PRODUCTION TECHNOLOGY OF PHILIPPINE
COMMERCIAL BANKS

By Mario B. Lamberte*

1. Introduction

This study attempts to analyze bank behavior. The bank is viewed here as a producing unit rather than merely an investor. Like any other producing unit, the bank has its own production technology, and knowledge of this production technology is extremely important in understanding bank behavior.

The usual practice of doing an empirical analysis of the behavior of any firm is to assume right away a specific production technology. This study deviates from this usual practice by presenting alternative forms of production technology, each of which describes a particular pattern of bank behavior, and by determining empirically which of them best describes the actual behavior of commercial banks.

Section 2 presents three hypothesized forms of the production technology of banks. The methodology is presented in Section 3. Section 4 discusses the empirical results. The last section concludes the study.

2. Alternative Forms of the Production Technology of Banks

1.1 The Unrestricted Form of the Production Technology of Banks

The banking firm produces several outputs (e.g., loans and investments) and provides various services to its customers (e.g., issuance of letters of credit, administration of trust funds). The output levels must be related in some way to the amount of inputs used by the bank, such as deposit funds, labor, capital, etc. The produc-

*Research Fellow, Philippine Institute for Development Studies (PIDS). This paper is based on the author’s dissertation “Behavior of Commercial Banks: A Multiproduct Joint Cost Function Approach” (1982). This paper has benefited from the suggestions of Dr. Edita A. Tan, Dr. José Encarnación, Jr., and Dr. Rolando A. Danao. The remaining errors are solely mine.
tion technology of banks relates the different combinations of outputs to the corresponding feasible combinations of inputs. This technology may be represented by the following transformation function,

\[ F(Q, X) = 0 \]

where \( Q (= q_1, q_2, \ldots, q_m) \) is an \( m \)-dimensional vector of levels of bank outputs, and \( X (= x_1, x_2, \ldots, x_n) \) is an \( n \)-dimensional vector of quantities of variable inputs.

It has been demonstrated by Shephard (1970), Uzawa (1962), Diewert (1971) and McFadden (1978) that if \( F \) has a strictly convex structure, a unique multiproduct joint cost function can be constructed from \( F \), and it can be written as

\[ C = C(Q, P) = \min P \cdot X \]

where \( P (= p_1, p_2, \ldots, p_n) \) is an \( n \)-dimensional vector of input prices. The minimum cost function (2) is homogenous of degree plus one, nondecreasing, and concave in \( P \).

The duality between \( C \) and \( F \) ensures that they contain the same information about the production technology of the firm. Thus, either function may be used equivalently to predict the firm's behavior.

The study chooses to start from a cost function rather than from a production function. This choice is dictated by the desire to approximate better the decision-making process done at the bank level. Past works usually assume banks to follow only the “asset management” practice wherein loan commitments are adjusted in response to changes in deposits, reserves and economic conditions of which banks have little control. Deposit funds, which are the most important factor inputs of banks, are regarded as completely exogenous to the bank. In this case, the production function can very well capture the decision-making process since it treats factor inputs as exogenous to the banking firm.

The introduction of the “liability management” technique in banking has changed the bank from a passive to an aggressive solicitor of funds.1 This is brought about mainly by the interest collapse

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1The “asset management” and “liability management” banking practices are sufficiently discussed in standard textbooks on money and banking. For example, see Havrilesky and Boorman (1978) and Horvitz (1979).
imposed on deposits. Given the relatively low interest ceilings on deposits, a bank can attract new deposits by paying implicitly interest on these deposits. This can be in the form of an extra cost incurred by the bank in providing a low cost or free additional services (such as overdraft privileges, advisory services, etc.) to its customers. The implicit interest rate is said to vary directly with the size of deposits and inversely with the market rate of interest (Havilesky and Boorman, 1978).

The adoption of the “liability management” approach by commercial banks also enables them to deal with the rapid development of the money market in the Philippines. When a bank needs funds to meet additional loan requirements and/or demand for more liquidity, it has now the option to issue deposit substitutes. It is to be noted that the money market is a relatively important source of funds, especially for smaller banks which are less able in acquiring deposits.

