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MEASURING THE EFFICIENCY OF CAPITAL ALLOCATION IN COMMERCIAL BANKING

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Abstract

Commercial banks leverage their equity capital with demandable debt that participates in the economy's payments system. The distinctive nature of this debt generates an unusual degree of liquidity risk that can, at times, threaten the payments system. To reduce this threat, insurance protects deposits; and to reduce the moral hazard problems of the debt contract and deposit insurance, bank regulation constrains risk-taking and defines standards of capital adequacy. The inherent liquidity risk of demandable debt as well as potential regulatory penalties for poor financial performance creates the potential for costly episodes of financial distress that affects banks' employment of capital.

The existence of financial-distress costs implies that many banks are likely to take actions, such as holding additional capital, that increase bank safety at the expense of short-run returns. While such a strategy may reduce average returns in the short run, it may maximize the market value of the bank by protecting charter value and protecting against regulatory interventions. On the other hand, some banks whose charter values are low may have an incentive to follow a higher risk strategy, one that increases average return at the expense of greater risk of financial distress and regulatory intervention.

This paper examines how banks' employment of capital in their production plans affects their "market value" efficiency. We develop a market-based measure of production efficiency and implement it on a sample of publicly traded bank holding companies. Our evidence indicates that banks' efficiency and, hence, the market value of their assets are influenced by the level and allocation of capital. However, even controlling for the effect of size, we find that the influence of equity capital differs markedly between banks with higher capital-to-assets ratios and those with lower ratios. For inefficient banks with higher capital-to-assets ratios, marginal increases in capitalization and asset quality boost their market-value efficiency. For inefficient banks with lower levels of capitalization, the signs of these effects are reversed. Controlling for asset size, it appears that less capitalized banks cannot afford to mimic the investment strategy of more capitalized banks, which may be using this greater capitalization to signal their safety to financial markets.

Introduction

A. Demandable Debt and the Roles of Equity Capital

Equity capital performs distinctive roles in commercial banking that complicate the problem of employing it optimally. These distinctive roles arise from commercial banks' leveraging equity capital with demandable debt that participates in the economy's payments system. This demandable debt--banks' demand deposits--affords them a comparative advantage over nonbank lenders in obtaining information needed to assess credit risk and to monitor customers' financial performance. Hence, commercial banks specialize in producing information-intensive assets and off-balance-sheet products, such as loans, credit guarantees, and swaps.[1] Their employment of capital to produce these products and to obtain the benefits of leverage reflects this comparative advantage.

Demandable debt also gives banks a comparative advantage over nonbank lenders by reducing the moral hazard problem inherent in the debt contract.[2] Unlike equity, debt payments are fixed and, thus, do not vary with the financial success of the assets financed by the debt. As a result, the borrower has an incentive to substitute riskier assets to seek a greater payoff, but this higher expected payoff is unlikely to increase the value of equity more than it decreases the value of debt so that the market value of assets is diminished by shifting risk to debtholders. On the other hand, when debtholders can demand repayment at par at any time, particularly any time they suspect risk shifting, the incentive to engage in asset substitution is reduced. Since the informational advantage in assessing credit risk that banks obtain from their demandable debt is equivalently an informational asymmetry between them and their depositors concerning the riskiness of banks' assets, uninsured depositors have an incentive to liquidate their claims whenever bank assets *appear* to be unduly risky. The demandable nature of these uninsured claims translates the appearance of poor asset quality into a probable liquidity crisis for the bank. In turn, this liquidity risk disciplines bank risk-taking. Thus, demandable debt not only offers an informational

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[1]See Bhattacharya and Thakor (1993) for a review of the extensive literature on banking theory.

[2]See Jensen and Meckling (1976) for a discussion of the debt contract's moral hazard problem.

advantage in lending, but it also reduces the debt contract's inherent incentive for the borrower to substitute riskier assets that transfer value from debtholders to shareholders. Hence, the discipline that demandable debt exerts over bank risk-taking influences the level and allocation of capital and improves the value of banks' assets.

The demandable nature of banks' debt does not entirely eliminate this moral hazard problem. In the usual debt contract, covenants protect the debtholders from risk-shifting. However, DeYoung, Hughes, and Moon (1997) note that banks' depositors are not explicitly covered by such covenants; instead, bank regulation substitutes for these missing covenants. To issue demandable debt that participates in the economy's payments system, banks must obtain a valuable charter and comply with numerous safety-and-soundness regulations (or covenants). When banks experience episodes of financial distress, they must submit to additional regulatory constraints (or remedial covenants) on their risk-taking and may even have their charters revoked. To reduce these expected costs of financial distress, banks are likely to take actions that increase bank safety at the expense of short-run returns.[3] While such a strategy decreases current profitability, it maximizes banks' market value by protecting them from liquidity crises, regulatory intervention, and loss of their valuable charters. The employment of capital is an important part of this stategy. Its allocation to risk-producing assets and off-balance-sheet products shapes banks' overall risk while its level directly protects banks from financial distress. Moreover, the level of capital also signals a bank's safety to less informed creditors, since it represents the bank's own bet on asset quality.[4] To the extent that banks can credibly signal their asset quality, they can reduce the probability of liquidity crises, lower the cost of their borrowed funds, and, hence, increase their market value.

