Bank Profitability, Interest Rates, and Monetary Policy

Author(s): Diana Hancock

Source: *Journal of Money, Credit and Banking*, May, 1985, Vol. 17, No. 2 (May, 1985), pp. 189-202

Published by: Ohio State University Press

Stable URL: https://www.jstor.org/stable/1992333

DIANA HANCOCK

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1. INTRODUCTION

THIS PAPER EXAMINES THE EFFECT ON BANK PROFITS and rate of return on capital of changes in interest rates and other components of monetary and regulatory policy. A monetary policy that focuses on the growth or level of quantities of money can imply fluctuations in interest rates. At issue is whether banks benefit from high interest rates imposed by restrictions on monetary quantities.

There are three features of the procedure used. First, bank profits depend on all interest rates for asset and liability items, as opposed to one market interest rate.[1] The latter is appropriate only if assets and liabilities can be aggregated, with price per unit of services equal to the market interest rate. There is no adjustment for differences in liquidity, risk, and maturity between various assets and liabilities. Second, it is based on user costs for all financial items. These user costs depend not only on interest rates, but also service charges, reserve requirement costs, and deposit insurance premiums. The effect on profits of monetary or regulatory policy changes acting through variables other than interest rates thus can be examined. Third, account is taken of relative price changes between financial and nonfinancial items, permitting flexible substitution and transformation between inputs and outputs. Some interest rates can rise relative to others and relative to the prices of

The author is grateful to Erwin Diewert, Peter Chinloy, and two anonymous referees for their helpful comments. The data have been obtained from the Federal Reserve Bank of New York with the kind assistance of Carl Allen. Josef Roehrl provided research assistance.

[1]Flannery (1981) estimates the effect of interest rates on bank profits using the Treasury bill rate as the market rate.

DIANA HANCOCK *is assistant professor of finance, University of Santa Clara.*

Journal of Money, Credit, and Banking, Vol. 17, No. 2 (May 1985)

nonfinancial services such as labor.[2] To include the effects of all prices on profits, the variable profit function, as opposed to the cost function, is estimated. The latter does not take account of the effect of interest rates on revenues. Further, output quantities are exogenous in the cost function.[3]

The effect of interest rates on bank profits has been examined by Samuelson (1945). It is shown that under general conditions, bank profits increase with rising interest rates. "The banking system as a whole is immeasurably helped rather than hindered by an increase in interest rates . . . and commercial banks would profit more than savings banks" (Samuelson 1945, p. 25). This conjecture that banks benefit from "high" rather than "low" interest rates is tested. Whereas at the aggregate level increases in interest rates reduce output and employment, this does not necessarily obtain in each sector.

Also tested is the effect on bank profits of the spread or margin, the difference between loan and deposit interest rates. It is an appropriate explanatory variable if the effect on profits from a percentage point interest rate change for loans and deposits is identical except for sign and if interest rates alone represent the prices of financial services. The hypothesis that a spread can be used as an explanatory variable, replacing both interest rates, requires a separability test, which is derived and applied.

Section 2 develops a testable model of production, which includes both financial and nonfinancial goods. The bank maximizes variable profits or revenues less costs for a given quantity of capital. The resulting variable profit function is dependent on prices of all variable goods other than capital and on the quantity of capital. The derivative of the variable profit function in capital is its marginal rate of return. This is a function of the quantity of capital and all prices, the latter dependent on interest rates. The effect of interest rate changes on the rate of return can be computed directly, as can the effect on variable profits. Demands for outputs and supplies for inputs are estimated simultaneously with the variable profit function to ensure more precise measurement of the parameters.

Data are required on capital and variable profit, as well as prices and quantities for financial and nonfinancial services. The procedures to obtain economic from accounting financial statements are described in section 3. With these data, cash and other financial commodities can be included in production with nonfinancial services such as labor.

In section 4 the economic financial statements and estimation of rates of return to capital are derived for a longitudinal sample of New York–New Jersey commercial

[2]Hence interest rates and other costs of assets and liabilities are combined. By comparison, Ho and Saunders (1981) use noninterest costs to explain margin spreads. There, all loans and deposits are aggregated. The procedure here includes both interest and noninterest items for each asset and liability. These user costs determine economic profits.

[3]In strict terms, the construction of a cost function dependent on prices of inputs and quantities of outputs does not require the latter to be exogenous. In a two-stage formulation, output can be determined first and then the cost of producing this output minimized. However, output exogeneity has usually been assumed in application, leaving financial firms with no control over output levels. If this is not the case in practice, biases in estimation arise.

