptation to increase the risk exposure by either speculative derivative trades or to totally avoid derivatives use. We also include two proxies for asset composition to capture the influence of credit risk on the decision to use derivative securities: the ratio of commercial and industrial loans to total assets (CI) and the ratio of residential real estate loans to total assets (RESLOAN). These variables are included to reflect the idea that BHCs with a greater portion of their loan portfolio in risky, largely unsecured commercial and industrial loans may have different incentives to use derivatives (either as hedges or speculations) than BHCs with a greater portion of their loan portfolio in less risky, typically secured, residential real estate loans.

Prior research has also found that accounting-based measures of risk are useful in explaining the systematic interest rate risk of, and the use of interest rate derivatives by, financial intermediaries. In general, interest rate risk in banking arises because the rates on BHC assets and liabilities reset at different times; these timing differences can significantly influence the cash flow characteristics. The disparity in the timing mismatch makes the value of the firm vulnerable to changes in interest rates, with the magnitude of the mismatch reflecting the degree of interest rate risk assumed by the BHC. A common measure of the direction and extent of the asset-liability mismatch is the difference (or gap) between the dollar volume of assets and liabilities that reprice within a specified period of time because of

[1] These variables are not independent of each other and so their coefficients estimated via the probit model may not be individually robust. But the probability of BHCs' derivative choice estimated through the probit model as a function of all the variables, jointly, still remains robust.

either contractual maturity or repricing terms: RSA_{th} - RSL_{th}, where RSA_{th} [RSL_{th}] is the book value of assets [liabilities] at time t which reprice within horizon h. One-year horizon for the value of h is commonly used to gauge a financial intermediary's exposure to interest rate risk under the gap management framework. A negative one-year interest rate gap indicates that more liabilities than assets have the ability to reprice within the next one year period, thus making earnings (and firm value) vulnerable to upward swings in interest rates. Conversely, a positive gap indicates that more assets than liabilities have the ability to reprice over the next one-year period, indicating that earnings are vulnerable to downward interest rate movements during this time frame. We use the absolute value of the 1-year rate gap normalized by total assets (GAP) to proxy for the extent of a BHC holding company's exposure to interest rate risk. The moral hazard hypothesis predicts a negative association between GAP and derivatives usage, while the market-discipline hypothesis predicts this association will be positive.

We also include two variables related to the credit quality of a BHC's asset portfolio: the ratio of non-performing loans (90+ days past due) to total loans [NONPERF], and the ratio of loan-loss reserve to total loans [RESERVE]. These two accounting based measures of asset risk directly influence the BHC's probability of failure. Higher non-performing loan ratios, for example, generally suggest asset quality problems and an enhanced likelihood of default by the BHC. Loss reserves measure expected losses and are therefore directly associated with failure probability. To the extent that failure probability affects a BHC's risk-taking behavior, NONPERF and RESERVE will directly influence a BHC choice of derivative trading

3. The data

Data on the seven variables used in the probit model are collected from quarterly Y-9C reports. Since these reports are filed on a quarterly basis whereas asset returns are measured by month, we compute monthly measures of the variables by interpolating quarter-end data. In particular, we calculate the change in quarter-to-quarter balance sheet measures and average this change over the interim months. Because information on derivatives usage is also available only at quarter-end, we also calculate dummy variable values for interim months. If the institution reported using derivatives at the end of quarter q, we set $I^{U}_{bt} = 1$ for the two months subsequent to q, e.g., if a BHC reported using derivatives in their quarterly filing dated December 1995 then $I^{U}_{bt} = 1$ for January 1996 and for February 1996; whether I^{U}_{bt} (I^{N}_{bt}) equals 1 for March 1996 will depend on whether the BHC reported (did not report) using derivatives in their March 1996 quarterly filing. We examine quarterly filings of the "Consolidated Financial Statements for BHCs" (i.e., Federal Reserve Y-9C Reports) made by 123 exchange-traded BHCs over the 37-quarter period, March 31, 1988, to March 31, 1997. In this section, we provide information about the contents of the Y-9C reports and describe the reasons for selecting this time period. We also detail the sample selection process and report descriptive information about the final sample of BHCs.

Y-9C reports are filed with the Federal Reserve by BHCs with assets over \$150 million or which own multiple banking subsidiaries. Among the documentations in these reports is information about BHCs' balance sheet compositions and their involvement with interest rate derivative securities. In particular, beginning June 30, 1986, Y-9C reports contain information about the notional principal amount of various interest rate derivative securities held by BHCs. The information reported on interest rate derivative contracts includes data on contracts related to interest-bearing financial instruments and to securities with cash flows that are determined by referencing interest rates (or another interest rate contract). These contracts are generally used to adjust either the BHC's interest rate risk exposure, or, if the BHC is an intermediary, the interest rate risk exposure of others. Interest rate contracts include single currency interest rate swaps, basis swaps, forward rate agreements, and interest rate options, including caps, floors, collars, and corridors.