Since neither the demandable nature of bank debt nor the disciplining covenants of

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[3]See Smith and Stulz (1985) for a discussion of the effect of potential financial distress on the firm's investment strategy. Tufano (1996) and Smith and Stulz (1985) examine various reasons why value-maximizing firms might trade current profits for reduced risk.

[4]For example, Ross (1977) and Leland and Pyle (1977) employed a signaling framework to illustrate how capital structure can resolve informational asymmetries. Greenbaum and Thakor (1995) give several examples of different signaling mechanisms in lending. Hughes and Mester (forthcoming) find evidence from cost data that banks use capital to signal risk.

bank regulation completely eliminate the potential for liquidity crises and disruptions to the payments system, bank deposits are protected by deposit insurance. Deposit insurance eliminates the need for insured depositors to fear asset substitution. To the extent that this component of bank discipline is replaced by insurance premiums that properly price risk-taking, insurance should not lead to increased moral hazard. However, when a bank's insurance is underpriced, it subsidizes risk-taking and works against the risk-reducing incentives of financial distress.[5] Thus, the optimal employment of capital is influenced, as well, by the risk subsidy of mispriced deposit insurance.

In summary, the problem of allocating capital efficiently must account for the roles of capital as a source of loanable funds, as protection against financial distress, and as a signal of risk. In addition, it must allow for the incentives created by mispriced deposit insurance. Banks that achieve efficient allocations maximize the market value of their assets. To investigate how commercial banks' employment of equity capital affects their financial performance, we develop a market-based measure of production efficiency and implement it on a sample of publicly traded bank holding companies. We test how banks' employment of capital in their production plan affects their "market-value" efficiency, and we draw conclusions about the efficient allocation of capital in commercial banking. In particular, we find evidence of a signaling equilibrium where banks signal better asset quality with their capitalization.

B. Measuring Bank Efficiency

Numerous studies have measured bank efficiency by estimating frontier cost and profit functions to identify "best-practice."[6] However, the ultimate arbiter of bank efficiency is the market value of the bank. If financial markets are informationally efficient, a bank's efficiency should be reflected in its market value. The standard profit and cost functions may not fully account for market value. Modigliani and Miller (1958) note that, when uncertainty

[5]See Merton (1977).

[6]Berger and Humphrey (1997) and Berger and Mester (1997) provide an extensive survey of this literature.

exists, the objective of profit maximization fails to account for the riskiness of the production plan and, hence, the rate of interest at which the stream of profits is discounted. Thus, maximizing the market value of the firm to its owners is a more appropriate goal of the firm's managers. Another advantage of using market values to measure efficiency is that these values reflect not only the current prices and quantities of inputs and outputs, but also all relevant expected future cash flows and expected costs of financial distress. If a firm undertakes expenditures that have low or even negative returns in the short run, but increase profits in the future, efficient financial markets will accurately reflect the discounted value of those expenditures. Thus, if a bank's management is efficiently taking actions that lower profitabilitiy while protecting charter value and guarding against liquidity crises and regulatory interventions, we would expect these decisions to increase the market value of the bank.

Since a bank's market value reflects all these various considerations, we propose to measure the bank's efficiency by comparing its market value to those of its peers. To compute market-value inefficiency, we identify "best-practice" banks of a given size by estimating a stochastic frontier for the market value relative to the book value--both of assets and of equity. We measure inefficiency by the distance of the bank's observed market value from the "best-practice" market value on the frontier. This distance is the bank's lost market value due to its production inefficiency and its poorer market opportunities. We designate this distance as the bank's *market-value inefficiency*, and we ask how it responds to the bank's employment of capital in its production plan.

We have suggested that some banks might improve market value by increasing safety at the expense of lower short-term profits. These banks would reduce their market-value inefficiency by lowering leverage and generally lowering risk. On the other hand, some banks may be able to profitably exploit the deposit insurance subsidy and will increase market value by increasing leverage and taking greater risk. We find evidence in our data of both types of banks. These two types are distinguished by their degree of capitalization. Controlling for size, we find that banks with high capital-to-assets ratios increase market value when they increase capital or raise the quality of their assets. In contrast, banks with

low capital-to-assets ratios enhance their market value when they increase leverage and assume greater credit risk. This dichotomy in capital's effect on market value appears consistent with the signaling role of capital. More capitalized banks seem able to signal their relatively low risk credibly and, consequently, to increase their market value. To the extent that these banks are inefficient because of their employment of capital, they can reduce this inefficiency by *increasing* their capitalization. To the extent that less capitalized banks are inefficient because of their employment of capital, they diminish this inefficiency by *decreasing* their capitalization.

In the sections that follow, we consider banks' unique asset production problem that results from leveraging their portfolios with demand deposits. We show how banks that are efficient producers of assets maximize their market value. We suggest that capital plays a dichotomous role in promoting market-value efficiency, a role that depends on the amount of risk banks assume in their production plans. Finally, we develop our market-value measures of efficiency and apply them to a sample of the highest level bank holding companies[7] in the United States in 1994 to investigate how banks' employment of capital influences their financial performance.

