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Evidence on the Objectives of Bank Managers [1]

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Abstract: We present evidence on the objective function of bank management--that is, are they risk neutral and maximize expected profits, or are they risk averse and trade off profit for risk reduction? We extend the model of Hughes and Mester (1993) to allow a bank's choice of its financial capital level to reflect its preference for return versus risk. A multiproduct cost function, which incorporates asset quality and the risk faced by a bank's uninsured depositors, is derived from a model of utility maximization. The utility function represents the bank management's preferences defined over asset levels, asset quality, capital level and profit. Endogenizing the bank's choice of capital level in this way permits the demand for financial capital to deviate from its cost-minimizing level. The model consists of the cost function, share equations and demand for financial capital equation, which are estimated jointly. We then are able to explicitly test whether bank managers are acting in shareholders' interest and maximizing expected profits, or whether they are maximizing a utility function that exhibits risk aversion. We believe this is the first such test.

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This paper is a revision of "Accounting for the Demand for Financial Capital and Risk-Taking in Bank Cost Functions."

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EVIDENCE ON THE OBJECTIVES OF BANK MANAGERS

1. Introduction

Are bank managers risk neutral and act on behalf of shareholders to maximize expected profits, or are they risk averse and maximize a utility function that trades off profits for risk reduction? The aim of this paper is to present some empirical evidence on this question by looking at a bank's choice of inputs, in particular, its choice of financial capital. Since increasing financial capital reduces the risk of insolvency, bank managers might choose levels of financial capital that are higher than the cost-minimizing (and therefore, profit-maximizing) levels. To shed light on this, we extend the model of Hughes and Mester (1993) to allow a bank's choice of its financial capital level to reflect its preference for return versus risk. A multiproduct cost function, which incorporates asset quality and the risk faced by a bank's uninsured depositors, is derived from a model of utility maximization. An explicit test of bank managers' objective function is then derived. We believe this is the first explicit test of bank managers' objectives concerning the risk vs. return tradeoff.

Most studies of bank costs estimate cost functions that do not account for the quality of a bank's assets or the risk faced by the bank's uninsured depositors, both of which influence cost in a variety of ways.[1] First, to the extent that uninsured depositors exact a risk premium, the cost of uninsured deposits will be affected by the bank's risk. Hannan and Hanweck (1988) report empirical evidence that the interest expense of uninsured deposits does indeed contain a risk premium.

Second, if different combinations of inputs that produce a given vector of outputs imply different degrees of risk, then a bank that is not risk neutral will not necessarily choose the least costly mix. For example, the amount of resources the bank devotes to credit analysis and monitoring will affect its credit risk. Additionally, the amount of financial capital the bank employs to produce any given vector of outputs directly affects its risk of insolvency. Financial capital is an alternative to deposits as a source

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[1]Exceptions include Hughes (1989), Gertler and Waldman (1990), Hughes and Mester (1993), and McAllister and McManus (1993).

of loanable funds, and for some banks, capital notes as well as other sources of capital may be cheaper than core deposits. However, financial capital is more than a source of funding; it is also a cushion against insolvency. Thus, the economic calculation of capital adequacy may require an accounting of risk when the bank is not risk neutral. While the usual moral hazard story is that bank stockholders, who have limited liability, desire more risk than is socially optimal, bank managers may have incentives to take on less risk in order to preserve the bank and therefore, their jobs, particularly in the recent environment of consolidation.

As in Hughes and Mester (1993), to allow for the possibility that the level of capitalization is not chosen to minimize cost, the cost function is made conditional on financial capital. But this paper extends Hughes and Mester by embedding the problem of cost minimization in a model of utility maximization, which is constructed to allow the demand for financial capital to deviate from its cost-minimizing level.

The utility function represents the bank management's preferences defined over asset levels, asset quality, capitalization, and profit. Utility is maximized subject to a "budget" or profit constraint and the conditional values of asset levels and asset quality to obtain the demand for financial capital and profit. Hence, the bank's choice between capitalization and profit can be viewed as one of risk versus return. Substituting the demand for financial capital into the conditional cost function, the employment of financial capital is made endogenous. (Asset quality can also be made endogenous in this fashion.) Note that the resulting reduced-form cost function will contain not just the usual arguments of input prices and output levels, but also arguments derived for the revenue function. Cost, then, depends on revenue as well. Thus, an explicit test for bank managers' objective function is obtained: if cost depends on revenue, bank managers are acting in a risk-averse manner and maximizing a utility function that trades off risk and return; if cost is independent of revenue, then bank managers are acting in a risk-neutral manner and maximizing expected profits.

One interpretation of the model is that it explicitly *models* a kind of X-inefficiency. That is, because a bank may desire to trade off risk and return, it may not use the cost minimizing level of financial capital. Thus, we are offering an explanation of why some banks may appear X-inefficient. This seems preferable to the usual black-box approach to X-inefficiency.

The rest of this paper is organized as follows. Section 2 discusses bank production and cost structures that explicitly take into account the quality of output and insolvency risk. Section 3 discusses the bank's demand for financial capital. Section 4 derives the cost function when the capital choice of the bank is determined endogenously. Section 5 discusses empirical implementation of the model. Section 6 gives formulas for the cost statistics we examine. The empirical results are discussed in Section 7 and Section 8 concludes.

2. Bank Production and Cost[2]

Let the bank's technology be summarized by the transformation function T(y,q,x,u,k) = 0, where y is a vector of quantities of outputs; q is a vector of variables characterizing output quality; u is uninsured deposits; x is a vector of inputs other than u; and k is a vector consisting of k_1, debt-based financial capital (subordinated debt), and k_2, equity-based financial capital and loan-loss reserves. T(y,q,x,u,k) describes the production possibilities set, and is nondecreasing in x, u, and k, and nonincreasing in y and q. Additionally, T(y,q,x,u,k) is strictly quasi-concave in x, u, and k so that the input requirement sets, $V(y,q) \equiv \{(x,u,k)\colon T(x,u,k;y,q) = 0\}$, which describe the set of all inputs needed to produce output quantities y with qualities q, are strictly convex, and the restricted input requirement sets, $\tilde{V}(y,q,k) \equiv \{(x,u)\colon T(x,u;y,q,k) = 0\}$, are strictly convex. T(y,q,x,u,k) is quasi-concave in y and q so that the production possibility sets $L(x,u,k) \equiv \{(y,q)\colon T(y,q;x,u,k) = 0\}$ are convex.

[2]This section closely follows Hughes and Mester (1993).

We assume banks are price-takers in the markets for inputs included in x so that the corresponding price vector w is competitively determined. The price of uninsured deposits, w_u, is also assumed to be competitively determined; however, if it includes a risk premium, then it may be affected by the bank's risk of failure as reflected in the quality, q, of its outputs, by its capitalization, k, relative to its size and mix of outputs, y, and by a vector, θ, of variables that characterize riskiness but do not affect the transformation function.[3] Thus, let $w_u = \omega F(y,q,k,\theta)$, where ω is a competitively determined, risk-free interest rate and $F(y,q,k,\theta) \geq 1$ represents the risk premium.[4] The cost of production is defined by,

$$C(y,q,w,\omega,k,\theta) \equiv \min_{x,u} \left[w \cdot x + \omega F(y,q,k,\theta)u : (x,u) \in \tilde{V}(y,q,k) \right] . \tag{1}$$

Conditioning cost on the bank's financial capital, k, has several advantages. First, it acknowledges that financial capital influences cost, since it provides an alternative to deposits as a source of loanable funds. Second, since the *level,* and not the price, is employed in the cost function, it does not assume that the level of financial capital is cost-minimizing. Allowance is thus made for objectives other than cost-minimization. Third, to the extent that credit risk varies by asset type, the degree of risk implied by the aggregated capital-asset ratio, $\Sigma_i k_i / \Sigma_j y_j$, will depend on the composition of assets. Allowing cost to depend on k rather than just the aggregated capital-asset ratio takes this into account.

The formulation in equation (1) exhibits all the standard properties of a cost function. It should be noted, however, that this is a partially reduced-form cost function, obtained by substituting in the price

[3]Hannan and Hanweck (1988) find evidence that the mean and variance of profit affect the premium that depositors charge on uninsured deposits; hence, the mean and variance of profits are examples of θ variables.

[4]This approach to the specification of an input price is suggested by Diewert (1982), who considered the case of a monopsony where the price is influenced by endogenous variables.

of uninsured deposits into the structural cost function. Since the price of uninsured deposits depends on output levels and qualities, capitalization, a risk-free interest rate, and other risk variables, θ, it does not explicitly appear in the cost function.[5] Since w_u does not explicitly appear, we cannot use Shephard's lemma to derive the cost share for uninsured deposits in the usual way. However, we can use a variant of the lemma: differentiate equation (1) with respect to the risk-free rate of interest, ω, and use the Envelope Theorem, to yield,

$$\frac{\partial C}{\partial \omega} = F(y,q,k,\theta)\ u^*(y,q,w,\omega,k,\theta) \ , \tag{2}$$

where $u^*(y,q,w,\omega,k,\theta)$ is the cost-minimizing level of u.