This innovative banking technique maintains that a bank bases its loan commitments on the anticipated cost of attracting new deposit and nondeposit funds. Clearly, the level of deposit and nondeposit funds used to meet loan demands and liquidity needs is an endogenous decision, whereas the prices of such funds are exogenous to the bank. It, therefore, calls for the use of a cost function which could very well capture such decision-making process since it treats the level of inputs as endogenous and input prices as exogenous.

Without further restrictions, the transformation function given in (1) describes a production technology which is rather general in the sense that it “permits arbitrary kinds of interaction between total factor intensities and the trade-off between various types of outputs” (Hall, 1973; p. 880). If the production technology of the banking firm takes this form, it implies the following interesting behavioral characteristics of the banking firm: First, the marginal cost of each output depends on the level of any output; and second, the ratios of any two marginal costs are dependent on factor prices or factor intensities. The second implication means that the bank’s choice of output mix depends on the allocation of its inputs. Hence, any change in the relative input prices will trigger a change in the combination of outputs.

While this general or unrestricted transformation function may reasonably describe the bank’s behavior, it is not necessary, in reality for the multiproduct production technology of banks to take this form. It is possible that a simpler or restricted form of the transformation function would more appropriately describe the bank’s
behavior. A number of these restricted forms are quite popular in economic literature dealing with multiproduct technologies. Two forms will be discussed because of their relevance to our analysis of bank behavior.

2.2 Restricted Forms of the Transformation Function

One way of restricting the transformation function is to assume that the bank's multiproduct production technology is characterized by nonjointness in the production process. In this framework, the multiproduct banking firm is seen to have separate production functions for each product.

Hall (1973) defines a nonjoint production technology thus: A technology with a transformation function (1) is nonjoint if there exist single product production functions, i.e.,

\[ q_i = q_i(x_1^i, x_2^i, \ldots, x_n^i), \quad i = 1, 2, \ldots, m \]

so that: (i) if (1) holds, i.e., if \( X \) can produce \( Q \), there is a factor allocation

\[ x_1^j + x_2^j + \ldots + x_m^j = x_j^j \quad j = 1, 2, \ldots, n \]

such that (3) holds for each of the \( q(\cdot) \); and and (ii) if (3) holds, then (1) holds for values of \( q_i \) in (3) and of \( x_j \) in (4).

By duality, each of the \( m \) single product production functions will have the corresponding minimum cost functions as follows:

\[ C_i = C_i(q_i, P), \quad i = 1, 2, \ldots, m \]

Merging these \( m \) single product cost functions into one multiproduct cost function results in the following multiproduct nonjoint cost function,

\[ C = C(Q, P) = \sum_{i=1}^{m} C_i(q_i, P) \]

that is, for a multiproduct firm to have a nonjoint production technology, its total cost function should equal the sum of the cost functions of producing each product separately. The merging of the

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2 This is also referred to as output independence by Laitinen (1980).
3 Examples can be found in Bell and Murphy (1968) and Sealey and Lindley (1977).
individual cost functions requires that there are no economies nor diseconomies in jointness: otherwise,

\[ C(Q, P) < \sum_{i=1}^{m} C_i(q_i, P) \]

if there are economies of jointness, or

\[ C(Q, P) > \sum_{i=1}^{m} C_i(q_i, P) \]

if there are diseconomies of jointness, and (6) does not hold anymore.

The implication of this restrictive form can be clearly seen in (6). Let marginal cost of each output be defined as \( \partial C/\partial q_i \). The marginal cost of each output is independent of the level of any other output. Consequently, the ratios of any two marginal costs are independent of the output mix. Moreover, a nonjoint production technology does not allow an output to be a substitute or complement of any other output (Laitinen, 1980).

Another way of restricting the general transformation function is to assume the existence of a single variable that can represent all the outputs of a multiproduct firm. This is equivalent to assuming the existence of the aggregate quantity measure \( Z \), where

\[ Z = h(Q) \]

and \( h \) is the quantity aggregator function which is a linearly homogeneous, concave and nondecreasing function. Given (7), the transformation function \( F \) can then be specialized to

\[ F(Q, X) = G[h(Q), X] = 0 \]

The transformation function having the form of (8) is referred to as a separable transformation function or a transformation function with separability restriction.