1. Efficient Production and the Employment of Capital[8]

Individual investors all face the same efficient risk-return frontier of market assets. Their choice set is determined exogenously by the risk and return characteristics of individual securities they purchase. Banks, however, face a more complex investment problem than that of individual investors. On the one hand, commercial banks in the United States cannot legally invest in many of the assets found in the individual investor's portfolio, but, on the other hand, only commercial banks can leverage their portfolios with demand deposits.

[7]Lower level holding companies--holding companies owned by the highest level companies--are not individually included in the sample since their business strategies are likely to depend on the strategy of their highest level owner. Hence, only the highest level companies are considered.

[8]The discussion in this section relies on Hughes and Moon (1995).

These deposits give commercial banks a comparative advantage in producing and investing in information-intensive loans. Hence, banks not only *purchase* assets, but they also use this comparative advantage to *produce* assets. When banks are efficient investors, they are also efficient producers.

Banks combine labor and physical capital as well as equity capital and borrowed funds to produce information-intensive assets and off-balance-sheet products. The production process for these assets and products involves collecting information, assessing credit risk, writing contracts, monitoring borrowers' financial performance, and managing borrowers' financial distress. Banks that are more efficient at accomplishing these tasks expect a higher return and a lower variance of return on individual loans. Hence, banks that are more efficient producers reduce both the systematic and idiosyncratic components of an individual loan's total variance through better credit assessment, contract writing, and monitoring.[9] Unlike individual investors, banks can influence the magnitude of an individual asset's systematic risk or "beta." When loans are combined in banks' portfolios, more efficient banks can expect a lower variance for any given return on their portfolios. Thus, capital markets price this efficiency.

Like individual investors, banks are concerned with the diversification of their portfolios and with their asset compositions. However, since banks are producing assets, their portfolios have a geographic reference that is associated with the location of their production processes. Banks in the United States have historically faced a number of legal restrictions on branching that have limited their size and ability to diversify geographically. These restrictions have led banks to seek other avenues of diversfication by using such means as loan participations, correspondent-respondent relationships, and interstate holding companies. These restrictions on branching have considerably complicated banks' investment decisions.

Because banks produce as well as purchase assets, their portfolio production processes generate idiosyncratic risk that is not eliminated by simply combining assets in banks' portfolios. Although banks' owners can diversify this risk in their own portfolios,

[9]Flannery (1989) made a similar point in a different context.

they cannot eliminate its effect on the expected cost of financial distress. Since idiosyncratic risk as well as systematic risk influences the probability of financial distress, it is likely that idiosyncratic risk will affect market value. Given two banks with the same total return, the bank that is more efficient at controlling idiosyncratic risk as well as systematic risk is likely to have a higher total market value, *ceteris paribus*.[10]

A bank's market value, of course, ultimately depends on the market's *perception* of its risk. The actual quality of a bank's assets and the resources and skill a bank brings to the task of maintaining asset quality are relatively opaque to outsiders. If banks with high quality assets can credibly signal their low risk to outsiders, they can improve their market value in two ways. First, by lowering the cost of borrowed funds, they improve their cash flows, and, second, by reducing the information asymmetry between bank insiders and outsiders, low-risk banks can decrease the "lemons" mark-up on the discount rate applied to their cash flows.

2. The Signaling Role of Equity Capital

Since capital is a cushion against losses and, hence, protection against financial distress, its level influences the probability of financial distress and is a critical consideration in dealing with liquidity risk. Moreover, since capital represents the bank's own bet on the quality of its assets and on its efforts at maintaining asset quality, the level of capital can function as a credible signal of the bank's exposure to risk.

Given their asset sizes, lower-risk banks may choose to hold higher levels of capital as a signal to outsiders that their exposure to risk is lower. A higher-risk bank cannot afford to mimic a lower-risk bank's signal because the opportunity cost of holding this extra capital

[10]Levy and Sarnat (1970) made a similar point about idiosyncratic risk in relation to conglomerate mergers. They argued that two unrelated firms that merge can reduce the expected costs of bankruptcy because there may be some states of nature where the cash flow from one subsidiary can be used to prevent the other subsidiary from entering bankruptcy. The authors note that this reduction in expected bankruptcy costs cannot be replicated by an external investor. This result has a direct parallel to a bank that merges with another bank since the expected costs of financial distress can be reduced in a way that an investor, such as a depositor, cannot duplicate. Therefore, the reduction of idiosyncratic risk via bank-initiated rather than investor-initiated diversification may affect the market value of the bank.

is greater for them. These banks, by definition, hold riskier assets than lower-risk banks, and, in an informationally efficient loan market, they expect a higher return on their assets than do lower-risk banks to compensate them for their assets' greater expected losses and variance. This difference in opportunity costs creates the potential for a separating equilibrium. If there were a pooling equilibrium, the average cost of borrowed funds would result in a "lemons" penalty on borrowing for lower-risk banks that would encourage them to take a greater equity stake in their assets' better-than-average performance, while, for higher-risk banks, the average cost of borrowed funds would represent a subsidy on borrowing, like the subsidy created by mispriced deposit insurance, that could be exploited by taking additional risks through increased leverage and reduced asset quality. Hence, these differences in incentives between higher and lower-risk banks can lead to a separating equilibrium in which higher-quality banks are able to signal their lower risk to outsiders by their degree of capitalization--the stake they take in the performance of the assets they produce. This signal is credible because the higher-risk banks cannot afford to mimic it.[11] The potential for signaling suggests that we might observe a distribution of capital structures in which the highest-quality banks, controlling for asset size, have the highest capitalization while the lowest-quality banks are least capitalized. Hence, the role of capital in promoting market-value efficiency is likely to differ across this distribution of structures.