Hence:

$$u^*(y,q,w,\omega,k,\theta) = \frac{\frac{\partial C}{\partial \omega}}{F(y,q,k,\theta)} = \frac{\omega}{w_u}\frac{\partial C}{\partial \omega} \ , \tag{3}$$

or, in terms of the uninsured deposits cost share equation:

$$\frac{w_u u^*}{C} = \frac{\partial \ln C}{\partial \ln \omega} \ . \tag{4}$$

The expression in equation (4) suggests that the application of this variant of Shephard's lemma to a translog cost function, for example, containing the argument ω, readily yields the share equation of uninsured deposits.[6]

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[5]The structural cost function is a function of (y,q,w,w_u,k). Substituting w_u, which is a function of (y,q,k,θ,ω), into the structural cost function yields the partially reduced-form condition cost function, which is a function of (y,q,w,ω,k,θ). Note that since the structural cost function is linearly homogenous in input prices, (w,w_u), the partially reduced-form cost function is linearly homogenous in (w,ω). The fully reduced-form cost function is obtained by substituting the demand for capital, k, into the partially reduced-form cost function. Because k is a function of (w,ω), the fully reduced-form cost function will not, in general, be linearly homogenous in (w,ω).

[6]In the estimation described below, since the cost shares sum to one, one of the cost share equations must be dropped to avoid singularity of the variance-covariance matrix. We drop the uninsured deposits cost share equation.

3. Demand for Financial Capital

Taking the vectors of outputs and their quality characteristics as given, the riskiness of the bank's portfolio is established. The effect of this risk on the probability of failure, and hence the security of the deposits, is influenced by the level and mix of financial capital. Financial capital provides a buffer against default. We assume the management has well-behaved preferences for financial capital and profit, given its mix of assets, y, and their quality characteristics, q. Before completing the formulation of the managerial utility function, we consider the definition of profit.

3.1 Profit

To calculate profit, the cost of capital, $v_1k_1 + v_2k_2$, must be added to cost in equation (l). The bank's rate of interest on debt-based capital, v_1, consists of a risk-free component, γ_1, and a risk premium, $\Gamma_1(y,q,k,\theta) \geq 1$; hence, $v_1 = \gamma_1\Gamma_1(y,q,k,\theta)$. Similarly, the required rate of return on equity-based capital is $v_2 = \gamma_2\Gamma_2(y,q,k,\theta)$. The interest rate charged on the i^{th} output is p_i.[7] Revenue received from sources other than output is represented by $m \equiv p_mM$, where $p_m = 1$, so this "price" can be used to normalize profit when it is an argument of the utility function. Consequently, a proportional variation in all prices will not alter normalized profit, $\hat{\pi}/p_m$, and hence, utility. In other words, normalized profit is homogenous of degree zero in (p,p_m,w,ω) (or equivalently, in (p,m,w,ω)). And this means that the demand for financial capital will be homogenous of degree zero in (p,m,w,ω) as well—a proportional variation in prices has no effect on normalized profit, which is an argument in the utility function; hence it will have no effect on the utility-maximizing level of financial capital.

It will be useful to define accounting profit, or net income, as well as economic profit. Economic profit is defined by,

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[7]In the empirical implementation, we treat pi as exogenous. Alternatively, one could endogenize the prices by considering p_i to be composed of a risk-free component, ρ_i, and a risk premium, $H_i(q_i)$. The bank's interest income could be denoted by $r(y,q,\rho) \equiv p \cdot y = \Sigma_i\rho_iH_i(q_i)y_i$. If the output is defined as a particular type of loan, then the interest rate on the loan is inversely related to the quality of the loan so that $\partial p_i/\partial q_i < 0$.

$$\hat{\pi} \equiv p \cdot y + p_m m - C(y,q,w,\omega,\theta,k) - v_1 k_1 - v_2 k_2 \ , \qquad (5)$$

while accounting profit, or net income, is defined by,

$$\pi \equiv \hat{\pi} + v_2 k_2 = p \cdot y + p_m m - C(y,q,w,\omega,\theta,k) - v_1 k_1 \ . \qquad (6)$$

The bank's return on equity is π/k_2, which consists of its required return, v_2, and its economic rent, $\hat{\pi}/k_2$.

3.2 Utility

The bank's preferences for profit, capitalization, quality, and size can be characterized by a twice-continuously differentiable, quasi-concave utility function, $U(\hat{\pi}/p_m,k,y,q)$. Utility is maximized with respect to profit and capitalization, subject to the budget constraint equation (5) and the vectors of outputs, y, and quality characteristics, q. A unique solution to the maximization problem will require that the cost function be strictly convex in k and, when q is also endogenous, in q.

This formulation of utility is quite general in that it accommodates various alternative objectives of the bank. If the bank maximizes profit, then q, y, and k will have no marginal effect on utility except through their effect on profit. On the other hand, the bank may maximize its rate of return on equity π/k_2. Or the bank may trade profit or return for greater capitalization and hence less insolvency risk. *Holding the levels of outputs, qualities, and debt-based financial capital constant,* and maximizing utility with respect to k_2, Figure 1 illustrates an equilibrium k_2^1 in which utility maximization corresponds to profit maximization and equilibrium k_2^2 in which profit is traded for extra capital and, in effect, for extra security. Since the cost function is assumed to be convex in k_2, the profit function is concave in k_2. The indifference curve U^1 gives no marginal significance to k_2 and, thus, yields the profit maximum as a utility maximum. The indifference curve U^2 attributes marginal significance to both profit and capital and so results in a utility maximum where profit is traded for lower risk. U^2 represents the preferences of risk-averse bank managers.

Figure 2 illustrates the case where rate of return on equity π/k_2, or equivalently, $\hat{\pi}/k_2$, is the focus of decision-making. The level k_2^3, which maximizes the rate of return, implies risk neutrality. In this case, indifference curves, such as U^3, are rays from the origin. On the other hand, risk aversion results in the trading of return for the safety of a greater capital cushion, say k_2^4 or k_2^5. It is not difficult to show that when the rate of return rather than profit is the bank's concern and bank management is risk averse, then the indifference curves can be positively sloped (e.g., U^4) or negatively sloped (e.g., U^5). Thus, the formation of the bank's objectives in terms of the utility function is sufficiently general to include a variety of objectives and attitudes toward risk.

The bank's use of financial capital is subject to regulatory review; therefore, we must incorporate constraints defining the minimum capital adequacy level imposed by regulation. For generality, assume these constraints are functions of the bank's asset mix, size, and other parameters, τ. If the output vector is assumed to contain the bank's assets as some or all of its components, then we can denote the constraints by $k_j \geq G_j(y,\tau)$.

The demands for debt-based and equity-based financial capital and for economic profit follow from the solution to the problem,

$$\max_{\hat{\pi},k} \; U(\hat{\pi}/p_m,k;y,q) \tag{7}$$

$$\text{s.t.} \quad \sum_i p_i y_i + p_m m - C(y,q,w,\omega,\theta,k) - \gamma_1 g_1(y,q,k,\theta)k_1 - \gamma_2 g_2(y,q,k,\theta)k_2 - \hat{\pi} = 0$$

$$T(y,q,x,u,k) = 0 \,,$$

$$\text{and} \quad k_j \geq G_j(y,\tau), \quad j=1,2 \,.$$

Assuming an interior solution, but not necessarily a binding regulatory constraint, and letting $z \equiv (q,\theta,\tau,p,w,\omega,\gamma)$, where p, γ, q, θ, and w are vectors, the demand functions for the components of financial capital are $k^m(y,z,m) \equiv (k_1^m(y,z,m),k_2^m(y,z,m))$, and the demand function for economic profit is $\hat{\pi}^m(y,z,m)$. (The argument p_m is suppressed.) Substituting these demand functions into equation (6) yields the demand for net income, $\pi^m(y,z,m)$.

4. Cost with Endogenous Financial Capital: A Test for the Bank Managers's Objective Function

Substituting the demand functions for financial capital, $k^m(y,z,m)$, into the cost function (1) yields cost that is unrestricted by capital,

$$C^m(y,q,z,m) \equiv C(y,q,w,\omega,\theta,k^m(y,z,m)) \quad . \tag{8}$$

Note that when financial capital affects utility marginally, i.e., when profit is traded for a reduction in risk, or when the bank's objective is evaluated in terms of the rate of return on financial capital, the cost function (8) contains arguments characterizing revenue.[8] Hence, the revenue the bank can obtain by producing any given vector of outputs, y, at given quality, q, affects the bank's capitalization and the cost of producing the given vectors y and q. On the other hand, when utility maximization corresponds to profit maximization, which also implies risk neutrality, financial capital will be employed only to the point of minimizing cost. Thus, revenue consideration will be irrelevant to this optimum. That is, when the bank maximizes profit, then *given* the bank's output, y, and quality, q, the revenue parameters p and m will not have any effect on cost. Thus, to test whether bank managers are maximizing profits or maximizing a utility function that trades off profits for risk reduction, we estimate the elasticities of cost with respect to p and m, taking into account the endogeneity of k. If these elasticities are non-zero, then this is evidence that managers are risk-averse and that they maximize utility.