The main rationale for the use of a cost function is that returns to scale can be estimated from the elasticity of cost with respect to output. Comparable tests can be applied to a profit function to determine whether the marginal rate of return on capital increases with the size of firm.

banks in Federal Reserve District #2 for 1973–78. Used in production are loans, demand deposits, time deposits, cash, labor, and material supplies, with capital fixed. In section 5 the economic rate of return on capital and the effect of interest rate changes are calculated. On interest rates, profits are relatively more responsive to changes in loan than deposit rates. This implies that the use of a spread, as opposed to separate inclusion of both loan and deposit interest rates in estimating the profit function, is not supported.

Increases in interest rates that leave the spread unchanged increase variable profit. This lends support to the Samuelson conjecture. The flow cost of reserve requirements is measured. If these were to be eliminated on demand and time deposits, variable profit would increase by approximately 5 percent in each case. These costs should be included in policy evaluations of expanding reserve requirements to other financial firms, as prescribed in depository institutions' deregulation legislation.[4]

2. BANK PRODUCTION AND TECHNOLOGY

Let the bank have a production technology represented by the transformation function $T(x, x_K)$, where $x = (x_1, \ldots, x_{K-1})$ are the variable input and output quantities. Capital is x_K, fixed during the production period. The inputs and outputs represent services from goods measured on the balance sheet and also from non-balance-sheet items such as labor.

Associated with the variable goods $x_1, \ldots, x_{K-1}$ are user costs per unit of service $u_1, \ldots, u_{K-1}$, where one of these is set at positive unity as a numeraire. The variable goods include financial assets such as cash and loans, physical assets in material supplies, and financial liabilities such as demand and time deposits and borrowed funds.

If a good entails net expenditure by the bank, it is an input with positive user cost. If it generates net revenue, then it is an output with negative user cost. This is a rule used to classify goods as inputs or outputs, where $x_i > 0$ for outputs and $x_i < 0$ for inputs.

Hence

$$\begin{aligned} x_i &> 0 \quad \text{if } u_i < 0; \qquad i = 1, \ldots, K-1 \\ x_i &< 0 \quad \text{if } u_i > 0 \end{aligned} \tag{1}$$

and

$$p_i = |u_i|; \qquad i = 1, \ldots, K-1, \tag{2}$$

where p_i is the price of the ith variable good, and $|u_i|$ is the absolute value of u_i.

[4]A complete cost-benefit analysis would indicate as benefits the perceived reduced risk of financial firms to depositors and facility to the central bank in conducting monetary policy. Here, reserve requirements act as a tax on the banking firm.

Cost functions have been used extensively in the estimation of bank technologies, particularly in testing for economies of scale. The bank objective is to minimize the input costs of producing a given level of output, with the technology given. The exogeneity of outputs requires that they be distinguished in advance. This implies that inputs also be distinguished, for their prices are arguments in the cost function. Incorrect classification as to outputs and inputs leads to bias in estimated parameters.

The absence of such a classification rule has led to controversy in the estimation of cost functions for bank production. Deposits have been regarded as inputs, being the base on which loans are made. These earning assets, either in unweighted or weighted form, are then classified as outputs (Sealey and Lindley 1977; Sealey 1980; Murray and White 1983; Clark 1984). Using a profit function, total loans constitute output in Mullineaux (1978). On the other hand, banks are argued as providing deposit services, the latter then being classified as outputs, either in dollar terms (Pesek 1970; Towey 1974) or in number of accounts (Horvitz 1963). A third approach is to treat both deposit and loan services as outputs (Benston 1965; Bell and Murphy 1968). By contrast, if the profit function is estimated, there is no prior requirement for inputs and outputs to be distinguished. Some services generate net revenue and others net expenses. However, if equations for demands for inputs and supplies for outputs are also estimated to aid in identification of profit function parameters, then a rule such as (1) and (2) is necessary.[5]

The profit function is preferable to the cost function because it is more plausible to view outputs as determined by the bank. Levels of inputs and outputs are both subject to control. Further, the behavioral rule that banks maximize profits can be applied, rather than one for minimizing costs. In this model, because some inputs are fixed, the bank maximizes variable profit. The variable profit function is the maximum of net revenue less expenses from all goods and services other than capital, which is fixed.

