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Chapter Author: Dennis J. Fixler, Kimberly D. Zieschang

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6 User Costs, Shadow Prices, and the Real Output of Banks

Dennis J. Fixler and Kimberly D. Zieschang

"The distinctive function of the banker—says Ricardo, begins as soon as he uses the money of *others*."[1] Indeed this aspect of banking lies at the foundation of the difficulties encountered in measuring bank output. Broadly speaking, such output consists of transactions (payments) services and the portfolio management services that banks provide to depositors while acting as their intermediary. There is no consensus in the banking literature on how to measure these services.

In this paper, we focus on the measurement of bank financial services arising from deposit products, securities, loans, and other financial services such as corporate payments services and trust services. Two measurement questions immediately arise: (1) Is the financial services output represented by the volume of transactions or the volume of money in the various products? and (2) Which products should be considered part of the output set? It is now generally recognized that the answer to the first question is that both dimensions are important.[2] The second question chiefly concerns the treatment of deposits. Because deposits are an input into the acquisition of earning assets, many argue that they should be treated as such. However, some argue that people purchase deposit accounts for the services of record keeping and safe-

Dennis J. Fixler is economist, Division of Price and Index Number Research, Bureau of Labor Statistics. Kimberly D. Zieschang is chief, Division of Price and Index Number Research, Bureau of Labor Statistics.

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1. As quoted in Bagehot (1915, 21).
2. See Benston, Hanweck, and Humphrey (1982, 1985).

keeping and that these services make deposit products outputs. A complicating feature of the argument is that some of the services purchased by depositors are typically not paid for explicitly. A bank recovers the cost of these services by setting a loan rate greater than the deposit rate.

The absence of an explicit price for many of the financial services attached to deposit products also complicates the measurement of financial services in the national income and product accounts. Specifically, the absence of an explicit payment has made it impossible to determine the value of these services, and so national income accountants must impute their value. Although the proper imputation has been the subject of a long debate, it has recently become more topical with the rise in the international trade in financial services.[3]

Fixler (1988) sets out how the financial model we use addresses output measurement and the preponderance of implicit prices. Briefly, all financial services are a part of the output set. Financial services are assumed to attach to each dollar in a financial product at a point in time. Variables such as the number of transactions are viewed as quality variables of the attached financial services bundle. The price of the attached bundle of financial services is characterized as the user cost of money associated with the product, a concept developed by Donovan (1978) and Barnett (1978, 1980) and applied to financial firms in Hancock (1985b, 1986). The fundamental components of a user cost price are an interest rate, a capital gains rate, and an opportunity cost of money or benchmark rate. Given the user cost prices of financial products, banks maximize variable economic profit conditioned on physical capital, labor, purchased materials and services, and technology.

The research we report in this paper is part of a program to develop a conceptual framework for a financial services component for the producer price index. Given the financial firm model for price measurement developed in Fixler (1988), this program addresses four questions defining areas of research relevant to the construction and applicability of a financial services output price index: (1) For what nominal sales aggregate could such an index be used as a deflator, and how does the financial firm model relate to concepts underlying the national income accounts for nominal sales of financial services? (2) On the basis of available data and given the current national income accounting conventions, what would the implications of such a price index be for financial services price and output over a recent period? (3) How would available quality of service attributes be incorporated into the user cost of money measurement framework? and (4) How good are the accounting rules of thumb as estimators of the opportunity cost of funds compared with a structural, econometric estimate, and what are the implications for the resulting financial services output measure?

3. In fact, the United Nations Statistical Office (UNSO) is in the process of revising their imputation of financial services. Our discussion of the UNSO approach below refers to the proposed revision.

Fixler and Zieschang (1991) addressed question 1. After reviewing past and present national income accounting treatments for financial services, it was shown that the financial firm model rationalizes the accounting methodology used by the Bureau of Economic Analysis (BEA) and an alternative methodology proposed by the United Nations Statistical Office (UNSO). Each accounting framework was shown to impute uncharged financial services on the basis of its own assumption about the opportunity cost of money. In the BEA framework, the opportunity cost rate was shown to be the interest rate charged on loans; in the UNSO framework the opportunity cost rate was shown to be a simple average of the rate charged on loans and paid on deposits. Because the construction of a financial services output price index compatible with each accounting methodology depends on the assumed opportunity cost, an empirical assessment of these assumptions was deemed necessary.

To address question 2, Fixler and Zieschang (1990) expanded on work begun in 1989 to compute price and quantity indexes for large banks based on data from the Federal Deposit Insurance Corporation (FDIC) for the years 1984–88. The paper also developed independent estimates of the capital gains component of the user cost prices. Use was made of results from Fixler and Zieschang (1991) on the opportunity cost of money assumptions underlying the BEA and UNSO accounting schemes to compute the user cost prices of monetary goods and their associated sales weights in Törnqvist price index formulas. The indexes considered were therefore designed to be compatible with the existing and proposed accounting treatments of financial services. The patterns and levels of price change found under the two imputation schemes were generally similar, and the output growth for the period was found to be approximately 40 percent, with the BEA opportunity cost rate.

To address question 3, Fixler and Zieschang (1992) conducted a study of the use of bank branches as correlates of or proxies for the quality of financial services delivered, again making use of FDIC data. In that paper, a technique was introduced for using hedonic estimates of the prices of characteristics (the numbers of six types of branches operated by a bank) to construct an exact quality adjustment to a superlative productivity index. The technique was inspired by earlier theoretical work on quality-adjusted superlative price indexes by Zieschang (1985, 1988) and adapted to the financial services price measurement context by Fixler (1988). The quality-adjustment method was then demonstrated by constructing depositor services and labor quality modifiers for multifactor productivity indexes for large banks. The adjustment was modest given the narrow focus on a single product and a single input, increasing the productivity index level by approximately 0.6 percent at the end of the 1984–88 period.

In the present paper, which addresses question 4, we characterize a bank's production of portfolio and payment services in a distance function framework. From standard duality results, we derive the opportunity cost of money for the bank as a shadow price. Econometric estimates of the distance function and the attending product shares are then used to estimate the shadow value of the opportunity cost of capital for the bank. Using FDIC data for approximately 480 banks with assets over $300 million in the years 1984–1988, we find that in any given year the resulting value of the econometric opportunity cost rate differs noticeably from the opportunity cost rates underlying the BEA and UNSO frameworks. Our estimated value of the opportunity cost rate also significantly differs from the 90-day Treasury Bill rate in three of the five years considered. The Treasury Bill rate is another commonsense value of the opportunity cost rate inasmuch as it is a short-term, risk-free rate readily available to banks. Using the estimated value of the opportunity cost rate, we construct price and quantity indexes. Fortunately for price- and quantity-index construction, we find that the Törnqvist output quantity index and its associated implicit price index are not sensitive to the opportunity cost estimate used; output growth was found to be approximately 40 percent; prices declined by approximately 4 percent. However, the insensitivity of index numbers to the opportunity cost estimate may not carry over to the imputations in the national income accounts. In Fixler and Zieschang (1991) we found that the level of the opportunity cost rate affects the imputed value of sector sales and thereby may have a significant effect on the division of gross sales of financial services between intermediate and final consumers.

The remainder of the paper is organized in the following way: Section 6.1 provides a detailed discussion of the output and price measurement concepts underlying the financial firm model. Section 6.2 sets out the distance function and section 6.3 its econometric estimation. Section 6.4 describes our data and our results. Section 6.5 concludes.