5. Empirical Implementation

Estimation of cost function (8) relies on the basic conditional cost function (l), which is conditioned on the characteristics of quality and on the level of financial capital. In principle, the

[8]The concept of revenue-driven cost is developed in greater detail in Hughes (1989).

conditional cost function is estimated jointly with its share equations and with a system of utility-maximizing demand equations for profit, debt-based financial capital, and equity capital. In the estimation described below, we used a somewhat simpler formulation to meet the limitations imposed by the data and the number of parameters.

We estimate the following model:

$$\mathbf{C(y,q,w,\omega,k,\theta) \equiv \min [w \cdot x + \omega f(y,q,k,\theta)u: (x,u) \in \bar{v}(y,q,k)]} \tag{9}$$

$$\mathbf{S_j \equiv \frac{w_j x_j}{C} = \frac{w_j}{C} \frac{\partial C}{\partial w_j}, \quad w_j \in w} \tag{10}$$

$$\mathbf{k \equiv k^m(y,z,m) \quad where \quad z \equiv (q,\theta,\tau,p,w,\omega,\gamma)} \cdot \tag{11}$$

We make the following simplifications. First, since nearly half of the banks in our sample do not have subordinated debt, the two types of financial capital are aggregated. Second, since estimating the behavior of costs does not require estimating the demand equation for profit, the profit function is dropped. Other simplifications and details are discussed below.

5.1 Data

We used 1989 and 1990 data from the Consolidated Reports of Condition and Income that banks must file each quarter. The 286 banks included in the sample are all the U.S. banks that operated in branch-banking states and that reported over $1 billion in assets as of 1988Q4, excluding the special-purpose Delaware banks chartered under that state's Financial Center Development Act and Consumer Credit Bank Act. We exclude banks in unit-banking states and the Delaware legislated banks to help control for the regulatory environment.[9] The banks included in the sample ranged from $1 billion to $74 billion in total assets in 1990.[10]

We include five outputs in the model: y_1 = real estate loans, y_2 = business loans (i.e., commercial and industrial loans, lease financing receivables, and agricultural loans), y_3 = loans to individuals, y_4 = other loans, and y_5 = securities, assets in trading accounts, fed funds sold and securities purchased under agreements to resell, and total investment securities. Each y_i is measured as the average of its dollar amount at the end of 1990 and its dollar amount at the end of 1989.

Since 138 banks in the sample have no subordinated debt, we aggregate the two categories of financial capital; hence, k is the average volume of equity capital, loan-loss reserves, and subordinated debt in 1990.

Four inputs, in addition to uninsured deposits and financial capital, are considered: (1) labor, (2) physical capital, (3) insured deposits, and (4) other borrowed money. The corresponding input prices are: w_1 = salaries and benefits paid in 1990 ÷ average number of employees in 1990, w_2 = occupancy expense in 1990 ÷ average dollar value of net bank premises in 1990,[11] w_3 = (interest paid on small

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[9]In addition, a few banks were dropped because of missing or misreported data.

[10]It could be that banks with less than the regulatory required level of capital are unable to choose their capital levels, because it is being dictated by the regulators. The regulatory capital requirement in 1990 was capital to total assets of at least 6 percent. Only two banks in the sample had capital ratios less than 6 percent, and dropping these banks from the sample does not qualitatively change any of the results reported below. As of 1992, when risk-based capital standards came into effect, total capital to risk-adjusted assets was required to be at least 8 percent. While we could not compute risk-adjusted assets (since the banks did not have to report this on their Call Reports in 1990), we did check to see whether dropping banks with total capital to total assets under 8 percent (a stricter requirement than the risk-based standard) affected our results. Dropping these banks from the sample does not qualitatively change any of the results reported below.

[11]This measure of the unit price of physical capital has been used in many other cost studies, including Hughes and Mester (1993), Mester (1991), and Hunter, Timme, and Yang (1990). As an alternative, the rental cost per square foot of office space at the bank's headquarters location could be used. However, it is not clear this would be a better proxy, since many of the banks in the sample have many branches at various locations. While in theory one could use the average rental cost over all markets in which the bank operates, data on branch location were not available.

deposits [i.e., under $100,000] in 1990 − service charges on deposits paid to the bank in 1990) ÷ average volume of interest-bearing deposits less CDs over $100,000 in 1990, w_4 = total expense of fed funds purchased, securities sold under agreements to repurchase, obligations to the U.S. Treasury, and other borrowed money in 1990 ÷ average volume of these types of funds in 1990.

The price of uninsured deposits, $w_u = \omega F(y,q,k,\theta)$, consists of a risk-free component, ω, and a risk premium $F(y,q,k,\theta)$. A bank-specific risk-free rate, ω, is a weighted average of yields on 3-month, l-year, 5-year, and l0-year Treasury securities in 1990, where the weights are calculated as the proportion of the bank's large time deposits with the corresponding maturity. The risk premium is incorporated into the conditional cost function and so does not explicitly appear.[12]

The price of financial capital, $v = \gamma\Gamma(y,q,k,\theta)$, consists of a risk-free component, γ, which has no maturity and so is assumed to be the same across banks; thus, it does not appear in the estimation. The risk premium, $\Gamma(y,q,k,\theta)$, is incorporated into the reduced form cost model. Thus, neither the price of financial capital, nor the price of uninsured deposits appears explicitly in the model.

The prices of the outputs, p, are measured by dividing total interest income derived from each output by the average dollar amount of assets that are accruing interest in the output category in 1990. Accruing assets in category i equal total assets in category i less assets not accruing interest in category i, i.e., $y_i - y_i^n$. Hence, $p \cdot (y - y^n)$ is the bank's *realized* total interest income. It is important to note that the bank's *potential* interest income is **p Ž y,**the amount that would be received if all assets were accruing. This distinction is important in interpreting the revenue arguments of the "budget" constraint

[12]Hughes and Mester (1993) developed a test to determine whether deposits are outputs or inputs. A variable cost (VC) function in which insured and uninsured deposits are entered in levels is estimated. If the derivative of VC with respect to insured deposits is positive, then insured deposits are an output; if the derivative is negative, then insured deposits are an input. The same test can be applied for uninsured deposits. Using a data set similar to the one employed here, Hughes and Mester (1993) found that both types of deposits were inputs. Hence, we treat them as inputs here as well.

in the utility-maximizing solution. Noninterest income, m, is measured by the amount of noninterest income for 1990.

The utility-maximizing solution contains arguments of the revenue function **p Ž y**+ m. To empirically implement the model, we need to consider whether to use realized or potential revenue. Since the bank's choice is described as one between potential return and risk, it would seem appropriate to measure revenue (and profit) as the potential rather than the realized value, i.e., the value of revenue and return needed to compensate the bank for the risk it assumes. The potential value can be viewed as a proxy for the expected revenue or profit. The effect of potential revenue on the utility-maximizing demand for capital is captured by including among its arguments the vector of interest rates earned by accruing assets, p, and noninterest income, m.

The quality of assets might be measured quite directly by the risk premium on each type of asset. Unfortunately, the data do not permit this calculation. Therefore, we include one quality variable, q, measured as the average total volume of nonperforming loans, i.e., loans past due 30 days or more plus nonaccruing loans. (Note that q is inversely related to quality.)[13] We include one risk variable, θ, measured by the standard deviation of the bank's yearly net income from 1986-1990.

Since the regulatory parameters, τ, are the same for all banks, they are omitted in the cross section model.

Finally, conditional cost, C, in equation (9), is measured by the sum of salaries and benefits, occupancy expense, and (interest paid on insured and uninsured deposits net of service charges, and the

[13]As discussed in Hughes and Mester (1993), this is an ex post measure of quality rather than an ex ante measure—not all low quality loans end up being nonperforming loans, and not all loans that are performing well today will continue to do so—but it seems to be the best available measure of the resources that went into monitoring the bank's loans. Also note that while the quantity of a bank's nonperforming loans will be influenced by the macroeconomy, its cross-sectional variation measures differences in quality across the banks.

expenses of fed funds purchased, securities sold under agreements to repurchase, obligations to the U.S. Treasury, and other borrowed money) x (total loans and securities/total earning assets).

Table 1 summarizes the data for our sample.