3. Efficiency Measurement Using Market Values

To measure efficiency, we focus on the difference between banks' market and book values of assets. In the absence of agency problems, maximizing the value of a firm's equity is equivalent to maximizing the value of its assets. However, the potential for agency problems, such as asset substitution, raises the possibility that maximizing the market value

[11]The "lemons" penalty for borrowing not only encourages safer-than-average banks to use greater equity financing, it also gives them the incentive to hold larger amounts of marketable government securities to avoid having to meet liquidity needs either by uncollaterized borrowing or by selling information-intensive assets, a point made by Lucas and McDonald (1992) to motivate a model in which holdings of government securities serve as a signal of risk.

of equity leads to a suboptimal value of assets. To allow for this latter case, we measure inefficiency from the market value of assets, but we also compute inefficiency from the market value of equity for comparison.

The book value of assets net of goodwill can be interpreted as a proxy for the assets' replacement cost.[12] The difference between a bank's market and book values depends both on its production decisions and on its external economic environment. The former reflects efficiency while the latter varies with such factors as market power and macroeconomic conditions in the markets in which it operates. Controlling for a bank's size, measured by its book value of assets net of goodwill, we compute the "best-practice" market value that we observe in our sample at this adjusted book value and gauge the bank's inefficiency by the difference between the "best-practice" value and its observed market value. This difference represents the bank's failure to attain the highest market value for its book value. Not all of this difference is due to inefficiency, but we do not need to make this distinction. For our purposes, it is sufficient to ask how this difference is affected by the production plan and, in particular, by the employment of equity capital since the answer to this question will identify how these factors contribute to efficiency.

To determine the "best-practice" market value for any particular adjusted book value, we use stochastic frontier estimation techniques to regress market value on a quadratic function of book value. The estimated stochastic frontier identifies an upper envelope of market value to book value. We then regress this difference on variables that characterize the bank's external market conditions and its leveraged portfolio production plan to identify how market value and efficiency are affected by them. In particular, we focus on how the bank's employment of capital and its allocation to bank assets and activities influence efficiency.

A. The Empirical Model for Measuring Inefficiency

[12]Since goodwill is a component of market value, it should be subtracted from book value to obtain a proxy for replacement cost. See Demsetz, Saidenberg, and Strahan (1996) for a discussion of using adjusted book value as a proxy for replacement costs.

To illustrate the relationship between book and market values, we use a simple discounted cash-flow model. In a multiple period setting, the current market value of the i-th firm's assets, $MVA_{i,0}$, is

$$MVA_{i,0} = MVE_{i,0} + MVL_{i,0}$$
$$= \sum_{t=0}^{\infty} \frac{E(CFE_{i,t})}{(1+k_i)^t} + \sum_{t=0}^{\infty} \frac{E(CFD_{i,t})}{(1+r_i)^t} \quad (1)$$

where $E(CFE_{i,t})$ is the i-th firm's expected cash flow paid to its shareholders at time t while $E(CFD_{i,t})$ is the expected cash flow paid to debtholders at time t. The shareholders' required return on equity for the i-th firm is k_i while r_i is the debtholders' required return. The expected cash flows are the sum of the expected cash flows in solvent states of the world and in financially distressed states. Hence, this sum accounts for the expected costs of financial distress.[13]

The cash flows depend on the i-th bank's current and future production plans. The production plan consists of the bank's on- and off-balance-sheet products, designated by the vector, $\boldsymbol{y}_{i,t}$; the level of equity capital, $k_{i,t}$; the amounts of other financial and nonfinancial inputs, $\boldsymbol{x}_{i,t}$; and by variables, $\boldsymbol{n}_{i,t}$, characterizing the credit quality of the outputs, $\boldsymbol{y}_{i,t}$. These variables are measured by their book values. We observe only the current production plan $(\boldsymbol{y}_{i,0}, k_{i,0}, \boldsymbol{x}_{i,0}, \boldsymbol{n}_{i,0})$. Hence, our investigation focuses on how the current plan influences the market value of assets, $MVA_{i,0}$, and of equity, $MVE_{i,0}$. Nevertheless, we might expect that the current production plan is a good proxy for future production plans and cash flows. The efficiency of a bank's current production plan is likely to indicate the bank's ability to generate future cash flows and to manage the risk that affects the discount rate on these cash

[13]The standard profit function used to measure efficiency accounts for the part of the expected cash flow to shareholders that is due to production in the current period, $E(CFE_{i,0})$. Since it assumes that current period profit is maximized, it does not allow for the influence of expected costs of financial distress on the current production plan or its expected profitability.

flows. In addition, some components of the current production plan may proxy expected costs of financial distress. For example, the expected cash flow and risk associated with the current production plan along with the degree of capitalization figure into the bank's risk of insolvency as well as its charter value. If we interpret the amount of nonperforming loans as one of the measures of asset quality, $n_{i,0}$, then it, too, may give some indication of the probability and magnitude of financial distress.