It is to be noted that a separable transformation function permits decentralization in decision-making or equivalently, a two-stage optimization process. In the first stage, the banking firm

\[ \text{The studies of Greenbaum (1967), Benston (1972), and Murray and White (1980) may serve as examples of this particular approach to the study of bank behavior. Although they recognize that banks are multiproduct firms, their analyses assumed one homogeneous bank output.} \]
optimizes the level of aggregate output $Z$ (which may be called loanable funds) for given input levels such as deposit funds, labor services, capital, etc., subject to the transformation function $F$. In the second stage, it optimizes the mix of components of the aggregate output subject to the quantity aggregator function $h$.

The imposition of separability on the transformation function implies that the cost function can be written as:

(9) \[ C = C[h(Q), P] \]

The restrictiveness of a separable transformation function process can be immediately observed from (9). If the technology of a banking firm is separable, the ratios of any two marginal costs, i.e., \[ \frac{\partial C}{\partial q_i} / \frac{\partial C}{\partial q_k}, \]

are dependent only on the output mix but not on the factor prices or factor intensities. With this kind of production technology, the banking firm can choose its output mix independently of its input mix. Thus, no specific interaction between any particular output and any particular input can be expected.

This interesting implication is related to the issue of the independence of asset and liability management tackled in the literature on banking.\(^6\) Klein (1971) pointed out that the original justification for interest rate regulation was that competition for deposits between banks would lead to "unsound" portfolio policies. A bank would prefer to hold high-yielding (and risky) earning assets if interest rates on its sources of funds are high. He proved this argument wrong by showing that in his model neither the cost of deposits nor the size and structure of deposit liabilities can affect asset selection or the mix of outputs chosen by the bank. His model was partly motivated by Benston (1964) who had earlier shown some empirical evidence on the independence of asset and liability management.

We have presented three alternative characterizations of the multiproduct production technology of the banking firm. The first describes a general or unrestricted form of the production technology, while the second and the third are special cases or restricted forms. As pointed out, each implies a particular pattern of bank behavior. It must, however, be recognized that the banking firms may take any of these forms, and it is the task of this study to determine

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\(^5\) See Denny (1970) and Hall (1973) for proof.

\(^6\) See Baltensperger (1980) for a discussion of this issue.
which of the three forms best describes the actual behavior of commercial banks in the Philippines.

3. Methodology

The task of this section is twofold: (1) to present a functional form that permits the estimation of the multiproduct joint cost function; and (2) to outline the procedure for estimating the parameters of the said function.

1.1 The Specific Functional Form for the Multiproduct Joint Cost Function

In choosing a functional form of our multiproduct joint cost function (MJCF), there are three considerations: First, the functional form is "flexible," that is, it does not a priori constrain the various elasticities of substitution as the Cobb-Douglas and CES models do. Second, it is capable of providing a second-order approximation to an arbitrary twice differentiable function. Third, it is parsimonious in parameters.

Three flexible forms can possibly represent the MJCF. The first is the "hybrid Dievert" multiproduct joint cost function (HDMJCF) proposed by Hall (1973). It is expressed as

\[ C = \sum_{i} \sum_{k} \sum_{j} \sum_{s} \alpha_{ikjs} \sqrt{q_i q_k} \sqrt{p_f p_s} \]

The second is the quadratic multiproduct joint cost function (qMJCF) presented by Lau (1974). It is written as

\[ C = \alpha_0 + \sum_{i=1}^{m} \alpha_i q_i + \sum_{j=1}^{n} \beta_j p_j \\
+ 1/2 \sum_{i=1}^{m} \sum_{k=1}^{m} \gamma_{ik} q_i q_k \\
+ 1/2 \sum_{j=1}^{n} \sum_{s=1}^{n} \lambda_{js} p_j p_s \\
+ \sum_{i=1}^{m} \sum_{j=1}^{n} \theta_{ij} q_i p_j \]
The third flexible form which is called the transcendental logarithmic (translog) multiproduct joint cost function (TMJCF) was suggested by Christensen et al. (1973). The TMJCF is written as

\[
\ln C = \alpha_0 + \sum_{i=1}^{m} \alpha_i \ln q_i + \sum_{j=1}^{n} \beta_j \ln p_j
\]

\[+ \frac{1}{2} \sum_{i=1}^{m} \sum_{k=1}^{m} \gamma_{ik} \ln q_i \ln q_k \]

\[+ \frac{1}{2} \sum_{j=1}^{n} \sum_{s=1}^{n} \lambda_{js} \ln p_j \ln p_s \]

\[+ \sum_{i=1}^{m} \sum_{j=1}^{n} \theta_{ij} \ln q_i \ln p_j \]

In reviewing the three flexible forms, Caves et al. (1980) pointed out that the QMJCF does not satisfy the regularity condition of linear homogeneity in factor prices. The condition is necessary to prove the existence of a duality relationship between the cost and transformation functions. While HDMJCF and TMJCF fulfill this regularity condition, the former has more parameters to be estimated than the latter. Thus, the TMJCF appears to be more suitable for our purpose, but only if there are nonzero output observations in the sample. Since none of the sample observations registered zero in any of the outputs, the TMJCF is chosen to represent the multiproduct joint cost function.