6.1 Bank Output and Prices

Financial services output primarily stems from the role of financial institutions as "users of the money of others." This role is greatly affected by two features of their environment: the existence of imperfect capital markets and the set of regulations designed to minimize the probability of bank failure and control the money supply. Of special importance to the latter is the fractional reserve system.

By capital market imperfections we mean the information asymmetries between lenders (depositors) and borrowers and the existence of substantial transaction costs for depositors to discover information about potential borrowers and to specify the loan contract. It is a bank's ability to reduce both the informational asymmetry and the attending transaction costs that is crucial to its role as an intermediary. Goodhart (1989) argues that, because banks provide information and lower transactions costs, as well as hold inventories of financial instruments, they act as market makers for money.

But a bank's behavior as an intermediary is substantially limited by bank regulation. Until recently, banks could not pay depositors any interest on their checkable deposits. Deposits cannot be used to acquire equity nor can they be used to underwrite new issues. The imposition of capital requirements limits the returns to a bank's stockholders. Perhaps the most significant restriction is the reserve requirement on deposits. This "tax" further limits the return that banks earn on their deposits, and, as shown by Barnett, Hinich, and Weber (1986), it is substantial: approximately $10 billion in the early to mid-1980s. The fact that the required reserve rate is less than 100 percent complicates modeling the role of deposits in a bank.

In a world with a 100-percent reserve requirement, banks could not lend out deposits and therefore would charge explicitly for the financial services, such as safekeeping and record keeping, provided to depositors.[4] But, because the reserve requirement is substantially less than 100 percent (approximately 12 percent for large bank demand deposit accounts and 3 percent for nonpersonal time deposit accounts), banks can lend most of their deposits. Thus a bank provides an intermediary portfolio service to depositors, in addition to record keeping and safekeeping, that produces a profit that can in turn finance interest payments to depositors or subsidize the costs of the services provided to them. Deposits are therefore simultaneously an input into the loan process and an output, in the sense that they are purchased as a final product providing financial services. Viewed in this way it is not surprising that the classification of deposits as an input or an output has sparked so much debate in the bank literature. It is also clear why it is difficult to price the financial services sold to depositors.

The financial firm model we use focuses on banks as producers of financial services. The financial services are attached to each dollar in the various financial products offered by a bank and are therefore measured in monetary units. All financial products are viewed as providing financial services and are produced by employing (physical) capital, labor, and purchased materials and services. But to simply say that all financial services are output is not sufficient to model bank behavior. One must also be concerned with the role of the financial products in the operations of banks; principally, the role of deposits as the raw material used to make loans and acquire other earning assets. To capture this intermediary aspect of bank behavior, it is necessary to assign a financial input or output status to each financial product.[5] It is important to keep in mind that this status reflects only the role of the product in the financial operations of the bank; the financial services output is the output being measured. A product is a financial output when its economic return is positive

4. Intermediation would also not take place if the interest rate paid to depositors were equal to the loan rate and the reserve requirement were less than 100 percent.

5. There is a considerable debate in the literature (and in this conference) about the input-output status of deposits. In our framework, the financial services attached to deposit products (inclusive of the intermediary service) are always considered an output. At the same time, deposits are allowed to act as an input to loan production; in fact, as shown below, the user-cost method explicitly accounts for the net interest earned on the deposit.

and a financial input when its economic return is negative. As is explained below, these designations are not permanent in the financial firm model, a flexibility that allows bank behavior to adjust to financial market conditions.

Financial products are essentially a bundle of financial services specified by a contract. The contract between depositors and the bank is standard. Fixed nominal values are deposited, and the bank promises to make them available on demand. That is, the provision of services like record keeping and safe-keeping do not impinge on liquidity. Product characteristics, such as allowed checks per month, determine the quality of the financial services provided. Measures of activity, such as number of accounts and transactions per account, can also be viewed as quality factors in this framework.

Loan contracts are more variable. Banks not only vary the loan contract by type of borrower, for example, between commercial and noncommercial ones, but also within a type according to credit risk and perhaps size of loan. Another feature of loan contracts is that the interest rate charged by the bank may not reflect the actual cost of the loan. Banks may require a borrower to keep a compensating balance in a deposit account or bundle the loan with some payment services, for example, becoming the issuer of dividend checks. Because these arrangements involve an implicit price for the loan service provided, we encounter the same problem as the one discussed above for deposit services.

To model fully the effect of such features as compensating balances and like factors affecting the implicit payment for services, we ideally want to augment the financial service bundle attached to each dollar in a product by a vector of product characteristics that captures the particulars of the contract between the bank and the depositor or borrower.[6] Such detailed characteristics information, however, is unavailable in our data set. But the data set does contain the number of bank branches, and we use this variable to ascertain the importance of the convenience of service characteristic.

Our financial services prices are the user cost of money rates per dollar in a financial product. The user cost of a financial product is an appropriate characterization of the financial services price because it measures the economic return to the bank for providing the financial service. The form of a product's user cost depends on its asset/liability status. The user cost for the ith asset financial product in period t for a particular bank is given by

$$u^t_{a_i} = \rho - h^t_{a_i}, \tag{1}$$

where ρ is the bank's opportunity cost of capital and h_{a_i} is the holding revenue rate obtained from the ith asset, which is given by $h^t_{a_i}$ = interest rate received

6. Fixler (1988) shows how a full treatment of product characteristics would be incorporated in the quantity index given later. That analysis further shows how, by adjusting changes in the price of the financial services for changes in product characteristics, the price index effectively synthesizes the nominal and activity-based characterizations of banking services.

+ capital gain rate − provision for loan losses. The user cost for the *i*th liability financial product is given by

$$u^t_{l_i} = h^t_{l_i} - \rho, \tag{2}$$

where h_{l_i} denotes the holding cost rate of the *i*th liability product and is given by $h^t_{l_i}$ = interest rate paid − service fees + ρ × reserve requirement.[7] The last term represents the reserve tax.

The sign of the user cost allows one to distinguish products as *financial* inputs and outputs. If the user cost is negative, then the product is a financial output, because it contributes to revenue, and, if the user cost is positive, then the product is a financial input. The user-cost approach's endogenous categorization of products as financial inputs and outputs is significant because of the extensive debate in the bank literature about the proper status of financial products.

The user cost expressions include the return to intermediation, the imputation for the uncharged-for financial service, as part of the price for the financial service. To see this, suppose that the holding cost for a deposit product was simply the interest rate paid less the per dollar service fee charged and that the opportunity cost of money was simply the loan rate. Using (2) above the user cost for the deposit product can be written as −[(loan rate − interest rate paid) + service fee].

If the loan rate were equal to the interest rate paid, then the value of the services provided would simply be the explicit service fee charged. If instead the loan rate were greater than the interest paid to depositors—the usual case—then the value of the financial services would be the implicit payment, represented by the difference in the interest rates, plus the explicit service charge. A similar interpretation applies to the user cost of asset products.

The above user cost expressions reveal the importance of ρ in determining the price of the financial services bundle: it represents the opportunity cost of money to the bank from the perspective of the next best alternative use, in contrast to the typical opportunity cost of capital in the finance literature, which focuses on the cost of capital as determined from its sources.[8]

The unobservability of ρ is a hurdle that must be overcome in implementing the financial firm model. As mentioned at the outset there are some commonsense candidates for ρ that are used by BEA and UNSO. In this paper we derive ρ from a model of the bank's technology and estimate it using FDIC data.