In addition to influencing expected cash flows, the current production plan affects the bank's required return on capital, k_i . If we assume that a single-factor, asset-pricing model adequately describes the bank's securities, the required return is a function of the bank's market "beta" and, to the extent that its expected costs of financial distress are significant, it is also a function of the bank's idiosyncratic risk. Since the bank produces these securities using the comparative advantage it obtains from demand deposits, it can alter the trade-off between the expected return and riskiness of its bank-specific assets through the resources and skill it brings to bear on the tasks of credit evaluation, contract writing, monitoring, and managing clients' financial distress. A change in these factors can alter the bank's exposure both to systematic risk, measured by "beta," and to idiosyncratic risk, measured by the market model's standard error. These factors are, of course, components of the bank's current production plan. Consequently, they are endogenous to the production process.

Since the current production plan influences both expected cash flows and the discount rates applied to the cash flows, we can summarize these notions in a stylized valuation model:

$$MVA_{i,0} = MVE_{i,0} + MVL_{i,0} = g(\mathbf{y}_{i,0}, k_{i,0}, \mathbf{x}_{i,0}, \mathbf{n}_{i,0}), \qquad (2)$$

which can, in turn, be used to estimate inefficiency.

If we denote the book value of the i-th bank's total assets by $BVA_{i,0}$, we can define the market-value inefficiency of its assets, IE_i, by the difference between the "best-practice" market value, $FMVA_0 |_{BVA_{i,0}}$, and the bank's observed market value, $MVA_{i,0}$:

$$IE_i = FMVA_0 \mid_{BVA\ i,0} - MVA_{i,0} . \quad (3)$$

The frontier market value can be interpreted as the market value of the most valuable bank of comparable size. To obtain this upper envelope of observed market values defined over adjusted book values, we employ stochastic frontier analysis.[14]

This upper envelope of market values is estimated by appending a composed error term to a regression of observed market values on adjusted book values. The composed error term, ε_i, consists of a two-sided term, v_i, that captures statistical noise and a one-sided term, μ_i, that gauges inefficiency. This composed term fits an upper boundary to the data rather than an average relationship. We employ a quadratic specification of the regression equation to allow for the possibility that the relationship between market and book value is nonlinear. The resulting equation is

$$MVA_{i,0} = \alpha + \beta (BVA_{i,0}) + \gamma (BVA_{i,0})^2 + \varepsilon_i \quad (4)$$

where

$\varepsilon_i = v_i - \mu_i$, $v_i \sim$ iid N($0,\sigma_v^2$), μ_i (≥ 0) ~ iid N($0,\sigma_\mu^2$), which is estimated using maximum likelihood. The frontier value is given by

$$FMVA_0 = \alpha + \beta (BVA_{i,0}) + \gamma (BVA_{i,o})^2 \quad (5)$$

while inefficiency is measured by

$$IE_i = E(\mu_i \mid \varepsilon_i) = FMVA_0 - (MVA_{i,0} - v_i) , \quad (6)$$

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[14]Jondrow, Lovell, Materov, and Schmidt (1982) first proposed this technique. It has been extensively employed in a variety of contexts. For its application to banking, see Berger and Humphrey (1997) and Berger and Mester (1997).

where $(MVA_{i,0} - v_i)$ is the noise-adjusted, observed market value of assets. These estimates are measured in dollars of lost market value.

Substituting (2) into (6), we obtain

$$IE_i = h(\mathbf{y}_{i,0}, k_{i,0}, \mathbf{x}_{i,0}, \mathbf{n}_{i,0}), \tag{7}$$

which indicates that a bank's level of inefficiency measured by market value is a function of the bank's production plan and, in particular, its employment of capital. We estimate this relationship using ordinary least squares. Measuring efficiency in terms of the market value of assets is appropriate when agency problems allow shareholders to transfer value from debtholders. In the absence of agency problems, efficiency can be measured equivalently in terms of the market value of equity. To compare the evidence that would be obtained from the latter measure, we compute both. Since we find no significant qualitative differences between the conclusions we draw from the two approaches, we report only the findings from the asset-based measure.

B. The Data

We estimate (4) and (7) using data on 190 highest level bank holding companies in the United States in 1994. The balance-sheet items were obtained primarily from the Federal Reserve Y-9C Consolidated Financial Statements for Bank Holding Companies. The end-of-year book values of equity and total liabilities as well as the number of shares outstanding were obtained from the Standard & Poor's Compustat data base while end-of-year stock prices were retrieved from the data banks of the Center for Research in Securities Prices (CRSP).