The variable profit function dual to $T(x, x_K)$ is

$$\pi(p, x_K) = \max_x \left\{ \sum_{i=1}^{K-1} p_i x_i : T(x, x_K) = 0 \right\}. \tag{3}$$

Variable profit is the net revenue from operations, and $\pi(p, x_K)/x_K$ is the average rate of return on capital. Demands for inputs and supplies of outputs are

$$x_i = \partial \pi(p, x_K)/\partial p_i; \qquad i = 1, \ldots, K-2, \tag{4}$$

where prices are measured relative to that for good $(K - 1)$, which is set at unity. In relative expenditure form, $e_i = \partial \ln \pi / \partial \ln p_i = p_i x_i / \pi$. The marginal rate

[5]The convention (1) and (2) follows Debreu (1959, p. 38). The profit function method, with its associated transformation function, is not as crucially dependent as the cost function on a classification as to inputs or outputs. The bank has various activities generating revenues and expenses. If input demands and output supplies are also to be estimated, the classification rule is required. It is not required if the profit or transformation function is estimated alone.

of return on capital is

$$q_K(p, x_K) = \partial\pi(p, x_K)/\partial x_K \,. \tag{5}$$

The prices p are determined by the user costs, and the latter depend on interest rates and regulatory policy exemplified by reserve requirements and deposit insurance premiums. The variable profit function and the demands for input and supplies for output (4) or in relative expenditure form with e_i provide estimates for the rate-of-return function.

From (5) the effect of monetary policy on bank profitability and the rate of return on capital across banks can be compared. If larger size is positively associated with greater rates of return on capital, then $\partial q_K/\partial x_K > 0$. Where the rate of return is independent of size or amount of capital invested, $q_K(p, x_K) = q_K(p)$. If interest rates and monetary policy have no effect on the rate of return, $q_K(p, x_K) = \bar{q}_K$, a constant.

Some of the prices and user costs have interest rates as components. Suppose the only arguments of user costs are interest rates r_i, and $u_i = r_i$, with $r_i > 0$ on good i for interest paid and $r_i < 0$ for interest received. Then $p_i = |u_i|$, and $p_i - p_j = r_i - r_j$ on goods i and j. Here $r_i - r_j$ is the interest rate differential or the spread. For the spread to be the determining factor in profitability, interest rates must be the only arguments of user costs, and the parameters in $\partial\pi/\partial r_i$ and $\partial\pi/\partial r_j$ must be identical. This is clearly testable.

If price differences depend only on the spread, certain separability conditions are required, but their failure does not deny the effects of interest rates on bank production and profitability. Interest rates retain their importance, but other monetary variables also affect profits through user costs and prices. Further, the effect of some interest rates on profits can be greater than others. If changes in loan interest rates affect profits more than changes in deposit interest rates, all in absolute values, then profits do not depend only on spreads.

Empirical implementation requires data on user costs and prices, as well as variable profit and capital stock in current dollars. The accounting balance sheet and income and expense statement contain such data but not in terms immediately amenable to economic application. First, physical capital assets are recorded at historical cost. Second, accounting and economic profit differ in definition. Third, appropriate prices and quantities are not always distinguished in accounting treatment but are central in estimation of economic models.

3. RECONCILIATION OF ACCOUNTING AND ECONOMIC FINANCIAL STATEMENTS

Construction of data on u_i, p_i, and x_i, $i = 1, \ldots, K - 1$, x_K, and π requires economic financial statements. The linkages between the accounting and economic data are the user costs, derived for all balance sheet items.

For assets such as loans and investments, each dollar extended is recorded as a disbursement by the bank, with an asset price of one dollar per unit. In the subsequent period, the bank is entitled to a claim on the initial dollar extended plus interest rate r_i. Service charges for late repayments and standby privileges are s_i and capital gains are c_i, with loan losses and insurance premiums d_i. The user cost of the services of an asset is

$$u_i = 1 - (1 + r_i + c_i + s_i - d_i)/(1 + R); \qquad i = 1, \ldots, A \tag{6}$$

for A asset categories, with discount rate R.

For liabilities such as deposits, each unit dollar received is an inflow to the bank. In the subsequent period, the liability of the bank to the depositor is for the unit dollar plus interest rate payable r_i and deposit insurance premium payable b_i, less service charges earned. The reserve requirement rate for banks so subject is k_i. The net inflow available for usage by the bank is $(1 - k_i)$, with user cost

$$\begin{aligned} u_i &= -(1 - k_i) + (1 - k_i + r_i - s_i + b_i)/(1 + R); \\ &\qquad\qquad\qquad\qquad\qquad\qquad i = A + 1, \ldots, A + L \\ &= -1 + (1 + r_i + b_i + Rk_i - s_i)/(1 + R) \end{aligned} \tag{7}$$

for L liabilities. On withdrawal, the depositor also has a claim $k_i/(1 + R)$ on required reserves. The asset and liability user costs, with rule (1), determine whether balance sheet items are inputs or outputs.