Our derivation of ρ relies on the parts of the bank technology concerned with making loans and purchasing securities. This use perspective reflects the

7. Barnett (1980) and Hancock (1985b) derive these equations. To simplify the analysis, we ignore the ramifications of discounting.
8. See, e.g., Van Horne (1983).

portfolio behavior of the bank, in particular the uses of the money obtained through deposits or otherwise borrowed. In banking, such portfolio decisions entail duration matching whereby short-term sources of money are matched with short-term uses, and so on, and balancing the volume of interest-sensitive assets with the volume of interest-sensitive liabilities to minimize the effect of interest rate risk on net worth.[9]

Bank models are unavoidably limited by the difficulties inherent in modeling the nuances of portfolio management, especially when dealing with large, complex, multiproduct banks such as the ones in our sample. We capture the portfolio management features, to some extent, by separately considering four loan categories and two security categories. The loan categories are loans secured by real estate, commercial and industrial loans, loans to individuals and credit card loans, and a catchall category—all other loans and leases. The security categories are securities backed by the U.S. government and a catchall, all other securities. The all-other-securities category includes such items as state and local government securities, federal funds sold, repurchase agreements, and foreign securities. Loans are typically long-term with fixed interest rates and no secondary market in which to trade them; securities have a well-developed secondary market that permit trades to counter interest rate risk. By isolating these products in our estimation of ρ, we allow for product-specific portfolio considerations to affect our estimate of ρ.

We seek a representative ρ that can serve in the construction of industry output and price indexes. To be acceptable, the representative ρ should not only reflect bank attitudes toward risk and maturity but also serve as an industry aggregate of the bank-specific portfolio assembly process. The value of ρ for each bank is taken as some proportion of its return on assets, and that proportion is assumed to be the same for all banks. Thus by estimating the proportion, we obtain an industry representative ρ, and by applying the proportion to each bank's return on assets we obtain the distribution of bank specifics ρ's.

6.2 The Bank Production Model

Like Hancock (1985b), we view banking firms as transforming the nonfinancial inputs capital, labor, and purchased materials and services into financial products. Our list of nonfinancial inputs is x_1 = number of employees and officers; x_2 = premises and fixes assets, in dollars; and x_3 = purchased materials and services, in dollars. The bank produces the following financial products: y_1 = loans secured by real estate; y_2 = commercial and industrial loans; y_3 = loans to individuals, including credit cards; y_4 = other loans, and leases; y_5 = federal funds purchased, and federal government securities and federal

9. Duration refers to the average time needed to recover the initial investment. It is in effect a measure of interest rate risk.

agency obligations; y_6 = obligations of states and political subdivisions, and foreign and other securities; y_7 = fiduciary activities, fees, and other noninterest income; and y_8 = interest and non-interest-bearing domestic and foreign deposits, federal funds sold, and Treasury demand notes.[10] All are measured in dollars. These y_i will be designated financial inputs or outputs according to the sign of their user cost.

Ideally, we would also include a vector of characteristics, say given by the letter a, describing the services provided. Our data, however, only allows us to include branching as a proxy for service attributes such as convenience. The FDIC call report data contains the number of six different types of branches operated by banks. In Fixler and Zieschang (1992) we examined the use of this branch information as quality indicators. There, we made use of hedonic equations relating service charge rates and the average salary of officers and employees to the branching variables to compute a quality-corrected multifactor productivity index, using a method of incorporating hedonic estimates into exact and superlative index numbers. We found certain branch variables to be significant in explaining cross-sectional interest-rate variation. We also found that branching had a mildly positive effect on banking industry output and productivity over time. Consequently, we include a branching variable in the current structural estimation context.

We characterize the bank's production technology as

$$D(\mathbf{x}, a, \mathbf{y}) = 1,$$

where the function D is the output distance function, defined as

$$D(\mathbf{x}, a, \mathbf{y}) = [\max \{\theta : (\mathbf{x}, a, \theta\, \mathbf{y}) \in T\}]^{-1}, \tag{3}$$

and T is the banking firm's technology set. D thus represents the reciprocal of the factor θ that scales the output vector $\mathbf{y} = (y_1, y_2, y_3, y_4, y_5, y_6, y_7, y_8)$ with characteristic a so that $\theta\mathbf{y}$ is just producible with inputs $\mathbf{x} = (x_1, x_2, x_3)$, where a = number of branches in the bank's domestic offices. It can be used to form the more familiar joint-production function

$$f(\mathbf{x}, a, \mathbf{y}) = D(\mathbf{x}, a, \mathbf{y}) - 1 = 0.$$

The distance function appeared in economics in the early 1950s in works by Debreu (1951), Shephard (1953, 1970), and Malmquist (1953). It has seen extensive, if often implicit, application in the economics and operations research literature on measuring technical efficiency beginning with Farrell (1957).[11] Malmquist (1953) and Moorsteen (1961) related the distance func-

10. In previous work, we found a difference in the classification of large certificates of deposit, domestic interest-bearing deposits, foreign interest-bearing deposits and non-interest-bearing deposits. The structural model developed below results in a system of asset share equations. Asset detail was therefore deemed more important than liability detail, and depositlike funds were combined to reduce the number of unknown parameters in the model.

11. For recent studies of cost efficiency in banking, see Ferrier and Lovell (1990) and Berger and Humphrey (chap. 7, this vol.).

tion to the theory of economic quantity indexes, and Caves, Christensen, and Diewert (1982) have related it to indexes of multifactor productivity. In general, D is linear homogeneous in $\mathbf{y}$ and nonincreasing in a scalar multiple of $\mathbf{x}$. Other properties often assumed for D include convexity and increasing monotonicity in $\mathbf{y}$, and quasi concavity and decreasing monotonicity in $\mathbf{x}$.

Shephard (1970) showed that when D is convex and increasing in $\mathbf{y}$, it is dual to the revenue function, defined

$$\pi (\mathbf{x}, a, \mathbf{p}) = \max_{\mathbf{y}} \{ \mathbf{p}'\mathbf{y} : (\mathbf{x}, a, \mathbf{y}) \in T \};$$

that is, D and π can be derived from one another as

$$D (\mathbf{x}, a, \mathbf{y}) = \max_{\mathbf{p}} \{\mathbf{p}'\mathbf{y} : \pi(\mathbf{x}, a, \mathbf{p}) \leq 1\}$$

and

$$\pi(\mathbf{x}, a, \mathbf{p}) = \max_{\mathbf{x}} \{ \mathbf{p}'\mathbf{y} : D(\mathbf{x}, a, \mathbf{y}) \leq 1\},$$

where $\mathbf{p}$ is a vector of known nonzero, nonnegative prices. If one of the outputs $\mathbf{y}$ is actually an input, with $\nabla_{y_i} D < 0$ and $\nabla_{p_i}\pi < 0$, then π can be reinterpreted as a restricted profit function (see, e.g., McFadden 1978).

Hancock (1985a, 1985b, 1986) used the restricted profit function in her studies of bank technology, focusing on the interest-rate and substitution elasticities of financial products. She estimated the holding revenue (cost) components of the user cost prices of financial products from interest rates, realized capital gains, insurance fees, and loss-provision data. The remaining component, the opportunity cost rate of money, was determined by reasoning that the opportunity cost must not be any higher than the maximum rate at which no bank in her sample would earn an economic loss.