5.2 Functional Form

We use the translog functional form for cost function given in equation (9). And we assume the demand for financial capital is log-linear. Thus, the model, which consists of the conditional cost function, the cost share equations for the 4 inputs other than uninsured deposits, and the demand for financial capital equations, is:

$$
\begin{aligned}
\ln C = {} & a_0 + \sum_i a_i \ln y_i + \sum_j b_j \ln w_j + \frac{1}{2}\sum_i \sum_j s_{ij} \ln y_i \ln y_j + \frac{1}{2}\sum_i \sum_j g_{ij} \ln w_i \ln w_j \\
& + \sum_i \sum_j d_{ij} \ln y_i \ln w_j + f_k \ln k + f_q \ln q + f_\theta \ln\theta + \frac{1}{2} r_{kk} \ln k \ln k + r_{kq} \ln k \ln q \\
& + r_{k\theta} \ln k \ln\theta + \frac{1}{2} r_{qq} \ln q \ln q + r_{q\theta} \ln q \ln\theta + \frac{1}{2} r_{\theta\theta} \ln\theta \ln\theta \\
& + \sum_j h_{ki} \ln k \ln y_i + \sum_i h_{qi} \ln q \ln y_i + \sum_i h_{\theta i} \ln\theta \ln y_i \\
& + \sum_j t_{kj} \ln k \ln w_j + \sum_j t_{qj} \ln q \ln w_j + \sum_j t_{\theta j} \ln\theta \ln w_j + b_\omega \ln\omega + \frac{1}{2} g_{\omega\omega} \ln\omega \ln\omega \\
& + \sum_j g_{j\omega} \ln w_j \ln\omega + \sum_i d_{i\omega} \ln y_i \ln\omega + t_{k\omega} \ln k \ln\omega + t_{q\omega} \ln q \ln\omega + t_{\theta\omega} \ln\theta \ln\omega + \epsilon
\end{aligned}
\tag{12}
$$

$$
S_j = b_j + \sum_i g_{ij} \ln w_i + \sum_i d_{ij} \ln y_i + t_{qj} \ln k + t_{qj} \ln q + t_{\theta j} \ln\theta + g_{\omega j} \ln\omega + \xi_j, \quad j=1,\ldots,4 \tag{13}
$$

$$
\ln k = A_0 + \sum_i A_i \ln y_i + \sum_j B_j \ln w_j + B_\omega \ln\omega + R_q \ln q + R_\theta \ln\theta + R_m \ln m + \sum_i R_i \ln p_i + \nu \tag{14}
$$

where: $s_{ij} = s_{ji}$, $g_{ij} = g_{ji}$, $r_{ij} = r_{ji}$ by symmetry,

$$b_\omega = 1 - \sum_j b_j, \quad g_{i\omega} = -\sum_j g_{ij}, \forall i, \quad g_{\omega\omega} = -\sum_j g_{j\omega}, \quad d_{i\omega} = -\sum_j d_{ij}, \forall i,$$

$$t_{k\omega} = -\sum_j t_{kj}, \quad t_{q\omega} = -\sum_j t_{qj}, \quad \text{and} \quad t_{ku} = -\sum_j t_{kj} \quad \text{by linear homogeneity,}$$

$$\text{and} \quad B_\omega = \sum_j B_j + R_m + \sum_i R_i \quad \text{by homogeneity of degree zero,}$$

C = conditional cost

y_i = quantity of output i, i= 1,...,5

w_j = price of input j (other than uninsured deposits), j=1,...4

ω = bank-specific risk-free rate of interest

k = financial capital

q = quality

θ = risk

m = noninterest income

p_i = price of output i, i= 1,...,5

S_j = j^{th} cost share, i.e., expenditures on input j divided by conditional cost, j= 1, . . . ,4

ϵ, ν, ξ_i are normally distributed error terms, j=1,...,4

and all variables (except the shares) are normalized by their means.

We allow the correlation of error terms on the cost function, share equations, and financial capital equation to be nonzero for any bank, but we assume the correlation is zero across banks. Since *ln* k is an endogenous variable that appears in the cost and share equations, we use iterative three-stage least squares to estimate the model. All the exogenous variables in the model as well as their squares and cross-products are used as instruments. (The squares and cross-products are uses since the square of the endogenous variable, i.e., $(ln\ k)^2$ appears in the cost equation (see Kelejian, 1971 and Greene, 1993, p. 609). The estimates we obtain are asymptotically equivalent to maximum likelihood estimates.[14]

Once the model is estimated, reduced-form coefficients can be calculated by substituting the demand for financial capital equation (15) into the cost and share equations. These coefficients can then be used to calculate certain characteristics like economies of scale and scope, input demand elasticities, and so on, taking into account the endogeneity of financial capital.

Note that it is possible to estimate the fully reduced-form cost model obtained by substituting equation (15) into the cost equation and share equations and then estimate the reduced-form using iterative seemingly unrelated regression estimation. A problem with doing this, however, is that the cost function's linear homogeneity in input prices cannot be imposed, so information is lost. Thus, we prefer to estimate the structural model.[15]

6. Cost Statistics

Our measure of scale economies takes into account asset quality, along with the endogeneity of financial capital. If quality is appropriately considered relative to asset size, then a variation in any output level y_i is a variation in the i^{th} individual quality-asset ratio (i.e., q/y_i) and also in the aggregate quality-asset ratio (i.e., $q/\Sigma_i y_i$). Thus, a variation in y_i is a variation in the bank's quality and the traditional scale economies measure does not hold quality constant. Following Mester and Hughes (1993), we derive a scale economies measure that holds quality constant, while taking into account the endogeneity of financial capital by substituting (14) into (12), and then considering the effect of a proportionate variation in the levels of all outputs in y and quality, q, on cost. Essentially, we are

[14]We are currently investigating whether the financial capital equation should include higher ordered terms, and whether the results are robust to a change in specification.

[15]Results regarding scale and scope economies based on the fully reduced-form cost function are similar to those reported in the text based on the cost model consisting of equations (12), (13), and (14).

measuring scale economies using C^m given in equation (8) (and taking into account quality). Consider **a composite output quantity and output quality bundle, $\zeta^0 \equiv (y^0, q^0)$, and suppose $\zeta = t\zeta^0$. Totally** differentiating with respect to a scaled variation in y and q yields,

$$\frac{dC}{\left(\frac{dt}{t}\right)} = \sum_i \frac{\partial C}{\partial y_i} y_i + \sum_i \frac{\partial C}{\partial k}\frac{\partial k}{\partial y_i} y_i + \frac{\partial C}{\partial q} q + \frac{\partial C}{\partial k}\frac{\partial k}{\partial q} q \ , \tag{15}$$

so that the degree of multiproduct scale economies is given by,

$$\text{SCALE} \equiv \frac{C}{\frac{dC}{\left[\frac{dt}{t}\right]}} = \frac{C}{\sum_i \frac{\partial C}{\partial y_i} y_i + \sum_i \frac{\partial C}{\partial k}\frac{\partial k}{\partial y_i} y_i + \frac{\partial C}{\partial q} q + \frac{\partial C}{\partial k}\frac{\partial k}{\partial q} q}$$
$$= \frac{1}{\sum_i \frac{\partial \ln C}{\partial \ln y_i} + \sum_i \frac{\partial \ln C}{\partial \ln k}\frac{\partial \ln k}{\partial \ln y_i} + \frac{\partial \ln C}{\partial \ln q} + \frac{\partial \ln C}{\partial \ln k}\frac{\partial \ln k}{\partial \ln q}} \tag{16}$$

where SCALE > 1 implies multiproduct economies of scale, and SCALE < 1 implies multiproduct diseconomies of scale.

It might be interesting to compare this scale measure with those obtained if we neglect to control for quality and/or financial capital endogeneity. These "partial" scale economies measures are:

$$\text{PARTSCALE}_1 = \frac{1}{\sum_i \left[\frac{\partial \ln C}{\partial \ln y_i}\right]} \ , \tag{17}$$

$$\text{PARTSCALE}_2 = \frac{1}{\sum_i \left[\frac{\partial \ln C}{\partial \ln y_i} + \frac{\partial \ln C}{\partial \ln k}\frac{\partial \ln k}{\partial \ln y_i}\right]} \ , \tag{18}$$

$$\text{PARTSCALE}_3 = \frac{1}{\sum_i \left[\frac{\partial \ln C}{\partial \ln y_i}\right] + \frac{\partial \ln C}{\partial \ln q}} \ . \tag{19}$$

$PARTSCALE_1$ is similar to the scale economies measure used in previous studies, in the sense that it does not take into account how the bank's capital choice changes as output level changes, nor does it hold output quality constant as output level changes. (Of course, since we include financial capital and quality measures in our cost function while previous studies did not, our estimate of $PARTSCALE_1$ need not be the same as estimates of scale economies in previous studies.) $PARTSCALE_2$ takes into account the endogeneity of k, but does not hold quality constant. $PARTSCALE_3$ holds quality constant, but does not take into account the endogeneity of k.