The data are from the *Functional Cost Analysis* collected by the Federal Reserve. The sample contains longitudinal information on financial statements and other data on employment for eighteen New York-New Jersey member banks of Federal Reserve District #2 for 1973–78. The reconciliation of accounting and economic approaches to the balance sheet is in Table 1, which measures all stock items in current dollars.

The quantity of cash x_1 is the dollar balance net of required reserves for demand and time deposits. Loans are divided into seven categories indicated in Table 1, with nondeposit funds and borrowed and purchased funds transferred from the liability side of the balance sheet and subtracted. The net balance in dollar units for loans is x_4. On the liability side, the dollar balances on the accounting financial statements are the quantities of demand deposits x_2 and time deposits x_3.

Total capital is constructed in current dollars and is disaggregated for two reasons. First, the option of varying some components of capital, with others fixed, is available. Second, physical asset categories of computers, other equipment, and plant are distinguished so that the economic balance sheet can correspond identically to the accounting version. For physical assets, the perpetual inventory method is used to construct stocks. Depreciation rates are derived from asset life estimates in the Treasury Department's *Bulletin F* series. Physical assets in constant dollars $K_{i,t}$ for type i at time t is

TABLE 1

BALANCE SHEET: ACCOUNTING AND ECONOMIC RECONCILIATION

Assets	Liabilities
Cash (x_1)	Demand deposits (x_2)
PLUS Loans (x_4)	PLUS Time deposits (x_3)
Investments	
Real estate mortgages	
Installment loans	
Credit card loans	PLUS Financial capital (in x_K)
Commercial, agricultural, and other loans	
LESS Nondeposit funds	
Borrowed and purchased funds	
= Financial assets	= Financial liabilities and capital
PLUS Materials and supplies[a]	
PLUS Physical capital[a]	PLUS Physical capital (including materials and supplies) in x_K
Equipment	
Computers	
Buildings and land	
= Total assets	= Total liabilities and capital[b]

[a]Evaluated at current dollars rather than historical cost.
[b]Total capital (x_K), the sum of financial and physical capital, is shareholders' equity in current dollars.

$$K_{i,t} = (1 - \delta_i)K_{i,t-1} + I_{i,t}$$
$$= (1 - \delta_i)^t K_{i,0} + \sum_{j=1}^{t} (1 - \delta_i)^{j-1} I_{i,j} ,$$

where δ_i is the depreciation rate and investment is $I_{i,t}$ in constant dollars. The initial or benchmark period estimate of physical assets i is $K_{i,0}$. The price of a unit of physical asset is $a_{i,t}$, using series from the Bureau of Labor Statistics' wholesale price index. Then $\Sigma_{i=1}^{3} a_{i,t}K_{i,t}$ is the value of physical assets at time t in current dollars. Total shareholders' equity x_K is the sum of physical assets and net financial assets $x_1 + x_4 - x_2 - x_3$. This is entered on the liability side of the economic balance sheet and is equal to assets less liabilities, or total shareholders' equity in current dollars. Table 1 is an economic balance sheet.

The flow analogue of Table 1 is in Table 2, an economic income and expense statement. User costs are constructed for cash, loans, demand, and time deposits. The classification rule (1) and (2) assigns each as an input or output item. Outputs generate income, and inputs expenses. For labor, which is on the income and expense statement only, a Tornqvist index (x_5) of managerial and nonmanagerial hours is constructed.[6] The growth rate of this index is a weighted average of the growth rates of each type of labor. The weights are arithmetic two-period moving averages of compensation shares. The quantity of materials and supplies is a Tornqvist index x_6 of stationery, printing, telephone and telegraph, and postage,

[6]This need not be the case for all firms. If an employee is bound to a firm by a long-term contract, this can be included as a balance sheet item. Even collective agreements could be included, but normally accounting procedures exclude them.