The production plan, $(\mathbf{y}_{i,0}, k_{i,0}, \mathbf{x}_{i,0}, \mathbf{n}_{i,0})$, is specified as follows. The outputs, $(\mathbf{y}_{i,0})$, include on- and off-balance-sheet products. The former consist of liquid assets (the sum of cash, balances due, federal funds sold, reverse repurchase agreements, and securities), commercial and industrial loans, agricultural loans, loans to individuals, real estate loans, other loans, leases, assets held in trading accounts, investments in unconsolidated

subsidiaries, intangible assets, customers' liabilities related to bank acceptances, and other assets. The off-balance-sheet products are credit guarantees (unused portions of lines of credit, standby letters of credit, and so on), the notional amount of swaps, and the notional amount of all futures and options activity. Equity capital, $k_{i,0}$, is measured by the book-value of shareholders' equity. The inputs, $\boldsymbol{x}_{i,0}$, consist of labor (measured by the number of full-time equivalent employees), physical capital (measured by the amount of premises and fixed assets), uninsured domestic deposits, all other domestic deposits, and other borrowing (foreign deposits, federal funds purchased, repurchase agreements, commercial paper, subordinated notes and debentures, mandatory convertible securities, trading account liabilities, mortgage indebtedness, and all other borrowing). The credit quality of output, $n_{i,0}$, is proxied by nonperforming loans (the sum of accruing and nonaccruing loans, leases, and other assets past due 90 days or more) plus gross charge-offs. We add charge-offs to past-due loans to account for differences among banks in their aggressiveness toward charging off past-due loans. To control for exogenous market conditions, a 10-year, weighted average growth rate of personal income is included: for each state in which the bank operates, the state's 10-year average growth rate in personal income is weighted by the bank's proportion of assets located in that state. Table 1 reports summary statistics for these data.

4. Explaining Differences in Efficiency

The results of regressing inefficiency, equation (7), on the variables that characterize the production plan are shown in Table 2. The first column of coefficients is derived by estimating (7) using the entire sample of 190 bank holding companies. Since the results may differ between larger and smaller banks, we divide the sample in half. The second and third columns of coefficients report the results for the two halves, whose dividing line occurs at $2 billion. The signs of the coefficients in these three columns are generally in agreement.

Another distinction between banks that could imply that the full-sample results are misleading is the level of capitalization. The possibility that lower-risk banks signal their riskiness with the level of capital they put at risk suggests that the role of capital will differ

between banks with higher and lower capital-to-assets ratios. Consequently, we divide the sample into more and less capitalized banks so that the latter group contains one-third of the sample while the former consists of two-thirds. The capital-to-assets ratio that brings about this division is 0.0773. The fourth and fifth columns of coefficients in Table 2 report the findings that follow from this breakdown.

Controlling for asset size, we find distinct differences between banks that have higher capital-to-assets ratios and those with lower ratios. The signs of the coefficients on types of assets are generally negative and significant for the less capitalized group while they are positive and significant for the more capitalized banks. Hence, if we control for the unadjusted book value of capital, an increase in the level of most types of assets or, equivalently, a decrease in the capital-to-assets ratio decreases inefficiency for less capitalized banks while it increases inefficiency for more capitalized banks.

When we turn to the effect on inefficiency of the level of capital, measured by its unadjusted book value, once again, after controlling for asset size, we find that the effect differs between the two groups. For the less capitalized group, an increase in capital increases inefficiency while, for the more capitalized group, it decreases inefficiency. Since an increase in capital, given asset size, is equivalent to an increase in the capital-to-assets ratio, this difference in coefficients on capital implies that an increase in the capital-to-assets ratio for the less capitalized group increases inefficiency while it decreases inefficiency for the more capitalized banks. Hence, the implications of the differences in sign between the coefficients on assets and those on equity capital are in agreement.

This evidence suggests that inefficient holding companies with lower capitalization improve their performance by reducing capital-to-assets ratios while those with higher capitalization achieve better financial performance by increasing their capital ratios. Hence, the less capitalized group appears to improve efficiency by taking on more risk, and the more capitalized group, less risk. This interpretation receives some support from the statistically significant negative sign on nonperforming loans (plus charge-offs) for the less capitalized banks. When these banks assume more credit risk, they can expect a higher level of nonperformance. Hence, the negative sign suggests that the less capitalized group can also

improve efficiency by assuming more credit risk.

These dichotomous findings extend as well to the signs on the coefficients for the three types of borrowed funds. The statistically significant positive signs for the holding companies in the less capitalized group imply that increased borrowing increases their inefficiency while, for the greater capitalized group, the negative signs indicate that increased borrowing reduces their inefficiency. This difference in signs suggests that investors distinguish between more and less capitalized banks.

If, in fact, investors discriminate among banks by their degree of capitalization, and if less capitalized, inefficient banks can enhance their efficiency by decreasing their capital ratios, it would appear that the more capitalized banks can provide a credible signal of their riskiness by the level of capital they put at risk.[15] Our evidence seems to suggest that the less efficient banks in this group can improve their performance by increasing their capital-to-assets ratios. In contrast, it would appear that banks in the group with lower capital-to-assets ratios cannot provide a credible signal by their level of capital. In fact, the less efficient banks in this group can improve their performance by reducing their capital-to-assets ratios. In line with our signaling argument, this evidence may imply that investors penalize less capitalized banks (by reducing their market valuation) whose capital levels appear to send a false signal that their assets are of better quality. That is, *less capitalized banks cannot afford to mimic the signal of better capitalized banks* because their opportunity costs are too high.