In addition to economies of scale, we also measure *within-sample economies of scope,* allowing the financial capital level to change endogenously as output changes. (That is, when measuring scope economies we evaluate cost at the bank's chosen financial capital level associated with each output level.) Within-sample economies of scope exist between outputs when the cost of producing them together in a single firm is less than the cost of producing them in firms that specialize in one of each of the outputs, but are not more specialized than the most specialized firm in the sample being studied [see Mester (1991, 1992)]. For five outputs, the degree of within-sample global economies of scope evaluated at y is defined as

$$\text{WSCOPE}(y) \equiv \frac{\sum_{\ell=1}^{5} C(\hat{y}_\ell, k(\hat{y}_\ell)) - C(y, k(y))}{C(y, k(y))} \tag{20}$$

where $\hat{y}_\ell$ is the output vector with i^{th} component equal to $y_i - 4y_i^m$ if $i=\ell$ and equal to y_i^m if $i \neq \ell$, and y_i^m is the minimum value of y_i in the sample.[16] Note that the scope measures treat k endogenously by

[16]Note that we replace the zeroes in the conventional measure of scope economies by y_i^m, which is within the sample for each output i and so avoids problems associated with extrapolating outside the sample. We subtract *four* times y_i^m from y_i so that the sum of the output levels across the five relatively specialized firms equals y, the point at which we are evaluating scope economies. For n outputs, we would subtract $(n-1)$ times y_i^m. The insignificant $WSCOPE_{ij}$ measures not reported in Table 4 are available from the authors.

evaluating cost at the level of k chosen by a bank producing output $\hat{y}_\ell$ or y. Similarly, the degree of within-sample economies of scope specific to a subset T of N outputs at y is defined as

$$\mathrm{WSCOPE}_T(y) \equiv \frac{C(\tilde{y}_T, k(\tilde{y}_T)) + C(\tilde{y}_{N-T}, k(\tilde{y}_{N-T})) - C(y, k(y))}{C(y, k(y))} \tag{21}$$

where $\tilde{y}_T$ is the output vector whose i^{th} component equals $y_i - y_i^m$ if $i \in T$, and equals y_i^m if $i \notin T$. Similarly, $\tilde{y}_{N-T}$ is the output vector whose i^{th} component equals y_i^m if $i \in T$ and equals $y_i - y_i^m$ if $i \notin T$.

As a robustness check on our scope economies measures, we also look at cost complementarities, which again permit the level of financial capital to adjust optimally as output varies. A sufficient condition for scope economies to exist at output vector, y, is that there are *weak cost complementarities* for *all* partitions of the product set N at *all* output levels up to y. That is, $d^2C(y')/dy_i dy_j \leq 0$, $i \neq j$ for all y' with $0 \leq y' \leq y$, with inequality holding strictly over a set of nonzero measure. Thus, we measure the complementarily between outputs i and j by

$$\mathrm{COMPL}_{ij} \equiv \frac{d^2C}{dy_i dy_j} = \frac{C}{y_i y_j}\left\{\frac{d\,ln C}{d\,ln y_i}\frac{d\,ln C}{d\,ln y_j} + \frac{d^2 ln C}{d\,ln y_i\, d\,ln y_j}\right\} \qquad \text{for } i \neq j\ , \tag{22}$$

where the derivatives of *ln* C in equation (19) treat k as a function of output and permit it to change as output changes.

7. Empirical Results

Parameter estimates and goodness-of-fit measures are reported in Table 2. Since the cost function is not homothetic, cost statistics, like scale and scope economies, will vary with the levels of the exogenous variables. Therefore, the statistics reported in Tables 3 and 4 are evaluated at the mean levels of the exogenous variables for banks in four size categories that correspond to the sample quartiles determined by total assets in 1990. These categories are assets ≤ \$1.77 billion, \$1.77 < assets ≤ \$3.22 billion, \$3.22 billion ≤ assets ≤ \$6.72 billion, and assets > \$6.72 billion. We also report these statistics evaluated at the mean levels of the exogenous variables for the entire size range of banks. Since these cost statistics are nonlinear functions of the parameters, standard errors are approximated by expanding each statistic as a Taylor series, dropping terms of order 2 or higher, and using the standard variance formula for linear functions of estimated parameters.

7.1 Demand for Financial Capital

The parameters in the demand for financial capital equation give the elasticity of demand with respect to the variables in the demand function. As expected, the elasticity of demand for financial capital with respect to each output is positive (see estimates $A_1,...,A_5$), and significantly so for each output except loans to individuals. The elasticities with respect to all input prices except labor are negative; the other borrowed money elasticity (i.e., B_4) is significantly different from zero. This suggests that other borrowed money is a substitute for financial capital. The other significant elasticities are those with respect to q, m, p_2, p_4, and p_5. R_q is significantly positive, which means that an increase in the volume of nonperforming loans implies an increase in the demand for financial capital, which seems reasonable. The fact that elements of the revenue function, i.e., m, p_2, p_4, and p_5, have a significant effect on financial capital, k, given output and quality, suggests banks may not be simple cost minimizers, but rather that they might be maximizing utility, which is a function of risk and return. We next examine whether these revenue variables have a significant effect on cost, via their effect on financial capital. If so, this can be interpreted as evidence of utility maximization.

7.2 Bank Managers' Objectives: Utility vs. Profit Maximization

Table 3 presents the elasticities of cost with respect to revenue variables, taking into account the endogeneity of k. As shown there, for banks in the three smallest size categories, i.e., with assets between $1 billion and $6.72 billion, revenue variables have a significant impact on costs, holding y and q constant. This is evidence that managers at these banks are trading off profits for financial capital, i.e., for lower risk, rather than maximizing profits. We cannot reject the hypothesis that banks in the largest size category, i.e., banks with assets over $6.72 billion are maximizing profits. We believe this is the first direct empirical test of the objective function of bank managers.

7.3 Scale Economies

Table 4 reports scale economies estimates, which take into account the effect of output level, output quality, and financial capital on cost. That is, when we compute SCALE, we take into account how a change in output level or output quality affects financial capital, k, which in turn affects cost. As indicated in the table, there are increasing returns to scale for banks in the three smallest size categories, since the point estimates are significantly greater than one, and there are constant returns to scale at banks in the largest size category, since the point estimates are insignificantly different from one. While the point estimates suggest the average cost curve is U-shaped, the magnitudes are small, suggesting the average cost curve is fairly flat. Thus, the results are not that different from Hughes and Mester (1993), who found constant returns across the entire size range of banks using a similar sample but different output definitions and treating financial capital as exogenous. The results are also consistent with McAllister and McManus (1993), who find that after declining over smaller asset sizes, the average cost curve flattens out.

$PARTSCALE_1$, $PARTSCALE_2$, and $PARTSCALE_3$, the measures of scale economies that do not take into account output quality and/or financial capital endogeneity, yielded estimates that were significantly greater than one for smaller banks and insignificantly different from one for larger banks. Although the divergence is greater for smaller banks, for all size banks, $PARTSCALE_3 > PARTSCALE_1 > PARTSCALE_2$. This makes sense: recall that $PARTSCALE_3$ holds quality constant as y increases, but doesn't take into account the endogeneity of k. That is, as output levels increase, k is held constant so default risk increases. Average costs appear to be declining more sharply here, i.e., the scale measure is high, because the cost of holding default risk constant as output levels increase is not taken into account. $PARTSCALE_2$ takes into account that k is endogenous and holds default risk constant as output increases, but does not hold quality constant. As output levels increase, with no change in q, the percentage of output that is nonperforming falls, i.e., the quality of output increases. This is reflected in a less rapid decline in average costs, i.e., a lower scale measure. Since $PARTSCALE_1$ is based on the percentage increase in costs when output levels increase, with default risk and quality both increasing as output levels increase, it lies between $PARTSCALE_3$ and $PARTSCALE_2$.

7.4 Scope Economies and Cost Complementarities

Table 5 displays the within-sample measures of global economies of scope. We also reported those product-specific scope economies measures and cost complementarity measures that were significantly different from zero for banks in at least one of the size categories or at the overall mean.[17] Global economies of scope is insignificantly positive for the mean bank and across the size categories, suggesting that there is no evidence of significant cost savings or dissavings from producing the five outputs in a multiproduct firm compared with producing the outputs in five separate, relatively specialized firms.

The within-sample product-specific scope economies measures are interesting in that they reveal some evidence of economies of scope. For all size banks, $WSCOPE_5$, $WSCOPE_{24}$, and $WSCOPE_{45}$ are significantly positive. For banks in the two smaller size categories, $WSCOPE_{15}$ and $WSCOPE_{23}$ are significantly positive, and for banks in the two larger categories, $WSCOPE_{35}$ is significantly positive. Recall that $WSCOPE_T > 0$ means that there are cost savings from having nonspecialized banks producing

[17] At the mean bank and for the four size categories at which we evaluate within-sample economies of scope WSCOPE(y), $y_i - 4y_i^m$ is within the sample and is greater than y_i^m for each output i, so that WSCOPE(y) is well defined. In our sample, the minimum levels of the outputs (in billions of dollars) are $(y_1^m, y_2^m, y_3^m, y_4^m, y_5^m) = (0.001039, 0.01596, 0.008762, 0.000713, 0.01355)$.

all the outputs compared to splitting up the outputs into banks that specialize in producing mainly the outputs in T and banks that specialize in producing mainly the outputs not in T. Our measures seem to suggest that there may be some apparent cost savings in producing business loans, y_2, together with securities, y_5, since in each of the significant $WSCOPE_T$ statistics, y_2 is separated from y_5. Inspection of the cost complementarities measures confirms this: business loans and securities are significant cost complements, so that splitting up these two outputs would be costly for the bank. This result provides some support to those that have argued that "narrow" banks would be at a cost disadvantage because of their inability to capture scope economies [see Litan (1987) for more on economies of scope and narrow banks].