The TMJCF is required to meet the following symmetry conditions:

\[
\gamma_{ik} = \gamma_{ki} \quad (13)
\]

\[
\lambda_{js} = \lambda_{sj} \quad (i)
\]

\[
\theta_{ij} = \theta_{ji} \quad (ii)
\]

In addition, every cost function should always exhibit linear homogeneity in input prices. The following parameter restrictions:

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7If one of the \( q_i \) is zero, \( \ln q_i = -\infty \), consequently \( \ln C = -\infty \) and \( C = 0 \). That is, whenever the firm does not produce all of the various products and the output of at least one product is zero, then the translog cost function automatically yields zero costs. This, of course, contradicts common sense. This point was raised by Prof. W.J. Baumol in his personal letter (August 19, 1981) to the author.
imposed on the TMJCF are necessary and sufficient for linear homogeneity in input prices:

\[ i) \sum_{j=1}^{n} \beta_j = 1 \]

\[ ii) \sum_{j=1}^{n} \lambda_{js} = 0 \]

\[ iii) \sum_{j=1}^{n} \theta_{ij} = 0 \]

The cost function which is dual to the transformation function obeys Shephard's lemma, i.e., a set of factor demand equations can be derived from the joint cost function. In our translog multiproduct joint cost function, the partial derivatives of (12) yield cost share equations of input \( j \). This is written as

\[ M_j = \frac{\partial \ln C}{\partial \ln p_j} = \beta_j + \sum_{s=1}^{n} \lambda_{js} \ln p_s + \sum_{i=1}^{m} \theta_{ij} \ln q_i \]

where \( M_j \) is the cost share (i.e., \( p_j x_j/C \)) of the \( j \)th input.

Since all the cost shares must add up to one, the following parameter restrictions are implied:

\[ i) \sum_{j=1}^{n} \beta_j = 1 \]

\[ ii) \sum_{j=1}^{n} \lambda_{js} = 0 \]

\[ iii) \sum_{j=1}^{n} \theta_{ij} = 0 \]

Since these are exactly the same parameter restrictions when linear homogeneity in the input prices is imposed on the cost function, therefore, no new parameter restrictions are added to the cost share equations.

As earlier discussed, nonjointness and separability in outputs may be imposed on the production process. The imposition of non-
jointness implies that the marginal cost of each output is independent of the level of any other output, i.e.,

\[ \frac{\partial^2 C}{\partial q_i \partial q_k} = 0, \; i \neq k \]

The TMJCF is then required to have the following parameter restrictions:

\[ \gamma_{ik} = 0, \; i \neq k \]

This reduces the number of parameters by \( (m)(m-1)/2 \).

A separable transformation function implies that the relative marginal costs are independent of input prices, or

\[ \frac{\partial}{\partial \ln p_j} \left[ \frac{(\partial \ln C / \partial \ln q_i)}{(\partial \ln C / \partial \ln q_k)} \right] = 0 \]

Applying this condition to the translog joint cost function, we have

\[ \frac{\partial}{\partial \ln p_j} \left[ \frac{(\alpha_i + \sum_{k=1}^{m} \gamma_{ik} \ln q_k + \sum_{j=1}^{n} \theta_{ij} \ln p_j)}{\alpha_k + \sum_{i=1}^{m} \gamma_{ik} \ln q_i + \sum_{j=1}^{n} \theta_{kj} \ln p_j} \right] = 0 \]

Separability holds if

\[ \theta_{ij} = 0, \; V_{i, j} \]

Since the imposition of linear homogeneity in the input prices leaves only \( m(n-1) \) free \( \theta_{ij} \)'s, the imposition of separability on the joint cost function further reduces the number of parameters by \( m(n-1) \).