TABLE 2

INCOME AND EXPENSE STATEMENT: ACCOUNTING AND ECONOMIC RECONCILIATION

Income	Asset/Liability	User Cost	Net Income
Loans[a] (x_4)	Asset	$u_4 < 0$	$p_4 x_4 > 0$[b]
Demand deposits (x_2)	Liability	$u_2 < 0$	$p_2 x_2 > 0$
LESS Expenses			
Cash (x_1)	Asset	$u_1 > 0$	$p_1 x_1 < 0$
Time deposits (x_3)	Liability	$u_3 > 0$	$p_3 x_3 < 0$
Labor (x_5)		$u_5 > 0$	$p_5 x_5 < 0$
Materials and supplies (x_6)	Asset	$u_6 > 0$	$p_6 x_6 < 0$
= Variable profit (π)			$\sum_{i=1}^{6} p_i x_i$
DIVIDED BY Capital (x_K)	Liability		
= Average rate of return on capital			

NOTE: User costs and prices are in annual percentages, so the conversion of stock to flow is performed here.
[a]Calculated separately for each of the seven categories indicated in Table 1.
[b]The classification on sign follows (1) and (2) in the text.

freight, and delivery. Price series for each of these are from the wholesale price index. The prices and quantities are cash (p_1, x_1), demand deposits (p_2, x_2), time deposits (p_3, x_3), loans (p_4, x_4), labor (p_5, x_5), and materials (p_6, x_6) with capital x_K.

The price of materials is a numeraire, with $p_6 = 1$. Normalized profit π is $\Sigma_{i=1}^{6} p_i x_i / p_6$. Table 2 derives variable profit from the income statement. Table 1, the balance sheet, provides a method for constructing economic capital. Both are required to estimate the profit function and the marginal rate of return to capital, dependent on prices and interest rates.

4. SPECIFICATION AND ESTIMATION

A translog specification for the variable profit function $\pi(p, x_K)$ is

$$\ln \pi = \alpha_0 + \sum_{i=1}^{5} \alpha_i \ln p_i + \alpha_K \ln x_K + \frac{1}{2} \sum_{i=1}^{5} \sum_{j=1}^{5} \beta_{ij} \ln p_i \ln p_j + \sum_{i=1}^{5} \beta_{iK} \ln p_i \ln x_K + \frac{1}{2} \beta_{KK} (\ln x_K)^2. \tag{8}$$

From the linear homogeneity restrictions, the parameters for materials are obtainable by $\alpha_6 = 1 - \Sigma_{i=1}^{5} \alpha_i$ and $\beta_{i6} = -\Sigma_{j=1}^{5} \beta_{ij}$.

Demands for input and supplies for output are

$$\partial \ln \pi / \partial \ln p_i = p_i x_i / \pi = \alpha_i + \sum_{j=1}^{5} \beta_{ij} \ln p_j + \beta_{iK} \ln x_K ; \quad i = 1, \ldots, 5 \tag{9}$$

TABLE 3

PARAMETER ESTIMATES, VARIABLE PROFIT FUNCTION (asymptotic standard errors in parentheses)

Parameter	Estimate	Parameter	Estimate
Intercept	14.638(0.409)	β_{23}(demand, time)	−0.002(0.004)
α_1(cash)	−0.073(0.013)	β_{24}(demand, loans)	−0.284(0.033)
α_2(demand)	0.515(0.061)	β_{25}(demand, labor)	0.053(0.036)
α_3(time)	−0.201(0.032)	β_{2K}(demand, capital)	−0.081(0.037)
α_4(loans)	1.280(0.073)	β_{33}(time, time)	−0.140(0.010)
α_5(labor)	−0.416(0.070)	β_{34}(time, loans)	0.153(0.023)
α_K(capital)	0.840(0.235)	β_{35}(time, labor)	−0.005(0.013)
β_{11}(cash, cash)	−0.035(0.033)	β_{3K}(time, capital)	0.000(0.019)
β_{12}(cash, demand)	0.020(0.036)	β_{44}(loans, loans)	0.070(0.061)
β_{13}(cash, time)	−0.002(0.004)	β_{45}(loans, labor)	0.054(0.037)
β_{14}(cash, loans)	−0.006(0.015)	β_{4K}(loans, capital)	−0.074(0.044)
β_{15}(cash, labor)	−0.010(0.010)	β_{55}(labor, labor)	−0.075(0.039)
β_{1K}(cash, capital)	0.006(0.008)	β_{5K}(labor, capital)	0.141(0.040)
β_{22}(demand, demand)	0.291(0.055)	β_{KK}(capital, capital)	0.013(0.058)

NOTES: Bank effects are included in each estimating equation "Demand" and "time" refer to deposit categories Symmetry of the β matrix and equality of parameters in the variable profit function and the demand and supply equations are imposed.

with x_i positive for loans and demand deposits and negative for cash, labor, and time deposits. With the addition of a disturbance term, the six equations in (8) and (9) constitute the estimating system. The exogenous variables (p, x_K) are normalized at unity at their geometric sample means.