The cost complementarities estimates also indicate that some outputs are non-complements. (This is why we do not find global scope economies.) For example, business loans, y_2, and loans to individuals, y_3, and business loans, y_2, and other loans, y_4, are non-complements. Since these loans are probably made to distinct groups of customers, there is probably no opportunity to share information or credit evaluations, and this might lead to noncomplementarity given the bank has limited resources. On the other hand, real estate loans, y_1, and loans to individuals, y_3, are likely to be made to the same set of customers (since residential mortgages are a large part of y_1), and we find they are cost complements.

These results differ from those in Hughes and Mester (1993), who found evidence of scope *diseconomies* at the largest banks in the sample. While the samples and output definitions differ somewhat between the two papers, the main difference is that here we endogenize the bank's choice of financial capital, whereas Hughes and Mester (1993) measured scope economies at a fixed level of financial capital, k. As they say in footnote 8, this makes their measures of scope economies difficult to interpret, since k is not permitted to vary with output level. Here, the scope economies statistics are calculated at each bank's (both specialized and nonspecialized banks) optimal capital level. This may account for the difference in the results.

8. Conclusion

This paper presents evidence on the objective function of bank management—that is, are they risk neutral and maximize expected profits or are they risk-averse and trade off profit for risk reduction? We extend the model of Hughes and Mester (1993) to allow a bank's choice of its financial capital level to reflect its preference for return versus risk. A multiproduct cost function, which incorporates asset quality and the risk faced by a bank's uninsured depositors, is derived from a model of utility maximization. The utility function represents the bank management's preferences defined over asset levels, asset quality, capital level, and profit. Endogenizing the bank's choice of capital level in this way permits the demand for financial capital to deviate from its cost-minimizing level. The model consists of the cost function, share equations, and demand for financial capital equation, which are estimated jointly. We then are able to explicitly test whether bank managers are acting in shareholders' interest and maximizing expected profits, or whether they are maximizing a utility function that exhibits risk aversion.

We find evidence that banks in the three smallest size quartiles are acting in a risk-averse manner, and maximizing a utility function that trades off profits for risk reduction. For banks in the largest size quartile, with assets over $6.72 billion, we cannot reject the hypothesis that they are acting to maximize expected profits. Our estimates of scale and scope economies based on this model show slight economies of scale at banks at the three smallest size categories and constant returns at banks in the largest size category. We also find some evidence of product-specific scope economies, cost complementarity between some outputs, and cost non-complementarity between other outputs.

Figure 1

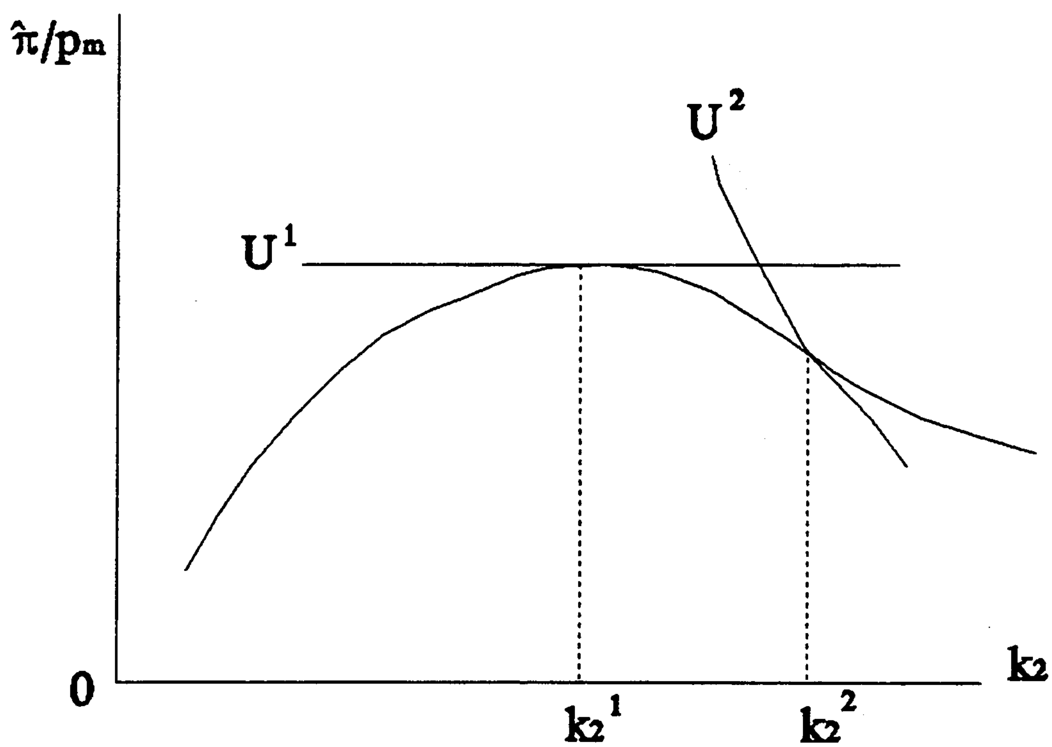

Figure 2

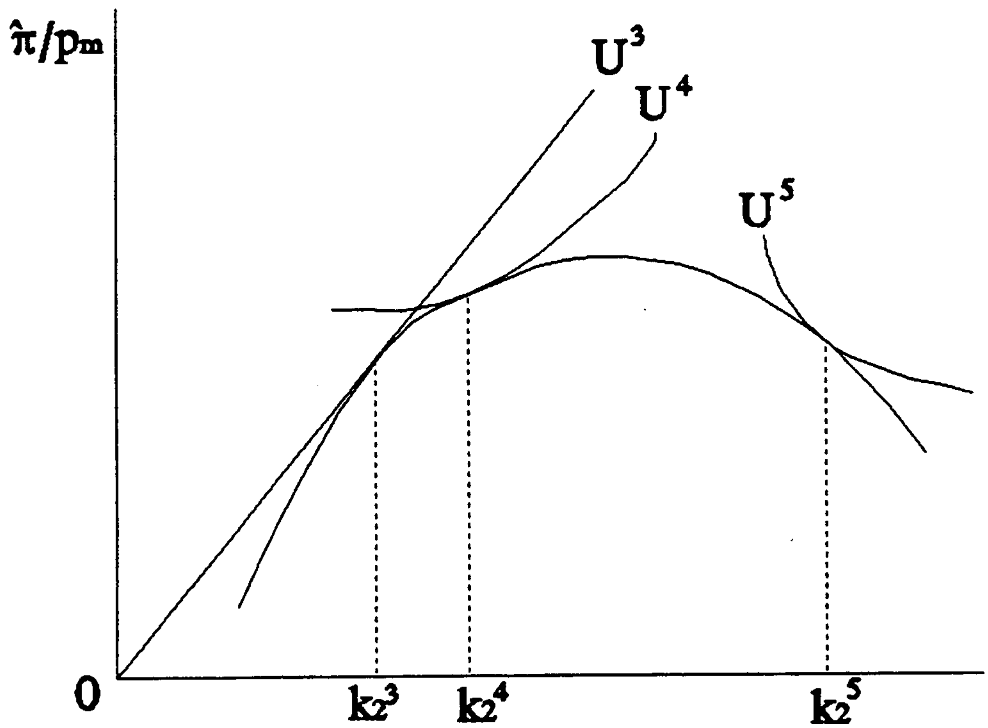

Table 1 Means of the Variables

	Banks with Assets under $1.77 Billion (71 banks)	Banks with Assets Between $1.77 and $3.22 Billion (72 banks)	Banks with Assets Between $3.22 and $6.72 Billion (72 banks)	Banks with Assets over $6.72 Billion (71 banks)	All Banks (286 banks)
$y_1^{\dagger}$ real estate loans	0.3645	0.6508	1.282	3.680	1.490
$y_2^{\dagger}$ business loans	0.2484	0.4686	0.9247	4.809	1.606
$y_3^{\dagger}$ loans to individuals	0.1864	0.3288	0.6582	1.520	0.6722
$y_4^{\dagger}$ other loans	0.03579	0.07722	0.1691	1.609	0.4703
$y_5^{\dagger}$ securities	0.3230	0.5542	0.9757	3.469	1.327
$w_1^{\dagger\dagger\dagger}$ price of labor	29.08	31.18	32.57	39.58	33.09
$w_2^{\dagger\dagger}$ price of physical capital	0.3907	0.3792	0.3810	0.4333	0.3960
$w_3^{\dagger\dagger}$ price of insured deposits	0.06010	0.06012	0.05935	0.0603	0.05996
$w_4^{\dagger\dagger}$ price of other borrowed money	0.08091	0.07901	0.08517	0.1034	0.08709
ω bank-specific risk-free rate	0.07673	0.07704	0.07702	0.07748	0.07707
$k^{\dagger}$ financial capital	0.1069	0.1867	0.3558	1.606	0.5618
$q^{\dagger}$ nonperforming loans	0.03800	0.08069	0.1533	0.7020	0.2426
$\theta^{\dagger}$ risk ≡ std. dev. of net income	0.005438	0.01229	0.02552	0.1294	0.04300
$m^{\dagger}$ noninterest income	0.01808	0.03352	0.06969	0.3777	0.1242