The notional values of interest rate swaps and limited data on futures and forward contracts are available since June 30, 1986. Beginning in 1990, more detailed information about futures and forward contracts and interest rate options is reported. The following table details the types of interest rate contracts and the dates of reporting availability.

Table 1. Description of interest rate contract data available in Y-9C reports[a]

Y-9C report number	Date range	Interest rate contract description
BHCK3424	063086-063090	Futures and forward contracts commitments to purchase
BHCK3425	063086-063090	Futures and forward contracts commitments to sell
BHCK3823	063090-123194	Interest rate contracts futures and forwards
BHCK3824	063090-123194	Written interest rate option contracts
BHCK3825	063090-123194	Purchased interest rate option contracts
BHCK8693	033195-033197	National value of interest rate futures contracts
BHCK8697	033195-033197	National value of forward interest rate contracts
BHCK8701	033195-033197	National value of written, exchange-traded interest rate contracts
BHCK8705	033195-033197	National value of purchased, exchange-traded interest rate contracts
BHCK8709	033195-033197	National value of over-the-counter written interest rate contracts
BHCK8713	033195-033197	National value of over-the-counter, purchased interest rate contracts
BHCK3450	033195-033197	National value of interest rate swap contracts

Notes: [a] Y-9C reports are filed quarterly with the Federal Reserve by BHCs with assets over $150 million or which own multiple banking subsidiaries. The column labeled "Date range" indicates the period over which the information described in the third column is available.

Although gross notional principal amount data are available for several years, these amounts do not completely describe the way derivatives affect a BHC's interest rate risk. For instance, the interest rate risk characteristics of an interest rate swap are determined by whether the holder of the swap is paying or receiving fixed or variable interest rates, as well as by other attributes such as the swap's maturity and the frequency of payments. These types of information are not detailed in Y-9C reports at the level necessary to profile the interest rate risk exposure of individual BHCs. Because our focus is on whether the BHC uses derivatives or not (as opposed to trying to quantify the extent of the risk exposure due to derivatives), the Y-9C information is suffcient to examine the question of how the market for BHC securities perceives and prices BHCs involvement with derivatives.

We examine the period March 1986 to March 31, 1997 for two reasons. First, this period is encompassed in a time frame during which the banking industry experienced problems unprecedented since the Great Depression. Moreover, during late 1980's, the number of commercial BHC failures trended upward. Between 1985 and 1997, approximately 2,300 commercial BHCs failed, with more than 75% of these failures occurring during the first six years of this period. Around this time, more than 1600 commercial BHCs insured by the FDIC were closed or received assistance – far more than any other period since the advent of federal deposit insurance in 1930's [1]. Also, this period is characterized by significant levels and changes in volatility (as measured by the standard deviation of BHC stock returns). Offsetting the increases in BHC risk which occurred during a portion of the sample time period were significant changes in the federal regulation of BHC activities, with some of these regulatory actions likely mitigating risk-taking incentives. For example, by introducing higher capital requirements and risk-based capital standards, the Financial Institutions Reform, Recovery and Enforcement Act of 1989 (FIRREA) likely reduced the ability and incentives of some BHCs to engage in risk-taking activities. This act, however, may have also provided disincentives for BHCs to hedge risks with off-balance sheet instruments, like derivative securities, because of the explicit capital charge levied on them. The sample period, then, is characterized both by economic forces leading to shifts in BHC risk taking behavior and by regulatory responses to these shifts. Such a setting should provide a powerful context for investigating the securities market responses to the risk-taking behaviors that prompted such regulations.

The second reason for choosing March 1988 to March 1997 is pragmatic: prior to the second quarter of 1986, regulatory agencies did not collect information on derivatives activity. As a result, assessments about the affect of derivative activities on systematic and unsystematic risk measures can not be conducted prior to June 1986. We avoided the pre-1987 stock market crash period to preclude outliers in stock returns.

We obtain a sample of BHCs by applying the following screens. We require that the Compustat Bank database includes monthly stock price information; these data are generally available for BHCs traded on the major stock exchanges. We further require

[1] See Federal Deposit Insurance Corporation, 1997.

that the BHC's stock have traded for at least 30 consecutive weeks during each sample year, 1988-1997; this requirement restricts the sample to relatively liquid securities. We next determine the availability of Y-9C reports for these firms. Because a unique numbering system is used to identify BHCs on the Y-9C reports (and it is not the CUSIP identifier per Bank Compustat), we hand match companies based on the company name fields in both databases. Where an unambiguous match could be found, we include the BHC in my sample. In total, 123 BHCs meet these data requirements; a list of these firms is contained in Table 2.