In this study, we are interested in developing and evaluating methods for price measurement and deflation of bank revenue to obtain a measure of bank output. Accordingly, we want to estimate the shadow prices of monetary goods, and we approach the problem of modeling bank technology from the primal, instead of the dual, side. We pose a shadow price problem because we want to infer the opportunity cost of money, a key component of the user cost expressions, directly from bank behavior using econometric methods.[12]

The system of output shadow price equations (up to a proportional constant) is given by the gradient of D with respect to $\mathbf{y}$, assuming that the distance function is differentiable in $\mathbf{y}$. Formally, the shadow price vector $\mathbf{p}^*$ is given by $\mathbf{p}^* = \nabla_{\mathbf{y}}D(\mathbf{x}, \mathbf{y})$, which is the obverse of the better-known Shephard-Hotelling lemma yielding the vector of revenue-maximizing outputs as $\mathbf{y}^* = \nabla_{\mathbf{p}}\pi(\mathbf{x}, \mathbf{p})$. We estimate the (conditional) distance function and its gradients, from which we obtain the shadow prices of loans and leases, $y_1, \ldots, y_4$,

12. Our econometric approach implements the Färe and Zieschang (1991) suggestion that the shadow price equations can be useful for determining the prices of nonmarketed commodities produced by nonprofit organizations, or in any situation where market prices are either absent or not believed to represent marginal revenue.

securities, y_5 and y_6, other services, y_7, and deposits, y_8. Using the expressions from Barnett (1980), Hancock (1985b), and Fixler (1988) to express the user cost of money prices of financial goods, and with knowledge of loan, security, and deposit interest rates, the securities appreciation rate, and the rate of provision for loan losses, we determine the opportunity cost rate, ρ. We compare this econometric estimate against the estimates implicit in the current and proposed national income accounting imputation methods, and other commonsense rates that might be used as opportunity cost estimates.

Our econometric model uses what we will call a conditional distance function. This distance function is conditioned on the level of deposits, y_8, and is defined by

$$D_c(\mathbf{x}, a, y_8; \bar{\mathbf{y}}_8) = [\max\{\theta : D(\mathbf{x}, a, \theta\bar{\mathbf{y}}_8, y_8) \leq 1\}]^{-1}, \quad (4)$$

where $\bar{\mathbf{y}}_8$ refers to all elements of the output vector $\mathbf{y}$ except deposits, y_8. The deposits conditional distance function D_c is linear homogeneous in $\bar{\mathbf{y}}_8$ by definition. Inasmuch as we use accounting data, we use this function because deposits and other liabilities are accounting inputs, a use of funds, even though they may be a source of financial services output. We show below that our representation of the production technology yields a system in which the accounting shares of individual asset and fee income in total asset and fee income are functions of the shares of individual assets in the asset portfolio and other variables. We hold that, from an econometric point of view, the gross revenue share system generated by the deposits conditional distance function in equation (4) is better posed than the net revenue share system that would be generated by the unconditional distance function in equation (3).[13]

6.2.1 Modeling the Opportunity Cost Rate

As discussed in section 6.1 above, the assumption of a constant opportunity cost rate across banks may be too restrictive in our sample of banks from the FDIC data set, which is heterogeneous and large by comparison with the Federal Reserve functional cost analysis survey data set used by Hancock. We therefore model the opportunity cost rate as a constant proportion of a bank's return on assets. This specification is appealing because banks with unusually high asset yields are likely to have concentrations of assets in relatively risky categories. Setting the opportunity cost rate as a fraction of return on assets

13. We show below that the deposits-conditional output distance function generates a system of equations that relate the shares of asset receipts in total asset income to the corresponding asset portfolio shares, and the vector of arguments of the conditional distance function. By analogy, it can also be shown that the "unconditional" distance function generates a system relating the "shares" of (positive) asset receipts and (negative) deposit payments in *net* asset income, to the corresponding *net* asset portfolio shares and the vector of arguments of the distance function. We consider this latter system ill posed because the net asset income shares are not bounded between zero and one and are likely to be very sensitive to the random variation in the interest rates that are effectively the endogenous variables in the system, particularly disturbances that happen to drive net asset income near zero. We examined the net asset shares in our data and can confirm they are very noisy with numerically large extreme values.

therefore takes into account variations in attitudes toward risk by management.

6.3 Using the Distance Function to Estimate ρ

Because we are interested in shadow prices and our data contain some price information, we wish to econometrically estimate the distance function with a system of share equations. Färe, Fukuyama, and Primont (1988) estimate a distance function along with a system of share equations in which the left-hand-side variables are computed from known price and quantity data. We cannot use this approach without modification, because the unknown opportunity cost rate is a determinant of the left-hand side of the Färe, Fukuyama, and Primont share system for our model.[14]

We therefore develop an alternative set of share equations. Recall that the first six products in the bank's production function are products associated with monetary asset stocks, the seventh is fee and services income, and the eighth is deposits and other liabilities. For $i = 1, \ldots, 6$, the ith product share is

$$\frac{(h_i - \rho)y_i}{R_A - \rho A} = \omega_i = \nabla_{lny_i} lnD_c(\mathbf{x}, a, y_8; \bar{\mathbf{y}}_8),$$

where h_i = the holding revenue rate on the ith asset; ρ = the opportunity cost rate of funds; $R_A = \Sigma_{i=1}^{6} h_i y_i + R_7$ = total asset holding revenue and service charges; R_7 = income from services produced other than those associated with asset/liability products; $A = \Sigma_{i=1}^{6} y_i$ = total assets; and $\omega_i = \nabla_{lny_i} lnD_c(\mathbf{x}, a, y_8; \bar{\mathbf{y}}_8)$. This can be restated with a change of variables as

$$w_i = \phi \cdot s_i + (1 - \phi) \cdot \omega_i, \tag{5}$$

where $w_i = h_i y_i / R_A$, the holding revenue share of the ith product in asset income; $s_i = y_i/A$, the asset portfolio share of the ith product; $\phi = \rho / r_{TA}$; and $r_{TA} = R_A/A$, the total rate of return on assets, including (nondeposit) service charge income.

For the seventh output, other services, we have

$$w_7 = (1 - \phi) \cdot \omega_7, \tag{6}$$

where $w_7 = \nabla_{lny_7} lnD_c(\mathbf{x}, a, y_8; \bar{\mathbf{y}}_8)$.

From the system of equations (5) and (6) we can form an econometric model of bank technology. Assuming the distance function D_c is translog, the economic shares ω are

14. Other recent studies on estimating distance functions include Färe, Grosskopf, Lindgren, and Roos (1989), Färe, Grosskopf, Lovell, and Yaisawarng (forthcoming), and Lovell and Zieschang (1992). These papers approach the estimation problem in one of two ways: direct fitting of the distance function to the data by linear programming methods, or estimation of a system of share equations.