Table 1, continued

	Banks with Assets under \$1.77 Billion (71 banks)	Banks with Assets Between \$1.77 and \$3.22 Billion (72 banks)	Banks with Assets Between \$3.22 and \$6.72 Billion (72 banks)	Banks with Assets over \$6.72 Billion (71 banks)	All Banks (286 banks)
p_1† price of y_1	0.1078	0.1112	0.1096	0.1073	0.1090
p_2† price of y_2	0.1135	0.1078	0.1099	0.0974	0.1072
p_3† price of y_3	0.1246	0.1182	0.1254	0.1246	0.1232
p_4† price of y_4	0.08268	0.09520	0.08417	0.0797	0.08547
p_5† price of y_5	0.08650	0.08476	0.08594	0.0934	0.08764
C† conditional cost	0.09286	0.1641	0.3231	1.202	0.4442

†in billions of dollars ††in dollars per dollar †††in thousands of dollars per employee

Table 2 Parameter Estimates and Goodness of Fit Measures

Parameter	Estimate (Approx. Std. Error)	Parameter	Estimate (Approx. Std. Error)	Parameter	Estimate (Approx. Std. Error)
a_0	0.003035 (0.01957)	d_{24}	0.01431 (0.01039)	t_{q2}	−0.01199* (0.003429)
a_1	0.2222* (0.02533)	d_{31}	0.009606* (0.004722)	t_{q3}	0.006022 (0.01172)
a_2	0.2639* (0.03439)	d_{32}	0.0009579 (0.002124)	t_{q4}	0.005423 (0.01216)
a_3	0.1354* (0.02273)	d_{33}	0.04203* (0.007248)	$t_{\theta 1}$	0.006057 (0.004965)
a_4	0.01229 (0.01890)	d_{34}	−0.009420 (0.007431)	$t_{\theta 2}$	0.006708* (0.002241)
a_5	0.2624* (0.02897)	d_{41}	−0.002042 (0.003221)	$t_{\theta 3}$	0.01554* (0.007639)
b_1	0.2221* (0.005307)	d_{42}	−0.001422 (0.001459)	$t_{\theta 4}$	−0.008985 (0.007975)
b_2	0.07838* (0.002389)	d_{43}	−0.003583 (0.005015)	b_{ω}	0.1241* (0.007498)
b_3	0.3982* (0.008104)	d_{44}	0.008808** (0.005283)	$g_{1\omega}$	−0.01369 (0.01797)
b_4	0.1773* (0.008603)	d_{51}	−0.01283* (0.005909)	$g_{2\omega}$	−0.002923 (0.007932)
s_{11}	0.1198* (0.02106)	d_{52}	−0.005876* (0.002677)	$g_{3\omega}$	−0.1066* (0.03477)
s_{12}	−0.09369* (0.02641)	d_{53}	0.01439 (0.009270)	$g_{4\omega}$	−0.04936* (0.01791)
s_{13}	−0.06455* (0.01358)	d_{54}	0.01722** (0.009818)	$g_{\omega\omega}$	0.2459* (0.04299)
s_{14}	−0.02463** (0.01310)	f_k	0.1174** (0.06563)	$d_{1\omega}$	0.004066 (0.007036)
s_{15}	−0.04984* (0.01664)	f_q	−0.05659* (0.02793)	$d_{2\omega}$	0.02615* (0.009228)
s_{22}	0.1261* (0.02347)	f_{θ}	0.01863 (0.01644)	$d_{3\omega}$	−0.04308* (0.007014)
s_{23}	0.02267 (0.01610)	r_{kk}	−0.4857* (0.1390)	$d_{4\omega}$	−0.001761 (0.004635)

Table 2, continued

Parameter	Estimate (Approx. Std. Error)	Parameter	Estimate (Approx. Std. Error)	Parameter	Estimate (Approx. Std. Error)
s_{24}	0.02620* (0.01087)	r_{kq}	0.07681 (0.05401)	$d_{5\omega}$	−0.01291 (0.008490)
s_{25}	−0.1195* (0.02181)	$r_{k\theta}$	0.01462 (0.03070)	$t_{k\omega}$	−0.003680 (0.01810)
s_{33}	0.08074* (0.01778)	r_{qq}	−0.1159* (0.04356)	$t_{q\omega}$	0.03643* (0.01099)
s_{34}	0.003718 (0.007697)	$r_{q\theta}$	0.06592* (0.02009)	$t_{\theta\omega}$	−0.01932* (0.007029)
s_{35}	−0.0591* (0.01338)	$r_{\theta\theta}$	−0.02117 (0.01721)	A_0	0.08642* (0.02656)
s_{44}	0.008150 (0.008517)	h_{k1}	0.2058* (0.03953)	A_1	0.06695 (0.02733)
s_{45}	−0.006605 (0.01459)	h_{k2}	0.05391 (0.06035)	A_2	0.1750* (0.02845)
s_{55}	0.2869* (0.02410)	h_{k3}	0.02562 (0.03159)	A_3	0.001731 (0.02573)
g_{11}	0.1014* (0.01283)	h_{k4}	−0.006503 (0.02604)	A_4	0.05814* (0.01485)
g_{12}	0.01616* (0.004767)	h_{k5}	0.01594 (0.05350)	A_5	0.1695* (0.02614)
g_{13}	−0.1135* (0.01365)	h_{q1}	0.02710 (0.02589)	B_1	0.08163 (0.08279)
g_{14}	0.009657 (0.009929)	h_{q2}	0.001128 (0.02394)	B_2	−0.04318 (0.03582)
g_{22}	0.01925* (0.002764)	h_{q3}	−0.01124 (0.01621)	B_3	−0.08285 (0.09189)
g_{23}	−0.04031* (0.006440)	h_{q4}	−0.01398 (0.01268)	B_4	−0.1625* (0.05708)
g_{24}	0.007830** (0.004742)	h_{q5}	−0.02792 (0.02738)	R_q	0.1616* (0.03480)
g_{33}	0.3498* (0.03079)	$h_{\theta 1}$	−0.07883* (0.01796)	R_θ	0.003955 (0.1646)
g_{34}	−0.01609 (0.01747)	$h_{\theta 2}$	−0.005617 (0.01917)	R_m	0.2133* (0.02864)

Table 2, continued

Parameter	Estimate (Approx. Std. Error)	Parameter	Estimate (Approx. Std. Error)	Parameter	Estimate (Approx. Std. Error)
g_{44}	0.04796* (0.01999)	$h_{\theta 3}$	−0.005257 (0.009630)	R_1	−0.08320 (0.08883)
d_{11}	0.006430 (0.004968)	$h_{\theta 4}$	0.001623 (0.007485)	R_2	−0.3929* (0.09369)
d_{12}	0.005817* (0.002234)	$h_{\theta 5}$	0.02167 (0.01879)	R_3	0.1150 (0.08588)
d_{13}	0.04505* (0.007654)	t_{k1}	0.07512* (0.01180)	R_4	0.05543* (0.02365)
d_{14}	−0.06136* (0.008153)	t_{k2}	0.03193* (0.005409)	R_5	0.3593* (0.1291)
d_{21}	−0.03091* (0.006351)	t_{k3}	−0.1602* (0.01923)	B_ω	−0.05998 (0.1933)
d_{22}	−0.01873* (0.002880)	t_{k4}	0.05683* (0.02047)		
d_{23}	0.009177 (0.009953)	t_{q1}	−0.03689* (0.007564)		

*significant at 5% level **significant at 10% level

$\bar{R}^2$ on cost equation = 0.9890
$\bar{R}^2$ on labor share equation = 0.2197
$\bar{R}^2$ on physical capital share equation = 0.1929
$\bar{R}^2$ on insured deposit share equation = 0.6440
$\bar{R}^2$ on borrowed funds share equation = 0.4362
$\bar{R}^2$ on demand for financial capital equation = 0.9384

Table 3 **Elasticities of Cost With Respect to Revenue Variables**[†]

	Banks with Assets under $1.77 Billion (71 banks)	**Banks with Assets Between $1.77 and $3.22 Billion** (72 banks)	**Banks with Assets Between $3.22 and $6.72 Billion** (72 banks)	**Banks with Assets over $6.72 Billion** (71 banks)	**All Banks** (286 banks)
$\frac{d\,ln\,C}{d\,ln\,p_1}$	−0.01786 (0.01991)	−0.01531 (0.01721)	−0.01493 (0.01673)	−0.001156 (0.006218)	−0.006276 (0.008328)
$\frac{d\,ln\,C}{d\,ln\,p_2}$	−0.08434* (0.03218)	−0.07230* (0.02950)	−0.07051* (0.03113)	−0.005462 (0.02921)	−0.02964 (0.02602)
$\frac{d\,ln\,C}{d\,ln\,p_3}$	0.02468 (0.01895)	0.02116 (0.01657)	0.02064 (0.01614)	0.001598 (0.008482)	0.008675 (0.009147)
$\frac{d\,ln\,C}{d\,ln\,p_4}$	0.01190** (0.006085)	0.01020** (0.005361)	0.009946** (0.005568)	0.0007704 (0.004140)	0.004181 (0.003920)
$\frac{d\,ln\,C}{d\,ln\,p_5}$	0.07712* (0.03467)	0.06612* (0.03171)	0.06448* (0.03231)	0.004995 (0.026618)	0.02711 (0.02411)
$\frac{d\,ln\,C}{d\,ln\,m}$	0.04578* (0.01536)	0.03925* (0.01442)	0.03827* (0.01514)	0.002965 (0.01584)	0.0169 (0.01360)

[†]Cost statistics evaluated at size-category means of input prices, quality measure, risk measure, and output levels. Approximate standard errors in parentheses.