Table 2. List of sample BHCs

№	ID number	CUSIP	IBHC name	№	ID number	CUSIP	IBHC name
1	1078604	32165	Arnsouth Bankcorporation	63	1074923	472387	Jefferson Bankshares
2	1048812	42744	Arrow Financial Corporation	64	1068025	493267	Keycorp
3	1199563	45487	Associated Banc Corporation	65	1117781	493482	Keystone Financial, Inc.
4	1250530	55652	BSB Bancorp	66	1117183	493480	Keystone Heritage Group, Inc.
5	1117736	55763	BT Financial Corporation	67	1076002	502158	LSB Bancshares, Inc. NC
6	1134096	55918	BNHBankshares, Inc.	68	1066544	530175	Liberty Bancorp, Inc. OK
7	1068294	59438	Bank One Corporation	69	1074866	560633	Mainstreet Bankgroup
8	1097614	59692	Bancorpsouth, Inc.	70	1199497	571834	Marshall & Ilsley Corporation
9	1143481	62401	Bank of Granite Corporation	71	1068762	585509	Mellon Bank Corporation
10	1032473	66365	Bankers Trust New York Corporation	72	1094211	587342	Mercantile Bancorporation
11	1076776	68055	Barnett Banks, Inc.	73	1072442	587405	Mercantile Bankshares Corporation
12	1199460	107211	Brenton Banks, Inc	74	1023239	588448	Merchants Bancshares, Inc. VT
13	1140994	117665	Bryn Mawr Bank Corporation	75	2023012	589167	Merchants NY Bancorp, Inc.
14	1099467	126126	CNB Bancshares, Inc.	76	1070952	594930	Mid AM, Inc.
15	1029222	126600	CVB Financial Corporation	77	1037115	616880	Morgan (JP) & Company
16	1074875	153469	Central Fidelity Banks, Inc.	78	1030611	632587	National Bancorp Alaska, Inc.
17	1039502	16161A	Chase Manhattan Corporation	79	1123531	635312	National City Bancorp MN
18	1042351	173034	Citicorp	80	1069125	635405	National City Corporation
19	1027518	178566	City National Corporation	81	1093728	635449	National Comm Bancorp TN
20	1080465	195493	Colonial Bancgroup	82	1117026	637138	National Perm Bancshares, Inc.
21	1199844	200340	Comerica, Inc.	83	1073757	638585	Nations bank Corporation
22	1117679	200519	Commerce Bancorp Inc. NJ	84	1048429	659424	North Fork Bancorporation
23	1048867	203607	Community Bank Systems, Inc.	85	1199611	665859	Northern Trust Corporation
24	1078529	20449H	Compass Bancshares, Inc.	86	1120754	669380	Norwest Corporation
25	1116300	218695	Corestates Financial Corporation	87	1199705	679833	Old Kent Financial Corporation
26	1200393	220873	Corus Bankshares, Inc.	88	1075201	682419	One Valley Bancorp WV
27	1072237	226091	Crestar financial Corporation	89	1069778	693475	PNC Bank Corporation
28	1102367	229899	Cullen/Frost Bankers, Inc.	90	1025309	694058	Pacific Century financial CP
29	1116702	238282	Dauphin Deposit Corporation	91	1070617	743834	Provident Bancorp
30	1079946	249555	Deposit Guaranty Corporation	92	1039427	751366	Ramapo Financial Corporation
31	1029035	284679	Eldorado Bancorp California	93	1078332	758940	Regions Financial corporation
32	1048399	300182	Evergreen Bancorp, Inc. DE	94	1075126	766570	Riggs National Corporation
33	1074567	302374	F&M National Corporation	95	1085013	811707	Seacoast Banking Corp. FL
34	1070345	316773	Fifth Third Bancorp	96	1072107	826681	Signet Banking Corporation
35	1117204	317903	Financial Trust Corporation	97	1094828	828730	Simmons First national CP
36	1078426	318900	First American Corporation TN	98	1079441	844730	Southtrust Corporation
37	1199974	318906	First of America Bank Corporation	99	1070961	845186	Southwest National Corporation
38	1119794	319279	First Bank System, Inc.	100	1070251	855083	Star Banc Corporation
39	1118797	31928N	First Banks America, Inc.	101	1111435	857477	State Street Corporation
40	1199778	31945A	First Chicago NBD Corporation	102	1039454	859158	Sterling Bancorp NY
41	1080371	319779	First Commerce Corporation	103	1033872	866005	Summit Bancorp
42	1096523	319825	First Commercial Corporation	104	1131787	867914	Suntrust Banks, Inc.