(7) $$\omega_i = \alpha_i + \gamma_{ya,i} lna + \Sigma_{j=1}^{8} \gamma_{yy,ij} lny_j + \Sigma_{k=1}^{3} \gamma_{yx,ik} lnx_k,$$

$i = 1, \ldots, 7$. From the homogeneity of the distance function: $\Sigma_{i=1}^{7}\alpha_i = 1$, $\Sigma_{i=1}^{7}\gamma_{ya,i} = 0$, $\Sigma_{i=1}^{7}\gamma_{yy,ij} = 0$, $j = 1, \ldots, 8$, and $\Sigma_{i=1}^{7}\gamma_{yx,ik} = 0$, $k = 1, 2, 3$. Substituting (7) into (5) and (6) and appending an error term, we have

(8) $$w_i = \phi\, s_i + \mu_i + \psi_{ya,i} lna + \Sigma_{j=1}^{8} \psi_{yy,ij} lny_j + \Sigma_{k=1}^{3} \psi_{yx,ik} lnx_k + \varepsilon_i,\ i = 1, \ldots, 6;$$

and

(9) $$w_7 = \mu_7 + \psi_{ya,i} lna + \Sigma_{j=1}^{8} \psi_{yy,7j}\, lny_j + \Sigma_{k=1}^{n} \psi_{yx,7k} lnx_k + \varepsilon_7,$$

where $\mu_i = (1 - \phi) \cdot \alpha_i$; $\psi_{ya,i} = (1 - \phi) \cdot \gamma_{ya,i}$; $\psi_{yy,ij} = (1 - \phi) \cdot \gamma_{yy,ij}$; $\psi_{yx,ik} = (1 - \phi) \cdot \gamma_{yx,ik}$; and where, again, ϕ is the ratio of the opportunity cost rate to total return on assets for the industry. From the earlier homogeneity conditions: $\Sigma_{i=1}^{7}\mu_i = 1 - \phi$; $\Sigma_{i=1}^{7}\psi_{ya,i} = 0$; $\Sigma_{i=1}^{7}\psi_{yy,ij} = 0$; $\Sigma_{i=1}^{7}\psi_{yx,ik} = 0$; and $\Sigma_{i=1}^{7}\varepsilon_i = 0$. We estimate ϕ as a constant parameter that corresponds to our maintained assumption that the opportunity cost rate is a constant fraction of the total rate of return on assets.

6.4 Data and Results

Our data set is a subset of the FDIC reports of income and condition. The FDIC data consist of quarterly balance sheet and income statement call reports for the approximately 13,000 commercial banks that are covered by deposit insurance, and we hereafter refer to it as the call reports file. We consider only the banks that have international operations or assets over $300 million (FDIC classes FFIECO31 and FFIECO32). These banks file more detailed quarterly reports than other reporting banks and cover more than half the deposits of all banks in the United States.

We further filtered the set of banks considered by applying the following criteria: banks had to have positive net assets, positive total liabilities and positive total assets, and positive net income from interest and noninterest sources. This yielded a sample of more than 400 banks in each quarter for the period from 1984(1) to 1988(4). We aggregated the report of condition data into annual averages for the years 1984–88. The reports of income contain the annual income and expense flows that match our annual average asset and liability data from the reports of condition. They are annually cumulative, and we used the reports for the last quarter within each year for which each bank reported data. In most cases, this was quarter 4, but some institutions disappeared during each year, and the associated quarters of data used for these banks ranged from 1 to 3. The account classes were initially aggregated to the lowest level possible for which comparable stock and flow information could be computed from the balance sheet and income data and then further aggregated to the classes defining our output variables $y_1, \ldots, y_8$. Table 6.1 con-

Table 6.1 Components of Financial Product Aggregates

Aggregate Output Class	Report of Income Code	Description
Loans & leases:		
y_1	4011	Secured by real estate
y_2	4012	Commercial & industrial
y_3	4050*	Loans to individuals
y_4	4019	To depository institutions
	4024	To farmers
	4026	Acceptances of other banks
	4056	To foreign governments
	4057	Nonsecurity obligations of states
	4058	All other loans in domestic offices
	4059	Loans in foreign offices & edge & agreement corporations
	4100	Balances due from depository institutions
	4065	Leases
Securities:		
y_5	4020	Federal funds sold & repurchase agreements
	4027	U.S. Treasury securities and agency obligations
y_6	4066	Securities issued by states & political subsivisions
	4067	Other domestic securities (debt & equity)
	4068	Foreign securities (debt & equity)
	4069	Securities in trading accounts
Directly charged services:		
y_7	4070	Fiduciary activities
	4075	Trading gains & fees from foreign exchange transactions
	4076	Other foreign transactions gains
	4078	Other noninterest income
Deposits & other liabilities:		
y_8	NINT*	Non-interest-bearing deposits in domestic offices
	4174	Time certificates of deposit larger than $100,000 in domestic offices
	4176	All other deposits
	NFNT*	Non-interest-bearing deposits in foreign offices
	4172	All other deposits in foreign offices
	4180	Federal funds purchased & repurchase agreements
	4185	Demand notes with the U.S. Treasury

Notes: NINT and NFNT are placeholders for report of condition accounts that do not appear on the report of income because they do not earn interest. Code 4050 is the sum of report of condition codes 4054 and 4055, which segregate credit card income from other income. The reports of condition contain only account values for the sum of credit card and other loans to individuals.
*Created code.

tains the detail of this product aggregation scheme. In table 6.2 we report means of the shares of assets and charged services in asset and service charge income w_i, the asset portfolio shares, s_i, and sample sizes.

6.4.1. Construction of the Holding Revenues and Holding Costs

Before describing the econometric aspects of estimating ρ, we describe the construction of the holding revenues of assets and the holding costs of liabili-

Table 6.2 **Sample Sizes and Asset-Weighted Means Holding Revenue and Portfolio Shares**

Variable	All Data	Data without Zeros	Data without Zeros and Influentials
		1984	
N	482	464	424
*W*1	0.113	0.115	0.119
*W*2	0.186	0.186	0.183
*W*3	0.087	0.087	0.093
*W*4	0.367	0.367	0.364
*W*5	0.102	0.102	0.102
*W*6	0.040	0.040	0.037
*W*7	0.078	0.078	0.077
*S*1	0.127	0.127	0.134
*S*2	0.184	0.184	0.182
*S*3	0.082	0.082	0.087
*S*4	0.442	0.441	0.432
*S*5	0.097	0.098	0.099
*S*6	0.057	0.058	0.057
		1985	
N	473	455	410
*W*1	0.115	0.115	0.122
*W*2	0.162	0.162	0.164
*W*3	0.095	0.095	0.101
*W*4	0.333	0.332	0.327
*W*5	0.116	0.117	0.114
*W*6	0.061	0.061	0.057
*W*7	0.089	0.089	0.087
*S*1	0.131	0.132	0.139
*S*2	0.180	0.180	0.184
*S*3	0.090	0.090	0.094
*S*4	0.419	0.418	0.408
*S*5	0.102	0.102	0.101
*S*6	0.068	0.068	0.064
		1986	
N	472	451	415
*W*1	0.126	0.126	0.131
*W*2	0.149	0.149	0.152
*W*3	0.099	0.100	0.106
*W*4	0.290	0.291	0.285
*W*5	0.111	0.111	0.110
*W*6	0.074	0.073	0.068
*W*7	0.107	0.107	0.106
*S*1	0.141	0.141	0.147
*S*2	0.176	0.176	0.180
*S*3	0.092	0.092	0.097

(continued)

Table 6.2 (continued)