5. Conclusions

Our evidence indicates that the level and allocation of equity capital influences banks' efficiency and, hence, the market value of their assets. However, even controlling for the

[15]This difference in the effect of capital on market value efficiency could also be due to differences in charter value. If banks in the more capitalized group have a higher ratio of market value to book value, they may hold more capital to protect their higher charter value, and among those banks that are inefficient, they may improve their efficiency by adding more protection. However, examining the market-to-book ratios for assets and equity in Table 1 shows that there is no statistically significant difference between banks in the more and less capitalized groups.

effect of asset size, we find that the influence of equity capital differs markedly between banks with higher capital-to-assets ratios and those with lower ratios. This dichotomy in effect suggests that banks with higher capital-to-assets ratios are able to provide a credible signal of their riskiness by the level of capital they put at risk.

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Table 1. Summary Statistics of Bank Holding Companies

+Measured in thousands of dollars.
*Inefficiency ratios are the amount of lost value divided by the observed market value.

I. Full Sample (n = 190)	Mean	Std. Dev.	Minimum	Maximum
Asset Inefficiency Ratio*	0.0289168	0.0341621	0.00013625	0.2231045
Equity Inefficiency Ratio*	0.4459849	0.8749832	0.0028606	7.6140949
Market-to-Book Assets	1.0363696	0.0321529	0.9702756	1.1718826
Market-to-Book Equity	1.4368271	0.3743982	0.5631479	2.6226742
Market Value of Assets+	12822466	31512790.75	155108.25	249287434
Adjusted B.V. Assets+	12549629.8	31328410.3	159860	250447500
Book Value of Assets+	12613070.6	31505390.21	159860	250489000
B.V. Capital/B.V. Assets	0.0849826	0.0159363	0.0442443	0.1353974
II. Smaller Half of Sample (Total Assets < $2 Billion, n = 96)				
Asset Inefficiency Ratio*	0.0521778	0.0346014	0.016013	0.2231045
Equity Inefficiency Ratio*	0.815847	1.1134749	0.1155143	7.6140949
Market-to-Book Assets	1.0385358	0.0374851	0.9702756	1.1718826
Market-to-Book Equity	1.4300979	0.417894	0.5631479	2.5431147
Market Value of Assets+	934999.85	527957.47	155108.25	2139888.75
Adjusted B.V. Assets+	897583.17	503686.99	159860	1975677
Book Value of Assets+	900645.83	505049.42	159860	1984629
B.V. Capital/B.V. Assets	0.0900651	0.0166454	0.0442443	0.1353974
III. Larger Half of Sample (Total Assets > $ 2 Billion, (n = 94)				
Asset Inefficiency Ratio*	0.0051609	0.0044498	0.00013625	0.0164349
Equity Inefficiency Ratio*	0.0682533	0.0630257	0.0028606	0.3000964
Market-to-Book Assets	1.0341573	0.0256092	0.9825025	1.1286057
Market-to-Book Equity	1.4436995	0.326166	0.7522922	2.6226742
Market Value of Assets+	24962857	41509240.79	2103458	249287434
Adjusted B.V. Assets+	24449592.4	41364937.64	2030235	250447500
Book Value of Assets+	24574695.9	41601834.34	2030235	250489000
B.V. Capital/B.V. Assets	0.0797919	0.0133865	0.0484868	0.1333966
IV. Less Capitalized 1/3 of Sample (Capital-to-Assets Ratio < 7.73%, n=64)				
Asset Inefficiency Ratio*	0.024398	0.0399184	0.00013625	0.2231045
Equity Inefficiency Ratio*	0.5887181	1.3798845	0.0028606	7.6140949
Market-to-Book Assets	1.0240151	0.0298291	0.9702756	1.1111299
Market-to-Book Equity	1.3597754	0.4377585	0.5631479	2.4884998
Market Value of Assets+	24368550	43227901.15	155108.25	249287434
Adjusted B.V. Assets+	23977140.9	43055584.16	159860	250447500
Book Value of Assets+	24058305.9	43130004.12	159860	250489000
B.V. Capital/ B.V. Assets	0.0694074	0.0068875	0.0442443	0.0772241
V. More Capitalized 2/3 of Sample (Capital-to-Assets Ratio > 7.73%, n = 126)				
Asset Inefficiency Ratio*	0.031212	0.0307522	0.00016452	0.1450918
Equity Inefficiency Ratio*	0.3734854	0.4268425	0.0033018	2.1866924
Market-to-Book Assets	1.0426449	0.0315727	0.9751226	1.1718826
Market-to-Book Equity	1.4759645	0.3328312	0.690944	2.6226742
Market Value of Assets+	6957788.45	21372293.92	238472	211675396
Adjusted B.V. Assets+	6745179.75	21186140.24	238216	211764250
Book Value of Assets+	6799617.73	21496996.2	238216	215475000

B.V. Capital/B.V. Assets	0.0928938	0.0131452	0.0778753	0.1353974

Table 2. OLS Regressions of Bank Inefficiency

*Significant at the 10% level, **at the 5% level, ***at the 1% level.T-statistics are reported in parentheses. White standard errors are computed from a multiplicative heteroskedastic model.