Table 2 (continued). List of sample BHCs

№	ID number	CUSIP	IBHC name	№	ID number	CUSIP	IBHC name
43	1028355	319900	First Commercial Bancorp, Inc.	105	1078846	87161C	Synovus Financial CP
44	1037003	320076	First Empire State Corporation	106	2367921	890110	Tompkins County Trustco, Inc.
45	1071276	320209	First Financial Bancorp, Inc. OH	107	1030330	894069	Transworld Bancorp CA
46	1025608	320506	First Hawaiian, Inc.	108	1048513	898349	Trustco Bank Corp NY
47	1029428	33615C	First Regional Bancorp	109	1079562	898402	Trustmark Corporation
48	1024058	336294	First Security Corporation DE	110	1049828	902788	UMB Financial Corporation
49	1199602	336901	1ST Source Corporation	111	1111583	902900	UST Corporation
50	1094640	337162	First Tennessee National Corporation	112	1094369	908068	Union Planters Corporation
51	1073551	337358	First Union Corporation NC	113	1250259	910909	United National Bancorp NJ
52	1071968	337477	First Virginia Banks, Inc.	114	1025071	911596	US Bancorp
53	1199479	33761C	Firstar Corporation	115	1048184	91288L	US Trust Corporation
54	1202137	337613	Firstbank Illinois Company	116	1117316	917292	US Bancorp, Inc.
55	1113514	338915	Fleet Financial Group, Inc.	117	1048773	919794	Valley National Bancorp
56	1207002	349337	Fort Wayne National Corp. IN	118	1114931	924180	Vermont Financial Services Corporation
57	1416859	352433	Franklin Bancorporation, Inc.	119	1136157	929771	Wachovia Corporation
58	1117129	360271	Fulton Financial Corporation	120	1027095	949740	Wells Fargo & Company
59	1048625	404382	Hubco, Inc.	121	1025541	957090	Westamerica Bancorporation
60	1078921	428656	Hibernia Corporation	122	1888193	971807	Wilmington Trust Corporation
61	1068191	446150	Huntington Bancshares	123	1027004	989701	Zions Bancorporation
62	1199732	464119	Irwin Financial Corporation				

Table 3 provides some summary descriptive information on the sample firms, measured as of the end of the first quarter of 1997. The average size (in terms of total assets) of the sample BHC is $25.0 billion. The smallest institution reported assets of roughly $150 million; this compares to over $340 billion for the largest sample institution. In general, the sample institutions are large relative to the average BHC in the Compustat population (many of which are not exchange traded). Although the sample BHCs are not likely to be representative of all BHCs, the combined total assets of the sample firms comprise the majority of the assets in the banking industry and make up the bulk of the exposure in the industry. In particular, on March 31, 1997, the total assets of the sample BHCs are roughly $3.1 trillion, or approximately 73% of the total assets of all financial top-tier BHCs filing consolidated regulatory reports at that time.

Table 3. Descriptive statistics

Variable	Symbol	NOBS	Mean	Std. Error	Minimum	Maximum
DUMMY	I_{bt}^{U}	13204	0.598152	0.490290	0.000000	1.000000
SIZE	x_{b1t-1}	13083	14.674146	1.608853	11.264079	19.003907
CAPITAL	x_{b2t-1}	13204	0.077452	0.017537	0.023330	0.170870
CI	x_{b3t-1}	12776	0.149485	0.077397	0.003100	0.518000
RESLOAN	x_{b4t-1}	12962	0.294749	0.122104	0.003950	0.769360
GAP	x_{b5t-1}	12971	0.189531	0.158809	-0.481320	0.924910
NONPERF	x_{b6t-1}	13078	0.016503	0.015458	0.000401	0.130546
RESERVE	x_{b7t-1}	13083	0.019715	0.0114779	0.004928	0.127502
EQRET	R_{bt}	13204	0.010203	0.082065	-0.606578	2.271466
BHCRET	R_{bt}	13196	0.002417	0.006067	-0.055148	0.133588