For the eighteen banks over 1973–78, the system of six estimating equations is a pooled time series and cross section. The banks are grouped by size and divided into six categories. Dummy variables for bank size, five in number, are included as regressors in each of the estimating equations. This has the effect of measuring the data as deviations from the bank group mean, in each time period. This is the "within" method of Mundlak (1978) for pooling time series and cross-section data and is unbiased, also reducing heteroskedasticity. A time effect is measured by the price of cash, since this is the same for each bank in each year but differs between years.[7]

The parameter estimates of the variable profit function are in Table 3. These are with bank effects included. Testing is also performed for the regularity conditions of monotonicity and convexity, and the variable profit function satisfies both at the geometric sample mean.[8]

[7]The use of the time effect applies in each equation to the demands and supplies as well as the variable profit function. The sample has a relatively large number of cross-section (banks) to time series (years) observations.

[8]Monotonicity requires $\partial\pi/\partial p_i > 0$ for an output and $\partial\pi/\partial p_i < 0$ for an input, $i = 1, \ldots, 6$. Now $e_i = \partial \ln \pi/\partial \ln p_i = p_i x_i/\pi$, so $\partial\pi/\partial p_i = e_i\pi/p_i$. Given that $p_i > 0$ and $\pi > 0$ for short-run bank operation, $\text{sign}(e_i) = \text{sign}(\partial\pi/\partial p_i)$. At the geometric sample mean, the e_i values are loans 1.280, cash −0.073, demand deposits 0.515, time deposits −0.201, labor −0.416, and materials −0.105, so the variable profit function is monotone, being increasing in output prices and decreasing in input prices.

Convexity requires that the principal minors of the Hessian matrix be positive. For an arbitrary variable profit function, this matrix has typical element

$$H_{ij} = \partial^2\pi/\partial p_i \partial p_j = (\pi/p_i p_j)[e_i e_j + p_j(\partial e_i/\partial p_j) - e_i(\partial p_i/\partial p_j)].$$

5. EMPIRICAL RESULTS

A. *Introduction*

With the results, the rate of return to capital and the effect on bank profitability of monetary policy can be determined. The estimates of rates of return on capital and profits differ from those that are obtained directly from stock market data or accounting financial statements in three respects. First, they are based on the economic financial statements. Second, they are functions of the prices, which depend on interest rates. Third, marginal rates of return and average rates of return can be estimated, whereas direct measurement can only provide information on the latter.

The spread examined is the differential between the interest rate received on loans and that paid on time deposits. A comparison of the effect on profitability can be made between interest rate increases that leave the spread unchanged and those that increase the spread.

The reserve requirement tax per unit time is Rk_i, on deposit i. These increase costs relative to those financial firms exempt from such requirements. To measure the cost of the requirement, Rk_i is set at zero for all deposits and is compared with profit levels at existing rates.

B. *Rate of Return on Capital*

In profit function estimation without demands and supplies, the rate of return on capital has proved difficult to identify.[9] The marginal rate of return on capital is $\partial\pi(p, x_K)/\partial x_K$, and for short-run operation some quasi-rents must be covered. For the specified variable profit function,

$$\partial \ln \pi/\partial \ln x_K = \alpha_K + \sum_{i=1}^{5.} \beta_{iK} \ln p_i + \beta_{KK} \ln x_K \tag{10}$$

and

$$\begin{aligned} \partial\pi/\partial x_K &= q_K = (\partial \ln \pi/\partial \ln x_K)\pi/x_K \\ &= \left[\alpha_K + \sum_{i=1}^{5} \beta_{iK} \ln p_i + \beta_{KK} \ln x_K\right]\pi/x_K \end{aligned} \tag{11}$$

For the translog, $\partial e_i/\partial p_j = \beta_{ij}/p_j$, and at the geometric sample mean where $[p] = 1$,

$$H_{ij} = \partial^2\pi/\partial p_i \partial p_j = \alpha_i\alpha_j + \beta_{ij} - d\alpha_i$$

with $d = 1$ if $i = j$ and 0 otherwise. The principal minors of the matrix are 0.42912, 0.03249, 0.00813, 0.00009, and 0.000011, and hence the variable profit function is convex at this point.