Variable	All Data	Data without Zeros	Data without Zeros and Influentials
$S4$	0.394	0.395	0.384
$S5$	0.102	0.102	0.103
$S6$	0.085	0.084	0.079
		1987	
N	464	439	402
$W1$	0.153	0.153	0.157
$W2$	0.169	0.167	0.168
$W3$	0.107	0.108	0.113
$W4$	0.215	0.214	0.210
$W5$	0.053	0.053	0.058
$W6$	0.055	0.056	0.051
$W7$	0.141	0.141	0.138
$S1$	0.161	0.162	0.169
$S2$	0.176	0.175	0.180
$S3$	0.090	0.090	0.094
$S4$	0.369	0.369	0.358
$S5$	0.110	0.110	0.112
$S6$	0.081	0.082	0.074
		1988	
N	453	426	385
$W1$	0.155	0.156	0.167
$W2$	0.161	0.160	0.166
$W3$	0.095	0.095	0.104
$W4$	0.304	0.305	0.274
$W5$	0.087	0.087	0.085
$W6$	0.068	0.068	0.059
$W7$	0.116	0.117	0.111
$S1$	0.179	0.180	0.191
$S2$	0.178	0.177	0.183
$S3$	0.092	0.090	0.098
$S4$	0.344	0.344	0.331
$S5$	0.115	0.116	0.115
$S6$	0.080	0.080	0.070

Note: W is used for asset-weighted means holding revenue; S for portfolio shares.

ties. The holding cost and revenue components of the various product user costs were constructed by item. As given earlier, the complete expression for the holding revenue of the ith asset is given by

$$h_i^t = \text{interest rate received} + \text{capital gain rate}$$
$$- \text{provision for loan losses}$$

and the expression for the holding cost of the *i*th liability is given by

$$h_i^l = \text{interest rate paid} - \text{service fees} + \rho \times \text{reserve requirement}.$$[15]

To calculate the interest rates used in the analysis, fourth-quarter income for a particular asset or liability product for each bank in the sample is divided by the annual average of the corresponding aggregate balance sheet item. Asset detail on loan and lease loss provisions was not available in our FDIC data. We therefore allocated the available aggregate loan and lease loss provisions for each bank proportionately (and admittedly somewhat arbitrarily) to the portfolio share of each loan item in the loan and lease portfolio. Because loss provisions reduce taxable corporate income, we multiplied loss provisions by one minus the marginal tax rate (see n. 21 for the tax rates).[16] Deposit service charges per dollar are estimated by the ratio of total service charge income to the annual average of interest and non-interest-bearing deposits in domestic branches, again owing to a lack of account detail in the FDIC service charge data. This amount is then subtracted from the interest rates for the deposit products.

We set the capital gains term equal to zero in all holding revenue expressions for assets that are not marketable. This leaves the following security categories for which a capital gain term is relevant: assets held in trading accounts; U.S. Treasury securities; U.S. government agency and corporate obligations; state and local securities; other domestic securities (mainly mortgage related and Federal Reserve stock); and foreign securities.[17]

Our assumption about marketable assets does not take into account the recent rise in loan sales by banks. The deregulation of banks and the attending rise in competition has forced banks into a position of diversifying portfolios by selling loan assets in their entirety or in parts. Consequently, secondary

15. The holding cost for a liability product should also include a deposit insurance premium assessed by the FDIC. Because all banks are assessed the annual premium of 1/12 of 1 percent of total domestic deposits, the exclusion of this term does not qualitatively affect our analysis. The premium term would have to be included if the premium becomes dependent on bank risk—a suggestion that is often voiced in the face of the rising number of bank failures.

16. Our approach to the tax deductibility of loan loss reserves does not take into account the changes in such deductions that were a part of the 1986 Tax Reform Act. One of the provisions of the act limited loan loss reserves to actual charge offs, although banks can add to their reserves as much as they wish. This provision applied chiefly to banks with assets over 500 million. Furthermore, the act required banks to recapture *existing* bad debts reserves into taxable income at a set schedule. Financially troubled banks were relieved of this provision until they were in better condition. Because these changes occurred within the period examined, we chose to incorporate a uniform treatment of loan loss reserves.

17. Although foreign securities earn capital gains, we did not consider these capital gains because the data were unavailable. Assets in trading accounts are typically held for only a short period of time, so capital gains income is likely to be fully realized. Realized gains in trading accounts from the call reports is thus used for the capital gains term in our user cost estimates for trading accounts. The capital gain for commercial real estate loans is set equal to zero because these loans are not typically traded, although an informal secondary market is beginning to form among the money center banks. Residential mortgages, on the other hand, are routinely securitized and sold.

markets for commercial and industrial loans, albeit informal, have arisen although the volume of such transactions is small.[18] Recently, the financing of leveraged buy outs has been inextricably tied to the ability of the lead lending banks to sell pieces of loans. At some banks, the salability of a loan has become as important as the borrower's credit worthiness.[19]

We approximate the effect of capital gains for Treasury securities and U.S. government agency and corporate obligations by subtracting the computed sample average interest rate on Treasury securities and agency obligations from the average annual total return data, which are the sum of the market interest rate and the rate of capital appreciation, obtained from the Merrill-Lynch government master bond index.[20] This index includes various maturities of Treasury securities and U.S. agency securities.

The capital gains term for government securities other than Treasury securities was approximated by subtracting the computed sample average interest rate on government securities from the total return on these securities obtained from the Merrill-Lynch mortgage master index. Although this set of securities is not solely composed of mortgage-backed securities, all securities in this category were imputed with the mortgage master total return rate.

The capital gains on state and local securities are difficult to measure because the major indexes are not total return indexes, but rather simple averages of dealer estimates of what the coupon rate would have to be for a particular issue released on the day of the survey and sold at par. To measure changes in the total return to holding state and municipal securities we examined the Lipper index for the performance of a collection of tax-exempt mutual funds.[21] A potential problem with this measure is the variability in management performance inherent in a cross-sectional sample of tax-exempt

18. The following information was provided by Chris Bumcrot of Loan Pricing Corp. and gleaned from several issues of *Loan Pricing Report*, a publication of Loan Pricing Corp. Information about bank practices was also provided by Steve Woods and Nori Marshall, both of Bank of America.

19. Another motivation for the sale of loans is the new risk-adjusted capital reserve requirement schedule that goes into full effect in 1992. Under these requirements, in 1992 a bank would have to set aside $8, $4 of which must be in stockholder's equity, for every $100 of private loans (nongovernment supported or related). These requirements substantially reduce the holding revenue for a loan and thereby encourage loan sales.

20. We thank Chet Ragavan of Merrill-Lynch's Fixed Income Research Department for providing the total return data for the Merrill-Lynch government master bond index and the mortgage master index.

21. We are grateful to Julie Friedlander of Lipper Analytical Securities Corp. for supplying the quarterly total return on the Lipper General Municipal Bond Funds. We impute a tax-equivalent return for state and municipal securities by setting the federal tax rate at 46 percent for the years 1984–86, 40 percent in 1987 and 34 percent in 1988. These are the maximum statutory rates, which are applicable for the large banks in our sample. Our imputation does not take into account the percentage of interest payments disallowed. Before 1983 all of the interest incurred by a bank in acquiring tax-exempt securities could be deducted. In 1983, the tax law was changed to disallow 20 percent of the interest incurred for tax-exempt securities acquired after 1982. The 1986 tax law changed the disallowance to 100 percent of the interest incurred for securities acquired after August 6, 1986.

mutual funds. However, it is reasonable to suppose that a bank's management of its tax-exempt portfolio is similar to that of firms specializing in such management, otherwise the bank may be better off contracting out for the management of its tax-exempt portfolio. Because the interest on state and municipal bonds is tax-exempt, we incorporate the interest earned on these securities on a tax-equivalent basis.