This study intends to use a combination of time-series (1977, 1979) and cross-section data of 27 banks. The estimation of (18) with pooled time series and cross-section data would not allow for differences in production structure among the years. Before we impose restrictions of nonjointness and separability on the structure of production, we should test first the hypothesis that the structure of production differs among the years considered in this study. Thus, we introduce dummy variables for 1978 and 1979 (i.e., \( Y_1 = 1 \) in 1978, zero otherwise; \( Y_2 = 1 \) in 1979, zero otherwise) which allow the production structure to be different from that of 1977. The dummy
The expanded cost function can then be written as:

\[
\ln C = \alpha_0 + \alpha_{y_1} Y_1 + \alpha_{y_2} Y_2 \\
+ \sum_{i=1}^{m} \alpha_j \ln q_i + \sum_{j=1}^{n} \beta_j \ln p_j \\
+ \frac{1}{2} \sum_{i=1}^{m} \sum_{k=1}^{m} \gamma_{ik} \ln q_i \ln q_k \\
+ \frac{1}{2} \sum_{j=1}^{n} \sum_{s=1}^{n} \lambda_{js} \ln p_j \ln p_s \\
+ \sum_{i=1}^{m} \sum_{j=1}^{n} \theta_{ij} \ln q_i \ln p_j \\
+ \sum_{i=1}^{m} p_{i1} \ln q_i Y_1 + \sum_{i=1}^{m} p_{i2} \ln q_i Y_2 \\
+ \sum_{j=1}^{n} \delta_{j1} \ln p_j Y_1 + \sum_{j=1}^{n} \delta_{j2} \ln p_j Y_2
\]

Since a cost function should exhibit linear homogeneity in factor prices, the following additional parameter restrictions are required:

\[(a) \sum_{j=1}^{n} \delta_{j1} = 0 \]
\[(b) \sum_{j=1}^{n} \delta_{j2} = 0 \]

The following are the cost share equations implied in (22) by Shephard's lemma:

\[
\eta_j = \beta_j + \sum_{s=1}^{n} \lambda_{js} \ln p_s \\
+ \sum_{i=1}^{m} \theta_{ij} \ln q_i \\
+ \delta_{j1} Y_1 + \delta_{j2} Y_2
\]

\[8\text{See (14) for the first three sets of parameter restrictions.}\]
3.2 Statistical Method

The cost function and the cost share equations are estimated jointly using the Zellner Efficient (ZEF) method.\(^9\) Since the parameters appearing in the cost share equations also appear in the cost function, we can impose the restriction that they are equal.\(^10\) The joint estimation of the cost function and the cost share equations has the effect of adding degrees of freedom without adding unrestricted parameters.

We specify an additive disturbance term for each of the cost share equations and the cost function. Any deviations of the cost shares from logarithmic derivations of the translog cost function are assumed to result from random errors in cost minimizing behavior. Following Zellner (1962), we assume correlated disturbances across equations. To implement the ZEF method, it is necessary to drop one of the cost share equations since only \(n-1\) of said equations are linearly independent.\(^11\) However, this raises another problem that is, the estimators that are going to be obtained will not be invariant to whichever cost share equation to be omitted.

Barten (1967) had shown that the maximum likelihood parameter estimates are independent of the equation omitted. This requires the use of Full Information Maximum Likelihood (FIML) to obtain parameter estimates of the equation. Oberhofer and Kmenta (1974), however, demonstrated that if one were to iterate the ZEF method until the estimated coefficients and residual covariance matrix converge, asymptotically equivalent estimators to maximum likelihood estimators can be obtained. Therefore, the iterative ZEF method estimators are also invariant to the omitted equation. Thus the method employed in this study.

Figure 1 outlines the test procedure for determining the underlying production technology. Panel A presents the three models, the unrestricted model, a model with nonjoint production process.

\(^9\)This method is also called "Seemingly Unrelated Regression" or SUR for short. See Zellner (1962).

\(^10\)OLS may be applied to the cost function and to each of the cost share equations separately, and the results are consistent. However, these estimates in general will be inefficient because it has ignored the fact that the parameters appearing in the cost function are the same as those appearing in the cost share equations (see Lau, Lin and Yotopoulos, 1975).