Table 3 (continued). Descriptive statistics

Variable	Symbol	NOBS	Mean	Std. Error	Minimum	Maximum
MKTRET	R_{Mt}	13204	0.006502	0.033130	-0.105471	0.102306
CHGINT	R_{It}	13200	-0.000013	0.000173	-0.000467	0.000350
CRSPREAD	R_{Ct}	13204	0.000693	0.000165	0.000458	0.001175
L	L_{bt}	12657	0.143103	0.453200	-0.276030	2.292235
L × MKTINT	$L_{bt} \times R_{Mt}$	12657	0.000792	0.015678	-0.209621	0.186824
L × CHGINT	$L_{bt} \times R_{It}$	12653	-0.000002	0.000081	-0.000825	0.000617
L × CRSPREAD	$L_{bt} \times R_{Ct}$	12657	0.000099	0.000325	-0.000324	0.002244
LATENT	$LATENT_{bt}$	12657	0.853405	0.686566	0.000159	2.976810
CDF	$N(\varepsilon_{bt})$	12657	0.611543	0.326293	0.003957	0.999975

$$L_{bt} = z_{bt}^{U}(\theta) I_{bt}^{U} + z_{bt}^{N}(\theta) I_{bt}^{N} ,$$

$$LATENT_{bt} = z_{bt}^{U}(\theta) - z_{bt}^{N}(\theta) .$$

As discussed earlier, we use a modified three-factor market model to derive measures of systematic and unsystematic risk. The three factors include indices relating to market-portfolio returns, interest rate changes, and credit spreads, each of which has been shown in previous research to explain returns in banking. For each sample firm, we calculate monthly stock returns for 1986.06 to 1997.03 using month end stock prices, adjusted for stock dividends and stock splits, from the Compustat Bank database[1].

The monthly return on the equally-weighted Standard & Poor's 500 index of stocks is used to proxy for the market portfolio return. Bloomberg Financial Services provided the month-end index of the S&P 500. We approximate the market return as the log of the ratio of the current month-end index to the previous month-end index[2]. The interest rate factor (R_{It}) represents the monthly change in yields on 30-year constant maturity U.S. Treasury bonds. The yield series used to construct R_{It} is obtained from the Federal Reserve Economic Data (FRED), maintained by the Federal Reserve Bank of St. Louis. Finally, the credit spread factor (R_{Ct}) equals the difference between the yields on Moody's BAA- and AAA-rated corporate bonds reported at the end of month t. This factor is used to proxy for the general credit conditions of the economy: widening (narrowing) spreads suggest deterioration (improvement) in credit conditions. The corporate bond yield series was obtained from the Board of Governors FAME database.

4. Empirical results

Table 3 shows summary information on the independent variables in the probit model for the entire sample. In total, there are 123 BHCs and 111 monthly observations from January 1988 through March 1997, but 15,610 firm-month observations with data on at least one of the probit variables are available. About 59.8% of the observations represent users and the remaining reflect non-users.

Table 4 presents the results of the probit estimation. In total, 13,040 observations are usable in the estimation. Each of the variables is statistically significant (at the 0.01 percent level) in explaining the probability of derivatives use. The positive coefficient on loan size is consistent with the informational and scale-economies hypothesis. The significant negative coefficients on RESLOAN (residential mortgages to total loans), and CAPITAL (total capital to total assets) and the significant positive coefficient on GAP (one-year sensitivity gap to total assets) are consistent with the market discipline hypothesis. The NONPERF (the ratio of 90+ days past due loans to total loans) is significantly negatively related to the probability of derivative use, consistent with the moral hazard hypothesis. The significantly negative coefficient of CAPITAL lends support to the moral hagard hypothesis that weaker BHCs are more prone to use derivatives than stronger BHCs.

[1] The Federal Reserve Bank of San Francisco supplied these data.

[2] This approximation is consistent with other measures commonly used in the capital markets literature.

Table 4. Probit estimates of determinants of derivative use at BHCs:

Dependent variable, $I_{bt}^{U}=1$ whenever derivative securities are used for trading, and 0 otherwise

Variable	Symbol	Estimate	Std. Error	*t*-stat	*p*-value
Constant		-8.333	0.213	-39.05	0.00000
Size	(x_{b1t-1})	0.705	0.013	53.61	0.00000
Capital	(x_{b2t-1})	-15.968	0.900	-17.74	0.00000
CI	(x_{b3t-1})	-0.849	0.201	-4.23	0.00001
Resloan	(x_{b4t-1})	-1.182	0.126	-9.41	0.00000
Gap	(x_{b5t-1})	0.843	0.092	9.15	0.00000
Nonperf	(x_{b6t-1})	-5.895	1.371	-4.30	0.00001
Reserve	(x_{b7t-1})	7.811	1.939	4.03	0.00003

We use the parameter estimates from the probit regression to calculate the values of the conditional means of the latent information, i.e., $z_{bt}^{U}(\theta)$ and $z_{bt}^{N}(\theta)$ in equation (17). We then use standard OLS procedures to estimate equation (17). Table 5 presents the results of estimation based on four different assumptions. Basic Model in Table 5 is simply equation (1) pooled for all BHCs, i.e., when α_b, β_{Mb}, β_{Ib}, β_{Cb} are common to all BHCs and $\delta_M = \delta_I = \delta_C = 0$. The systematic risk estimates in Basic Model can be interpreted as banking industry's common factor risks. For example, a market beta estimate of .047 is the asset beta of an average BHC. Similarly, the interest rate risk estimate of -1.381 and credit risk estimate of -15.449 are pooled across all BHCs. The unconditional levels of systematic market risk, interest rate risk, and credit risks are all statistically significant. Asset returns are positively associated with the market factor, but negatively associated with the interest rate and credit spread factors. The positive market beta of assets implies that, on average, the present value of BHCs' asset portfolios increases as returns on the market portfolio increase. The negative interest rate beta and credit spread beta imply that the BHC asset value decreases as interest rates rise or credit risk of the economy moves up.