Dependent Variable		**Book Value Assets**	**Book Value Assets**	**Less Capitalized**	**Better Capitalized**
	Full	**< $2 Bil.**	**> $2 Bil.**	**< 7.73%**	**> 7.73%**
N	**190**	**96**	**94**	**64**	**126**
Constant	34729***	34601***	34991***	34655***	34639***
	(481.87)	(1753.92)	(166.28)	(250.71)	(838.82)
Cash and Securities	-0.00060***	-0.00047	-0.00073**	-0.00202***	0.00131***
	(-2.94)	(-1.17)	(-2.16)	(-7.67)	(4.24)
C&I Loans	-0.00023	-0.00072	-0.00034	-0.00020***	0.00103***
	(-1.13)	(-1.55)	(-1.03)	(-6.32)	(3.53)
Agricultural Loans	-0.00180***	-0.00071	-0.00196***	-0.00150*	0.00265***
	(-4.92)	(-1.15)	(-2.96)	(-1.73)	(7.11)
Individual Loans	-0.00050**	-0.00068	-0.00053	-0.00184***	0.00105***
	(-2.51)	(-1.50)	(-1.61)	(-6.20)	(3.95)
Real Estate Loans	-0.00059***	-0.00090	-0.00070**	-0.00194***	0.00122***
	(-2.95)	(-1.85)	(-2.13)	(-8.31)	(3.97)
Other Loans	-0.00106***	0.00045	-0.00110***	-0.00224***	0.00082***
	(-4.70)	(0.60)	(-2.78)	(-7.01)	(2.59)
Leases	-0.00146***	-0.00255***	-0.00153***	-0.00424***	0.00028
	(-5.17)	(-3.29)	(-2.97)	(-6.42)	(0.87)
Trading Account	-0.00084***	-0.00148**	-0.00095***	-0.00331***	0.00109**
	(-3.67)	(-2.52)	(-2.60)	(-7.31)	(2.49)
Unconsolidated	0.00777**	-0.02491**	0.00494	0.03744***	0.01759***
Subsidiaries	(2.22)	(-2.51)	(0.97)	(6.04)	(5.77)
Intangible Assets	-0.00122*	-0.00166	-0.00041	0.00082	0.00299***
	(-1.89)	(-1.37)	(-0.45)	(0.51)	(9.29)

Table 2. The Determinants of Bank Inefficiency (cont.)

Dependent Variable	**Full**	**Assets < $2 Bil.**	**Assets > $2 Bil.**	**Less Capital < 7.73%**	**More Capital > 7.73%**
Other Assets	0.00050	-0.00099	0.00048	-0.00272***	0.00175***
	(1.37)	(-0.66)	(1.18)	(-3.48)	(6.60)
Acceptances	-0.00176**	-0.01673	-0.00200	0.00574*	0.00304***
	(-2.20)	(-0.79)	(-1.44)	(1.68)	(5.14)
Book Value Equity	-0.00107***	-0.00069	-0.00147***	0.00175***	-0.00192***
	(-4.14)	(-1.21)	(-3.54)	(3.04)	(-4.20)
Nonperforming Assets	-0.00113**	0.00217***	-0.00073	-0.00666***	0.00068
	(-1.97)	(2.79)	(-0.70)	(-4.82)	(1.15)
Economic Growth	-222.95	-94.5627	-204.831	-791.495	-534.51
	(-0.32)	(-0.51)	(-0.11)	(-0.56)	(-1.43)
Credit Guarantees	0.00004***	0.00028***	0.00005**	-0.00010***	0.00004*
	(2.93)	(2.93)	(2.34)	(-3.05)	(1.84)
Swaps	0.00007***	0.00035	0.00007***	0.00005***	0.00009***
	(6.32)	(1.16)	(5.59)	(3.49)	(4.68)
Futures and Options	-0.000009**	0.00153**	-0.00001**	0.00004***	-0.00003***
	(-2.32)	(2.25)	(-2.09)	(2.91)	(-3.03)
Labor	0.05827*	0.20039**	0.02521	0.00046	0.01623
	(1.84)	(2.63)	(0.48)	(0.01)	(0.54)
Physical Capital	0.00129*	-0.00416***	0.00016	-0.00618***	0.00336***
	(1.67)	(-2.99)	(1.10)	(-2.76)	(6.94)
Uninsured DomesticDeposits	0.00116***	0.00072	0.00108***	0.00225***	-0.00132***
	(5.26)	(1.55)	(2.81)	(7.68)	(-4.45)
Other Domestic Deposits	0.00054**	0.00071	0.00067*	0.00221***	-0.00124***
	(2.53)	(1.44)	(1.90)	(7.05)	(-4.23)
Other Borrowed Funds	0.00061***	0.00093*	0.00077**	0.00220***	-0.00140***
	(2.86)	(1.89)	(2.15)	(7.39)	(-4.82)
Adjusted R^2	.836	.506	.826	.962	.874
F-statistic	42.74	5.24	20.23	69.97	38.85