6.4.2 Model Estimation and Results

Our econometric model relates the asset shares in asset holding and service fee revenue, w_i, to the asset portfolio share, s_i, the log of the branching characteristics variable a, the logs of outputs ($y_1, \ldots, y_8$), and the logs of inputs (x_1, x_2, x_3), as given in equations (8) and (9).

Before estimating the model we checked for influential observations by running a sequence of regression diagnostics on an aggregate loan equation with identical functional form to the equations in our more detailed system. We isolated and deleted observations that were tagged as influential via a heuristic test on the size of the diagonal element of the "hat" matrix corresponding to the observation, using the Belsley, Kuh, and Welsch (1980) recommended cutoff. This test is oriented toward finding observations with unusual leverage on the parameter estimates because of the values of their exogenous variables. An examination of this list of banks revealed that a number were in one of two categories: The first category is banks that were or later became troubled, including Continental Illinois in 1984, and a collection of Texas, California, and Florida Banks in each of the five years. The second category included U.S. subsidiaries of foreign banks, particularly Japanese banks located in New York and California. A third, small category included what were apparently savings and loans that had joined the Federal Reserve System. An examination of the loan holding revenue share for the set of "hat" influential banks also revealed some extreme values, including values less than zero and greater than one. Although our inclusion of provisions for loan losses as part of the loan return means that these values are not ruled out, they were rare outliers in our sample. All told, the diagnostic filter reduced our sample size by approximately 10 percent. A handful of observations were also deleted because of excessively large studentized residuals; that is, they had excessive influence on the model fit.

Our sample size was reduced somewhat further by the fact that some banks in the sample had no assets at all in certain categories, making them impossible for our translog model to handle.[22] This resulted in a further reduction in sample size of about 5 percent. We present statistics for selected variables from the full and edited samples in table 6.2.

We estimated the system of equations (8) for each of the years 1984–88 by

22. Using the generalized quadratic functional form recently discovered by Diewert (1992) may offer a solution to this problem.

the iterative seemingly unrelated regressions method, dropping without loss of generality equation (9) because of the singularity of the covariance matrix of the disturbances arising from the fact that $\Sigma_{i=1}^{7} \varepsilon_i = 0$. The parameter of greatest interest to us is ϕ, the coefficient of the portfolio shares s_i. Without exception, ϕ is estimated very precisely, and exhibits substantial stability over the period, rising from 1984 to 1985, a very profitable year for this group of banks, then declining through 1986 to a low in 1987, a year characterized by a profit squeeze, and rebounding in 1988.[23] In general, we expected the distance function derived economic shares to be positively related to the log of own output, because this is related to the convexity of the translog functional form we used. Our expectations were met for all the loan categories except other loans and leases, y_4, whose own elasticities were positive but insignificant in 1984, negative and significant in 1985, negative and insignificant in 1986, positive and significant in 1987, and negative and insignificant in 1988. The securities share equations in various years also displayed intermittent negative own output elasticities.

We did not enforce convexity on the distance function parameters. In light of the fact that the portfolio shares clearly swamped the distance function arguments as explanatory variables for the accounting revenue shares, it is very unlikely that imposing nonlinear restrictions on the coefficients of these variables (convexity constraints) would have appreciably changed the results for ϕ.

Our estimated aggregate opportunity cost rate is the asset-weighted average of the opportunity cost rates of the banks in our full sample, computed as $\bar{\rho} = \hat{\phi} \cdot \bar{r}_{TA}$, where $\bar{r}_{TA}$ is the asset-weighted average rate of total return on assets for the sample, and $\hat{\phi}$ is the estimate of ρ/r_{TA} from our econometric model. In table 6.3 we present a comparison of our econometric estimate of the opportunity cost rate with several plausible, and relatively easily obtained, alternatives. These are (1) the 90-day Treasury Bill rate, r_{T90}; (2) the rate of return on assets, $\bar{r}_A$; (3) the required rate to cover the interest cost of liabilities, r_{REQ}; and (4) the opportunity cost rate generating the proposed UNSO financial services imputation.

The asset-weighted sample mean total return on assets is computed as

$$\bar{r}_{TA} = \frac{\Sigma_{n=1}^{N} [\Sigma_{i=1}^{6} h_{in} y_{in} + R_{7n}]}{\Sigma_{n=1}^{N} \Sigma_{i=1}^{6} y_{in}},$$

where n indexes banks, and N is the sample size. Rate (2), the asset-weighted sample mean holding return on assets, is computed as

23. Our standard error estimates are not corrected for the studentized residual and DFFITS sample trimming techniques (defined in Belsley, Kuh, and Welsch, 1980) we applied to eliminate outliers and increase the resistance of our parameter estimates to influential observations. These filters truncate the dependent variables of our system, and the precision of our estimates is therefore somewhat overstated. However, very few observations were affected by these filters, and we would expect the bias in our standard error estimates from this source to be low.

Table 6.3 Opportunity Cost Rates Asset-Weighted Means

Variable	Description	1984	1985	1986	1987	1988
r_{T90}	90-day Treasury	.0952	.0747	.0597	.0578	.0667
r_{REQ}	Required rate	.0818	.0686	.0557	.0558	.0615
r_A	Asset rate	.1123	.1056	.0895	.0696	.0910
r_{TA}	Total asset rate	.1223	.1163	.1007	.0824	.1039
ϕ	ρ/r_{TA}	.7628	.8214	.6950	.6065	.7385
ρ	Econometric opportunity cost	.0933	.0961	.0700	.0500	.0767
ρ_{UNSO}	UNSO opportunity cost	.0970	.0871	.0726	.0627	.0762

$$\bar{r}_A = \frac{\sum_{n=1}^{N}\sum_{i=1}^{6} h_{in}y_{in}}{\sum_{n=1}^{N}\sum_{i=1}^{6} y_{in}}.$$

Rate (4), the asset-weighted sample mean required rate of return on assets, is computed as

$$\bar{r}_{REQ} = \sum_{n=1}^{N}\left[\frac{\sum_{i=1}^{6} y_{in}}{\sum_{n=1}^{N}\sum_{i=1}^{6} y_{in}}\right]\cdot [h_{8n}/(1 - k_n)],$$

where k_n is the ratio of reserves—currency and coin and deposits at Federal Reserve banks—to deposit and other liabilities for the nth bank.[24]

Fixler and Zieschang (1991) showed that the imputation scheme used by the BEA for allocating uncharged services provided by banks to customers in the business and final consumption sectors implicitly takes $\rho = \bar{r}_A$. They also argue that the proposed UNSO imputation method implicitly assumes that $\rho = [\bar{r}_{REQ} + \bar{r}_A]/2$.

To judge which of these alternatives is closest to our estimated ρ, we consider the average absolute difference between our estimate of ρ and these alternatives. We find that our estimated value of ρ is closest on average to the ρ given by the UNSO approach, the average absolute difference being 57 basis points, where a basis point is one one-hundredth of an interest rate percentage point. In contrast, the average difference between the 90-day Treasury Bill rate and ρ is 103 basis points; between the $\bar{r}_{REQ}$ and ρ it is 149 basis points; and between the BEA-determined ρ and our ρ the average absolute difference is 164 basis points. Thus our analysis suggests that the UNSO approach provides a reasonable rule of thumb for the calculation of ρ.[25]

Because it is a determinant of the weights by which quantity relatives are

24. k_n is not the same as the legally required reserve ratio for deposits because for many banks the currency and coin holdings are amounts necessary for business, and some banks may hold excess reserves on deposit at the Federal Reserve.