Table 5. Systematic risk shift due to derivative use dependent variable is asset return, R_{bt} :

$$R_{bt} = \alpha_b + \sum_{j=M,I,C} \left[\beta_{jb} + \delta_j L_{bt}\right] R_{jt} + \zeta_{bt}\,, \quad L_{bt} = z_{bt}^{U}(\theta) I_{bt}^{U} + z_{bt}^{N}(\theta) I_{bt}^{N}$$

Variable	Symbol	Basic model*		Model I*		Model II*		Model III*	
		Estimate	t-stat	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat
L × MKTRET	$L_{bt} \times R_{Mt}$			-0.013	-3.19	-0.008	-2.00	-0.005	
L × CHGINT	$L_{bt} \times R_{It}$			1.208	1.59	0.806	1.11	0.398	
L × CRSPREAD	$L_{bt} \times R_{Ct}$			2.118	13.18	0.416	2.60	0.468	
CONSTANT		0.002	39.40			0.002	36.66	†	
MKTRET	R_{Mt}	0.047	28.78	0.059	31.39	0.050	27.64	†	
CHGINT	R_{It}	-1.381	-4.43	-1.752	-4.88	-1.387	-4.06	†	
SPRDIFF	R_{Ct}	-15.449	-13.87	-18.112	-15.30	-15.095	-13.38	†	
Adjusted R^2		0.09414		0.00134		0.09728		0.14046	

Notes: * All models but Model III assume the same $\alpha_b, \beta_{Mb}, \beta_{Ib}, \beta_{Cb}$ for all firms. In the Basic Model $\delta_M = \delta_j = \delta_c = 0$. Model I and Model II are the same, except that the former has no intercept. † These are different for all firms.

Model I and Model II in Table 5 are also pooled across all BHCs, except that δ_M, δ_I, and δ_C are free parameters estimated from data. Model II has an intercept term that Model I does not have. These results show that derivative trading significantly reduces the market risk, but increases the credit risk and interest rate risk of BHCs. Results based on a more flexible Model III show that one has to exercise caution in making inferences based on Models I and II.

Model III in Table 5 presents estimates of BHC-specific coefficients $(\alpha_b, \beta_{Mb}, \beta_{Ib}, \beta_{Cb})$ and pooled coefficients δ_M, δ_I, and δ_C. Although δ_M, δ_I, and δ_C are pooled, shifts in systematic risks $\delta_j L_{bt}$, where $L_{bt} = z_{bt}^U(\theta)\, I_{bt}^U + z_{bt}^N(\theta)\, I_{bt}^N$, are BHC-specific since L_{bt} is dependent on BHC-specific attributes. We obtain 123 α_b estimates and 123 estimates each of $(\beta_{Mb}, \beta_{Ib}, \beta_{Cb})$, but cannot report in Table 5 due to space restrictions. However, the δ_M, δ_I, and δ_C estimates, which are of interest to us are presented in Table 5. These estimates show that shifts in the market risk and interest rate risk due to derivative use are statistically insignificant. The credit risk, however, increases statistically significantly due to derivative use.

Tables 6 presents results of estimation of (18). The significantly negative estimate of δ_σ (coefficient of L_{bt}) in this table shows that the idiosyncratic risk of derivative users is lower than that for the non-users. But the coefficient is estimated statistically insignificantly. We replicate the estimations by using equity return in place of asset return as the dependent variable in (17) and present the results in Tables 7 and 8. These results are consistent with those obtained for asset returns, except that the shift in the credit risk as measured by the estimate of δ_C in Table 7 is statistically insignificant, though positive.