*significant at 5% level **significant at 10% level

p_1 = price of real estate loans p_2 = price of business loans p_3 = price of loans to individuals
p_4 = price of other loans p_5 = price of securities m = noninterest income

Table 4 **Scale Economies†**

	Banks with Assets under \$1.77 Billion (71 banks)	Banks with Assets Between \$1.77 and \$3.22 Billion (72 banks)	Banks with Assets Between \$3.22 and \$6.72 Billion (72 banks)	Banks with Assets over \$6.72 Billion (71 banks)	All Banks (286 banks)
SCALE	1.095*,# (0.03516)	1.096*,# (0.03333)	1.080*,# (0.03617)	1.069* (0.04627)	1.088*,# (0.03863)
$PARTSCALE_1$	1.229*,# (0.09215)	1.189*,# (0.08332)	1.166*,# (0.08732)	1.011* (0.07613)	1.085* (0.07351)
$PARTSCALE_2$	1.093*,# (0.04207)	1.078*,# (0.03908)	1.061* (0.04090)	1.005* (0.04687)	1.045* (0.04111)
$PARTSCALE_3$	1.287*,# (0.1090)	1.256*,# (0.1008)	1.230*,# (0.1062)	1.079* (0.09344)	1.147* (0.09006)

†Cost statistics evaluated at size category means of input prices, quality measure, risk measure, and output levels. Approximate standard errors in parentheses.

*significantly different from 0 at 5% level #significantly different from 1 at 5% level
**significantly different from 0 at 10% level ##significantly different from 1 at 10% level

$$\text{SCALE} \equiv \frac{C}{\frac{dC}{\left[\frac{dt}{t}\right]}} = \frac{1}{\sum_i \frac{\partial lnC}{\partial lny_i} + \sum_i \frac{\partial lnC}{\partial lnk}\frac{\partial lnk}{\partial lny_i} + \frac{\partial lnC}{\partial lnq} + \frac{\partial lnC}{\partial lnk}\frac{\partial lnk}{\partial lnq}}$$

$$\text{PARTSCALE}_1 = \frac{1}{\sum_i \left[\frac{\partial lnC}{\partial lny_i}\right]}$$

$$\text{PARTSCALE}_2 = \frac{1}{\sum_i \left[\frac{\partial lnC}{\partial lny_i} + \frac{\partial lnC}{\partial lnk}\frac{\partial lnk}{\partial lny_i}\right]}$$

$$\text{PARTSCALE}_3 = \frac{1}{\sum_i \left[\frac{\partial lnC}{\partial lny_i}\right] + \frac{\partial lnC}{\partial lnq}}$$

Table 5 **Within-Sample Global and Product-Specific Economies of Scope and Cost Complementarities†**

	Banks with Assets under $1.77 Billion (71 banks)	Banks with Assets Between $1.77 and $3.22 Billion (72 banks)	Banks with Assets Between $3.22 and $6.72 Billion (72 banks)	Banks with Assets over $6.72 Billion (71 banks)	All Banks (286 banks)
WSCOPE	0.2705 (0.3757)	0.2921 (0.4544)	0.3959 (0.5727)	1.007 (1.301)	0.4955 (0.7235)
$WSCOPE_1$	1.679** (0.9477)	2.783** (1.680)	5.204 (3.406)	17.00 (14.21)	7.133 (4.917)
$WSCOPE_3$	0.1676 (0.1144)	0.2219** (0.1308)	0.3425* (0.1675)	0.6635* (0.2873)	0.3372* (0.1672)
$WSCOPE_5$	0.9507* (0.2648)	1.673* (0.4547)	3.077* (0.9190)	11.83* (4.988)	4.541* (1.498)
$WSCOPE_{15}$	2.744* (1.240)	5.629** (2.915)	13.57 (8.536)	99.06 (94.04)	23.31 (16.70)
$WSCOPE_{23}$	1.634* (0.8155)	2.988** (1.669)	6.221 (4.087)	27.57 (26.59)	8.617 (6.448)
$WSCOPE_{24}$	0.5959* (0.2534)	0.9797* (0.3968)	1.629* (0.6723)	5.679** (2.916)	2.360* (1.073)
$WSCOPE_{35}$	0.6318 (0.4061)	0.9915** (0.6018)	1.652** (0.9796)	4.877** (2.798)	2.188** (1.185)
$WSCOPE_{45}$	0.6870* (0.2344)	1.215* (0.3756)	2.213* (0.7107)	7.762* (3.365)	3.052* (1.059)
$COMPL_{13}$	-0.3115×10^{-7}** (0.1850×10^{-7})	-0.1858×10^{-7}** (0.1067×10^{-7})	-0.9290×10^{-8}** (0.5551×10^{-8})	-0.7194×10^{-8}** (0.3160×10^{-8})	-0.1290×10^{-7}** (0.6050×10^{-8})
$COMPL_{15}$	0.4318×10^{-7}* (0.1424×10^{-7})	0.2666×10^{-7}* (0.8088×10^{-8})	0.1484×10^{-7}* (0.4379×10^{-8})	0.5665×10^{-8}* (0.1755×10^{-8})	0.1099×10^{-7}* (0.3632×10^{-8})
$COMPL_{23}$	0.1195×10^{-6}* (0.3033×10^{-7})	0.6573×10^{-7}* (0.1658×10^{-7})	0.3295×10^{-7}* (0.8559×10^{-8})	0.1102×10^{-7}* (0.2947×10^{-8})	0.2743×10^{-7}* (0.6638×10^{-8})
$COMPL_{24}$	0.3096×10^{-6}* (0.1132×10^{-6})	0.1299×10^{-6}* (0.4948×10^{-7})	0.5566×10^{-7}* (0.2207×10^{-7})	0.4110×10^{-8}* (0.2092×10^{-8})	0.1653×10^{-7}* (0.6913×10^{-8})
$COMPL_{25}$	-0.8217×10^{-7}* (0.1702×10^{-7})	-0.4148×10^{-7}* (0.9817×10^{-8})	-0.2044×10^{-7}* (0.5862×10^{-8})	-0.1923×10^{-8} (0.1518×10^{-8})	-0.9289×10^{-8}* (0.3543×10^{-8})

†Cost statistics evaluated at size category means of input prices, quality measure, risk measure, and output levels. Approximate standard errors in parentheses.

*significantly different from 0 at 5% level **significantly different from 0 at 10% level

y_1 = real estate loans y_2 = business loans y_3 = loans to individuals
y_4 = other loans y_5 = securities

Table 5, continued

$$\text{WSCOPE}(y) \equiv \frac{\sum_{\ell=1}^{5} C(\hat{y}_\ell, k(\hat{y}_\ell)) - C(y, k(y))}{C(y, k(y))}$$

where $\hat{y}_\ell$ = output vector with i^{th} component equal to $y_i - 4y_i^m$ if $i=\ell$ and equal to y_i^m if $i \neq \ell$, and y_i^m is the minimum value of y_i in the sample.

$$\text{WSCOPE}_T(y) \equiv \frac{C(\bar{y}_T, k(\bar{y}_T)) + C(\bar{y}_{N-T}, k(\bar{y}_{N-T})) - C(y, k(y))}{C(y, k(y))}$$

where $\bar{y}_T$ = output vector with i^{th} component equal to $y_i - y_i^m$ if $i \in T$, and equal to y_i^m if $i \notin T$, and $\bar{y}_{N-T}$ = output vector with i^{th} component equal to y_i^m if $i \in T$ and equal to $y_i - y_i^m$ if $i \notin T$.

$$\text{COMPL}_{ij} \equiv \frac{d^2C}{dy_i dy_j} = \frac{C}{y_i y_j}\left\{\frac{d\,lnC}{d\,ln y_i}\frac{d\,lnC}{d\,ln y_j} + \frac{d^2 lnC}{d\,ln y_i\, d\,ln y_j}\right\} \qquad \text{for } i \neq j$$

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