25. It is also worth noting from table 6.3 that the *simple* average difference between r_{T90} and ρ is positive, with r_{T90} exceeding ρ by substantial amounts in three of the five years, and staying numerically close in the two years when it fell below ρ. Because r_{T90} is a rate on short-duration, risk-free assets, this evidence suggests that our estimate of ρ reflects the higher risk and (presumably) generally longer average duration of the asset portfolios held by U.S. banks over this period.

averaged to form an index number, ρ is important to the calculation of output quantity indexes. If the overall (aggregate) distance function is translog, as in (1), then, following Caves, Christensen, and Diewert (1982), we can compute the following, exact, period-to-period index number:

$$(10) \qquad Q = \left[\frac{D(\mathbf{x}^{t-1}, a^{t-1}, \mathbf{y}^{t})}{D(\mathbf{x}^{t-1}, a^{t-1}, \mathbf{y}^{t-1})} \cdot \frac{D(\mathbf{x}^{t}, a^{t}, \mathbf{y}^{t})}{D(\mathbf{x}^{t}, a^{t}, \mathbf{y}^{t-1})}\right]^{\frac{1}{2}}$$
$$= \prod_{i=1}^{8} \left[\frac{y_i^t}{y_i^{t-1}}\right]^{\frac{1}{2}\left[\frac{p_i^{t-1} y_i^{t-1}}{\sum_{i=1}^{8} p_i^{t-1} y_i^{t-1}} + \frac{p_i^t y_i^t}{\sum_{i=1}^{8} p_i^t y_i^t}\right]},$$

where $p_i^t = h_i^t - \rho$ for assets, and $p_i^t = \rho - h_i^t$ for liabilities. These expressions are the negative of the user cost expressions in (1) and (2); to enable the y_i to be always positive, negative user costs are employed. It follows that a negative price means that the product is a financial input and that a positive price means that the product is a financial output. We find that the financial input-output status of the financial products is fairly constant over the examined period, regardless of the estimate of the opportunity cost rate. For example, with our econometrically estimated ρ, there were a total of four financial input-output status switches: y_6 was an input in 1984 and switched to an output in 1985; y_5 switched from an output in 1986 to an input in 1987 and remained an input in 1988; and y_8 switched from an output in 1986 to an input in 1987 and back again to an output in 1988. The other financial products were always financial outputs. Interestingly, whenever a product became a financial input, the attending price was close to zero. For example, the price of y_5 was 4 cents per dollar in 1986, declining to −0.4 cents per dollar in 1987. This small value likely results from the value of the uncharged-for financial services nearly offsetting the explicit charges. The other values of ρ produced approximately the same number of financial input-output status switches, and these changes were concentrated in y_5 and y_6.

The cumulative, chained values of the index (10) and the associated implicit price index, computed under alternative opportunity cost estimates, are presented for the years 1984–88 in table 6.4. We found that the aggregate output of banks increased by approximately 40 percent over the period. In addition, it can be seen that our price and output measures are insensitive to the variations in the level of ρ represented by the alternatives we consider. One should keep in mind that our yearly sample of banks contains the large banks; that is, we consider more than 400 of the top banks measured in total assets from a total of (approximately) 13,000 banks. In terms of deposits, our sample of banks accounted for 54 percent of total deposits in 1988, and similar magnitudes were encountered in the other years. Because more than 12,000 banks accounted for the remainder of the deposits, it is likely that some of these banks were quite small and that some even experienced negative growth. Coupling this fact with the decline in the number of banks over the period, approximately 9 percent, it is quite likely that industry growth was smaller than 40

Table 6.4 **Price and Quantity Indexes under Alternative Opportunity Cost Rates**

Variable	Description	1984	1985	1986	1987	1988
	Aggregate Output Quantity Indexes					
r_{T90}	90-day Treasury	100.00	110.40	123.19	133.36	140.70
r_{REQ}	Required rate	100.00	110.61	123.46	133.59	140.92
r_A	Asset rate	100.00	109.83	122.24	132.85	140.31
ρ	Econometric opportunity cost	100.00	110.16	122.80	133.01	140.26
ρ_{UNSO}	UNSO opportunity cost	100.00	110.24	122.87	133.24	140.63
	Aggregate (Implicit) Output Price Indexes					
r_{T90}	90-day Treasury	100.00	110.20	102.60	76.25	96.16
r_{REQ}	Required rate	100.00	109.99	102.37	76.12	96.02
r_A	Asset rate	100.00	110.77	103.39	76.55	96.43
ρ	Econometric opportunity cost	100.00	110.44	102.92	76.46	96.47
ρ_{UNSO}	UNSO opportunity cost	100.00	110.37	102.86	76.33	96.21

percent. On the other hand, our output growth result compares well with the output growth computed in Berger and Humphrey (chap. 7, this vol.) for the same banks during the same period.

Of note in our output trend is the substantial, double-digit growth in the years 1984 and 1985. This may be explained by the relatively large interest rate margins (measured as $r_A - r_{REQ}$) of these years. The interest rate margin was 370 basis points in 1985 and fell to 138 basis points in 1987. Moreover, in the years beginning with 1985 there were increases in loan loss reserves, largely for loans to less developed countries and energy-related loans in the Southwest. These developments tended to push the return on assets down. We see correspondingly that the implicit output price indexes began to fall in 1986.

6.5 Conclusion

Hancock's (1985a, 1985b, 1986) studies of commercial banking showed how financial firms could be analyzed within a traditional neoclassical production model, in concert with the user cost of money innovation of Donovan (1978) and Barnett (1978). Fixler (1988) has shown that Hancock's translog restricted profit function, in concert with her constructed user cost prices, underlies a practical framework for price and output measurement for financial firms based on the Törnqvist (or other superlative) index number. The chief issue in the user cost framework, as in other applications in investment and durable consumption goods, is obtaining reliable estimates of the components of the user cost price. Our focus here has been on the opportunity cost rate, the single truly unobservable item in the user cost formula. We approach the estimation of the opportunity cost rate as a shadow price problem, and in contrast with Hancock, characterize technology in terms of its production or distance function instead of its restricted profit function. We estimate the relevant parameters of the distance function, under the assumption that the opportunity cost rate is an unknown, constant fraction of the rate of total return on assets. We find that our econometric estimate of the opportunity cost rate is in the same range as several rule-of-thumb estimates, including the return on assets, the required rate of return on assets, and the 90-day Treasury Bill rate. However, it is tightly estimated and significantly different from all of them.

Using our estimate of the opportunity cost rate, we construct Törnqvist quantity indexes for the years 1984–88. Over the period output grew 40 percent with double-digit output growth in the years 1984 and 1985. At first blush one might suppose that our output index is sensitive to the opportunity cost of money used. In fact, our superlative quantity index is shown to be insensitive to the variations in the opportunity cost rate given by the rule-of-thumb estimates. The importance of this finding to the production of price and (gross) output quantity-index numbers is that it establishes the commonsense rules of thumb as cheaper substitutes for the more expensive econometrically estimated opportunity cost of money.

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