Table 6. Idiosyncratic risk shifts due to derivative use dependent variable is asset return error, $2\ln(\hat{\zeta}_{bt}^2)$:

$$\ln(\hat{\zeta}_{bt}^2) = \gamma_0 + \delta_\sigma L_{bt} + k_{bt}.$$

Variable	Model I		Model II		Model III	
	Estimate	*t*-stat	Estimate	*t*-stat	Estimate	*t*-stat
CONSTANT	-11.567	-443.98	-11.968	-362.19	-12.023	-361.20
L_{bt}	-0.318	-5.23	-0.076	-1.07	-0.070	-0.98
Adjusted $\hat{R}^2$	0.00344		0.00019		0.00016	

Table 7. Systematic risk shift due to derivative use dependent variable is asset return, R_{bt}:

$$R_{bt} = \alpha_b + \sum_{j=M,I,C} \left[\beta_{jb} + \delta_j L_{bt}\right] R_{jt} + \zeta_{bt}, \quad L_{bt} = z_{bt}^U(\theta) I_{bt}^U + z_{bt}^N(\theta) I_{bt}^N$$

Variable	Symbol	Basic model*		Model I*		Model II*		Model III*	
		Estimate	t-stat	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat
L × MKTRET	$L_{bt} \times R_{Mt}$			-0.142	-2.81	-0.132	-2.60	-0.079	-1.08
L × CHGINT	$L_{bt} \times R_{It}$			9.247	0.95	8.390	0.86	0.835	0.06
L × CRSPREAD	$L_{bt} \times R_{Ct}$			8.054	3.91	4.426	2.06	4.643	1.55
CONSTANT		0.005	6.71			0.004	5.80	†	
MKTRET	R_{Mt}	0.683	31.09	0.739	30.86	0.720	29.81	†	
CHGINT	R_{It}	-22.912	-5.47	-24.038	-5.22	-23.261	-5.06	†	
SPRDIFF	R_{Ct}	-182.662	-12.18	-184.745	-12.18	-178.313	-11.74	†	
Adjusted R^2		0.10376		0.10474		0.10712		0.15761	

*All models but Model III assume the same $(\alpha_b, \beta_{Mb}, \beta_{jb}, \beta_{cb})$ for all firms. In the Basic Model $\delta_M - \delta_j - \delta_c - 0$. Model I and Model II are the same, except that the former has no intercept. † These are different for all firms.

Table 8. Idiosyncratic risk shifts due to derivative use dependent variable is equity return error, $\ln(\zeta_{bt}^2)$:

$$\ln(\zeta_{bt}^2) = \gamma_0 + \delta_\sigma L_{bt} + k_{bt}$$

Variable	Model I		Model II		Model III	
	Estimate	*t*-stat	Estimate	*t*-stat	Estimate	*t*-stat
CONSTANT	-6.898	-212.39	-6.890	-208.50	-6.987	-208.66
L_{bt}	-0.107	-1.49	-0.117	-1.62	-0.052	-0.71
Adjusted $\overline{R}^2$	-0.00035		0.00045		0.00009	

Table 9 presents results from a two-step procedure in which time series of $(\beta_{Mb}, \beta_{Ib}, \beta_{Cb})$ are estimated in the first step using model (1) and moving sets of past observations in the sample starting with the 48th month in the sample period. The results in this table are thus based on the latest 64 months of our sample period. In the second step, we regress the estimated betas on firm-specific attributes as well as the derivative use dummy. The first three columns of results are based on regression of estimated market risk, interest rate risk and credit spread risk, respectively, on firm-specific attributes. In the last column of Table 9, we report the regression of the natural log of the squares of residuals, obtained from one-pass estimation of (1), on firm-specific attributes. Table 9 shows that the market risk falls significantly due to derivative use, while the interest rate risk and credit risk rise due to derivative trading. As argued earlier, conclusions based on this two-step procedure are not very reliable mainly due to the fact that it does not account for endogenous choices by BHCs.

Table 9. Regressing systematic risk estimates (market beta, interest rate beta, credit spread beta, or unique risk) on firm-specific attributes.

Monthly time series of betas for period January 1993 through March 1997 have been estimated using equation (1) and sample data upto the month. Unique risk is proxied by the log of squared residuals from regression (1) over the entire sample period.

Variable	Market beta		Interest rate beta		Credit spread beta		Log of unique risk	
	Estimate	*t*-stat	Estimate	*t*-stat	Estimate	*t*-stat	Estimate	*t*-stat
CONSTANT	-1.844	-46.77	-149.358	-17.53	-127.222	-18.58	-5.602	-13.18
DERV DUMMY	-0.022	-2.78	13.771	8.17	9.446	6.97	-0.032	-0.37
SIZE	0.171	71.30	5.018	9.66	10.500	25.15	-0.096	-3.70
CAPITAL	-1.000	-5.09	450.081	3.40	-199.435	-5.84	-10.165	-4.61
CI	0.399	9.47	30.955	4.05	-8.778	-1.20	2.175	4.65
RESLOAN	-0.116	-4.21	24.154	-0.38	-11.232	-2.35	0.855	2.82
GAP	0.255	13.18	-1.589	14.75	38.585	11.46	-0.442	-2.08
NONPERF	3.250	12.32	841.453	-5.24	-32.773	-0.72	21.475	7.17
RESERVE	3.312	9.62	-390.025		-396.010	-6.62	2.329	0.61
Adjusted $\overline{R}^2$	0.50564		0.04959		0.13705		0.03374	