[9]Mullineaux (1978) estimates the variable profit function without associated demand and supply functions. The problem is that correlation between (p, x_K) and the large number of second-order terms introduces multicollinearity, making it difficult to identify parameters. The rate of return is biased toward zero without the demands and supplies.

with q_K the realized rate of return. The marginal rate of return is a function of prices of variable financial and nonfinancial goods and of capital. This is with the outputs of loans and demand deposits and all inputs variable. By contrast, with a cost function outputs are exogenous and sometimes aggregated without testing.

Under constant returns to scale and competitive markets for outputs and inputs, product exhaustion obtains, and variable profits are equal to payments to capital. Here $q_K x_K = \pi$ and $\alpha_K = 1$. A test for $\alpha_K = 1$ and $\beta_{iK} = 0$, $i = 1, \ldots, 5$ with $\beta_{KK} = 0$ is a sufficient condition for constant returns to scale. The likelihood ratio test rejects this hypothesis at the 0.01 level, with a chi-squared test statistic with 7 degrees of freedom of 8.75.

Hence the capital parameters accepted by the data are those of Table 3, with $\alpha_K = 0.840$, indicating that competitively priced capital services do not exhaust all profits made by banks in the sample. Locational rent, increasing returns, managerial productivity not measured in labor input, and uncompetitive market phenomena are other explanations.

The rates of return to capital, both marginal and average, depend on all prices and the quantity of capital. As an example of their calculation, they are evaluated at the geometric sample mean. Similar calculation can be performed for each bank and year. At the geometric sample mean, variable profits are, in millions of dollars, 6.098 and the value of physical and financial capital is 22.698. The ratio π/x_K, or average variable profit per dollar of capital, is 0.268. At the geometric sample mean, $\ln p_i = 0$, $i = 1, \ldots, 5$, so the marginal rate of return on capital is 0.268 times 0.84, or 0.225, or 22.5 percent before tax.

The marginal rate of corporate income tax paid during the sample period can be taken as 0.48. The average rate of return on capital after tax $\pi(1 - \tau)/x_K$ is 0.268 times 0.52 or 0.139, where τ is the marginal tax rate.[10] The after-tax marginal rate of return on capital is the product of this 0.139 and $\partial \ln \pi/\partial \ln x_K$, using (11). Since this is 0.84 at the geometric sample mean, the marginal rate of return after tax is 11.6 percent. More generally, any interest rate change can be investigated for its effect on the marginal rate of return, through (11).

C. *Interest Rates and Bank Profitability*

Of policy relevance is the effect of interest rate changes on the level of bank profitability. Comparisons can be made both in terms of increases in interest rates for one financial good and increases that have no effect on the spread. For the latter, interest rate increases on loan and time deposits are compared. As a result, the hypothesis that banks do not benefit from higher interest rates is testable.

The price of loans, from (1), (2), and (6) is

$$p_4 = -1 + (1 + r_4 + c_4 + s_4 - d_4)/(1 + R) \tag{12}$$

[10]The marginal corporate income tax rate faced by banks for respective dollar amounts are 20 percent on the first 25,000, 22 percent on the next 25,000, and 48 percent on any overage above 50,000. See the *Functional Cost Analysis: 1977 Average Banks* (Board of Governors of the Federal Reserve System 1979, p. 19A).

and $\partial p_4/\partial r_4 = 1/(1 + R)$. The effect of loan interest rates on bank profits is

$$\partial \ln \pi/\partial \ln r_4 = \partial \ln \pi/\partial \ln p_4(\partial \ln p_4/\partial \ln r_4). \tag{13}$$

The geometric mean price of loans is 0.038, or 3.8 percent after discounting. A one percentage point (100 basis point) increase in loan interest rates discounted raises the price of loans by 26.3 percent, and $\partial \ln \pi/\partial \ln p_4 = 1.28$, since the coefficient β_{44} is insignificant at the 0.05 level. Bank variable profits rise by 1.28*0.263 or 33.66 percent for a one percentage point, or by a 26.3 percent increase in loan interest rates unmatched by changes in deposit costs.

Another interpretation is that a 100 basis point increase in the spread increases variable profit by 33.36 percent if this arises from the loan side. A likelihood ratio test rejects the hypothesis that the parameters of the loan and time deposit equations are equal at the 0.05 level.[11]

Suppose there is a one percentage point decrease in time deposit interest rates and no change in loan interest rates, also causing the spread to increase by one percentage point. Then, analogously to (12), the price of time deposits is

$$p_3 = -1 + (1 + r_3 + b_3 + Rk_3 - s_3)/(1 + R) \tag{14}$$

and the discounted user cost is 0.76 percent. Consider a one percentage point discounted decrease in interest rates. The effect of this price change on profits is $\partial \ln \pi/\partial \ln p_3 = -0.201$, with β_{33}, the quadratic term in Table 3, insignificant at the 0.05 level.