Observe that while BHCs that trade derivatives increase their credit risk, one should not presume that any BHC that is currently not using derivatives will necessarily increase its credit risk by changing its decision. This uncertainty arises because the choice of whether to use derivative trades is endogenous and made conditional on information about firm risks not fully known by or revealed to the market. Some BHCs will likely find it beneficial not to trade derivatives. To examine this issue in the context of our empirical results, note that the risk (systematic or unsystematic) differential between users and non-users is monotonically related to the *k*-th attribute x_{bkt-1} in the set of BHC characteristics x_{bt-1}. The systematic risk differential between users and non-users is basically the difference between the expressions in (15) and (16). The unsystematic risk differential is given in (20). For brevity, let $\delta_j \Delta(\theta' x_{bt-1})$ denote the risk differential between users and non-users, for $j = M, I, C, \sigma$, where

$$\Delta(Q' x_{bt-1}) \equiv [z_{bt}^U(Q' x_{bt-1}) - z_{bt}^N(Q' x_{bt-1})]. \quad (22)$$

It can be checked that $z_{bt}^{N}(\theta' x_{bt-1})$ is an increasing function of $(\theta' x_{bt-1})$ and $z_{bt}^{U}(\theta' x_{bt-1})$ is a decreasing function of $(\theta' x_{bt-1})$ (See, e.g., Acharya, 1993). Thus, $\Delta(\theta' x_{bt-1})$ is a decreasing function of $(\theta' x_{bt-1})$. Then, we can check that

$$\underbrace{\frac{\partial[\delta_j \Delta(Q' x_{bt-1})]}{\partial x_{bkt-1}}}_{risk\ differential} = \delta_j Q_k \times [\underbrace{\frac{\partial[\Delta(Q' x_{bt-1})]}{\partial(Q' x_{bt-1})}}_{-ve}]. \quad (23)$$

Thus, the risk differential increases (decreases) due to a rise in the value of one of the BHC-specific attributes if and only if the attribute's coefficient in the probit model θ_j and the effect of latent risk δ_M, δ_I, and δ_C in (17), have the opposite (same) sign. Since δ_C is estimated to be significantly positive, the credit risk will be negatively related to a BHC-specific attribute if and only if the attribute has a significantly positive coefficient estimate in the probit model.

Table 4 shows that SIZE, GAP and RESERVE are significantly positively related to the probability of derivative use. These attributes are thus negatively related to the credit risk of BHCs. This means larger BHCs face lower credit risk due to derivative trading. BHCs with larger RESERVE allocations for loan losses also experience a lower credit risk due to derivative use. Derivative users with a larger value of GAP face smaller credit risk. Other BHC-specific attributes, such as, CAPITAL, CI, RESLOAN and NONPERF, are significantly negatively related to the probability of derivative use and, hence, raise the credit risk for derivative users. BHCs with high capital ratios or large commercial and industrial loan portfolios, large amount of residential and non-performing loans tend to increase their credit risk exposures due to derivative trading. It is reasonable that high levels of non-performing loans should enhance the credit risk of derivative users. It is not entirely clear, however, why BHCs with larger capital ratios (CAPITAL) and residential mortgages (RESLOAN) or commercial loans (CI) should face greater credit risks due to derivative trades. One reason could be that these BHCs ordinarily have low risks and derivative trading may cause a small absolute change in the risk, but this change may be large relative to the low risk.

Conclusion

This paper examines whether BHCs' use of derivative contracts affects the risk profiles of these institutions. We find that BHCs that use derivative trading significantly increase their systematic credit risk, while experiencing no significant change in the interest rate risk and market risk exposures. The effect of derivative-based hedging is statistically insignificant to the unsystematic risk of BHCs. We present a methodology for measurement of the effect of latent information in the choice of derivative trading by BHCs. Clearly, BHCs have a choice either to expand their loan portfolio to include more independent loans to enhance diversification or to hedge their risk based on derivative trading. Ultimately, the resulting decision will be BHC-specific and depend on a BHC's attributes as well as its choice process based on the latent evaluation of risk containment.

Our econometric approach deals with measurement of systematic effects associated with latent information-based endogenous choices of firms. This methodology can be applied to measure systematic effects of corporate firm policy changes – like dividend or capital structure – with no specific announcement event or associated effects. This departs from the existing event study methodologies designed for well-defined event announcement dates.

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