The effect on variable profit is -0.201 times -1.3157, or 0.2646, for a 26.46 percent increase. A change in the spread generated by higher loan interest rates increases variable profit more than one generated by deposit rates. The effect of spread changes is asymmetric. The differential between the increase in variable profit from loan prices and from time deposit prices is $33.26 - 26.46$, or 6.9 percent. Profits are relatively elastic in loan prices, but inelastic in the prices of deposits. Increases in interest rates raise variable profit, as do increases in interest rates which keep the spread constant.[12] This is because of the larger profit elasticity in loans than in time deposits, measured as absolute values.

D. *Reserve Requirements*

The analysis of reserve requirements permits examination of their extension to other liabilities and financial institutions. The Monetary Control Act of 1980 permits the Federal Reserve Board to impose reserve requirements on any liability of depository institutions such as credit unions, commercial banks, and savings banks. The flow cost of the reserve requirement for liability i is Rk_i. If k_i is unity, then the

[11]The test requires $\alpha_2 = -\alpha_3$ and $\beta_{2i} = -\beta_{3i}$, $i = 1, \ldots, 5$ with $\beta_{2K} = -\beta_{3K}$. There are seven restrictions and the likelihood ratio test rejects this hypothesis.

[12]Although the models used are substantially different, estimates by Flannery (1981) are performed on the effect of interest rates on profits. For fifteen U.S. banks from 1959 to 1978, the Treasury bill rate has no significant effect on net profits for thirteen banks, but a positive effect for the remaining two.

"100 percent money" policy of Irving Fisher (1935) applies. The reserve requirement imposes a tax on affected financial firms, as Fama (1980) notes.

Considering demand deposits, the sample mean cost of the reserve requirement is 0.048, expressed in percentage points. In similar units, the user cost for a discount rate of 0.05 is -4.625, or p_2 is 4.625.[13] With demand deposit services an output for the bank, elimination of the reserve requirement would increase the price received to 5.105 percentage points, or by 10.3 percent. The elasticity of variable profits with respect to demand deposit prices is 0.515, so profits would increase by 5.3 percent if reserve requirements were eliminated. On the 6.098 million dollar base, the elimination of reserve requirements on demand deposits would increase profits to 6.421 million dollars. If x_K remains 22.698 million dollars, $\pi(1 - \tau)/x_K$ becomes 0.147 at the geometric sample mean, and the after-tax rate of return on capital increases from 11.6 percent to 12.3 percent.

For time deposits, which are production inputs, the reserve requirement cost is 0.17 percent at the sample mean, and the user cost is 0.76 percent and positive. If reserve requirements were eliminated, with $u_3 > 0$, the price of time deposits would be reduced to 0.59 percent at $R = 0.05$, or by 22.4 percent. Since $\partial \ln \pi / \partial \ln p_3$ is -0.201, this increases profits by 4.5 percent. Elimination of reserve requirements on both forms of deposit would increase economic variable profit by almost 10 percent.

This measures the cost of the maintenance of zero-interest-paying balances at the Federal Reserve. If banks benefit because of a public perception of safety, there is an offset.

6. CONCLUDING REMARKS

The model derived is applicable to other financial firms. The effect of interest rate increases on other sectors of the economy can be determined. With the given data set and sample, the spread is not upheld as a summary statistic, and banks appear to have profits that increase with interest rates.

A possible area of extension of the model is to disaggregate loans and deposits. Loans could be distinguished by category and maturity. For the latter, the user cost would include the present value of the future returns from an increase in interest rates. If banks tend to borrow short and lend long, the possibility exists for examining the effect of interest rates on maturity and duration structure of loans. However, such disaggregated data are difficult to obtain.

A procedure has been suggested for reconciling economic and accounting definitions of income and capital. This permits cash and other financial goods to be incorporated in the technology. This is clearly important for banks, but also has implications for all firms, notably those in the finance, insurance, and real estate sector of the national accounts.

[13]There are also some negligible interest payments arising from the introduction of NOW accounts on November 1, 1978. Other than these, there are no interest payments on demand deposits during the sample period.

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