\(^11\)Since the cost shares add up to one, the sum of the disturbances in cost share equations is zero at each observation. This implies that the disturbance covariance matrix is singular and non-diagonal, thus it is necessary to omit one of the cost share equations in order to implement the ZEF method.
and a model with separable production process — with time dummies. Panel B gives the same three models minus the time dummies.\(^{12}\)

The testing of hypotheses proceeds as follows: First, the null hypothesis stating that there are no differences in the structure of production among the years is tested, i.e., the unrestricted model without time dummies is tested against the unrestricted model with time dummies. If the null hypothesis is accepted, the succeeding tests of hypotheses will follow and Panel B, i.e., the nonjoint and separable production processes are tested separately against the unrestricted model without time dummies. If, however, the null hypothesis is rejected, the succeeding tests of hypotheses will follow Panel A.

The various hypotheses will be tested using the likelihood ratio statistics:

\[
(25)\ -2 \log \lambda = n (\log(\hat{\gamma}_r) - \log(\hat{\gamma}_u))
\]

where \(\hat{\gamma}_r\) and \(\hat{\gamma}_u\) are the determinants of the restricted and unrestricted estimates of the error variance-covariance matrix, respectively, and \(n\) is the total number of observations. \(-2 \log \lambda\) follows an \(X^2\) distribution with degrees of freedom equal to the number of independent restrictions imposed.

Table 1 lists the variables included in the TMJCF. For the purpose of studying asset diversification, bank loans are classified by securities and maturities. This gives us two alternative ways of defining bank outputs. Aside from the different types of loans, the other outputs considered are represented by the contingency accounts which include trust accounts and unused letters of credits. These are relatively important sources of bank income. The variable input factors included are: deposits (savings and time), borrowed funds, labor, and other operating inputs. The input prices are derived following the method used by Mullineaux (1978).\(^{13}\)

\(^{12}\) Note that symmetry and homogeneity in input prices are imposed on all models.

\(^{13}\) See Lamberte (1983) for the determination of bank outputs and inputs.
### Table 1 — List of Variables Included in the TMJCF

<table>
<thead>
<tr>
<th>Notation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>$C$</td>
<td>Total current operating costs</td>
</tr>
<tr>
<td>$M_1$</td>
<td>Cost share of savings and time deposits</td>
</tr>
<tr>
<td>$M_2$</td>
<td>Cost share of borrowed funds</td>
</tr>
<tr>
<td>$M_3$</td>
<td>Cost share of labor</td>
</tr>
<tr>
<td>$M_4$</td>
<td>Cost share of operating inputs</td>
</tr>
</tbody>
</table>

#### A. Dependent Variables

1. **Bank Outputs**
   - Alt. I
     - $q_1$: Unsecured loans
     - $q_2$: Secured loans
     - $q_3$: Investments
     - $q_4$: Demand deposits
     - $q_5$: Other bank services
   - Alt. II
     - $q_1$: Short-term loans
     - $q_2$: Long-term loans
     - $q_3$: Investments
     - $q_4$: Demand deposits
     - $q_5$: Other bank services

2. **Factor Prices**
   - $P_1$: Price of savings and time deposits
   - $P_2$: Price of borrowed funds
   - $P_3$: Price of labor services
   - $P_4$: Price of operating inputs

3. **Time Dummies**
   - $\gamma_1$: 1 for 1978, 0 otherwise
   - $\gamma_2$: 1 for 1979, 0 otherwise

#### 4. Empirical Findings

Two alternative cost functions which are basically similar in almost all aspects in the manner of classifying loans are considered: Alternative I classifies loans according to securities while Alternative II classifies loans according to maturities. The test procedure outlined in the preceding chapter is applied to each alternative.
To test the various hypotheses mentioned in Section 3, $X^T$ test statistics is utilized. The overall significance level of our series of tests is set at 5 per cent. Table 2 summarizes the results of the tests.

First, we will test the hypothesis that there are no differences in the production structure of commercial banks among the years. That is, the unrestricted model without time dummies will be tested against the unrestricted model with time dummies. This implies that we should test the null hypothesis that

\[
\begin{align*}
&i) \quad \alpha_{y1} = \alpha_{y2} = 0 \\
&(26) \quad ii) \quad p_{i1} = p_{i2} = 0, \quad V_i \\
&\quad iii) \quad \sigma_{j1} = \sigma_{j2} = 0, \quad V_j
\end{align*}
\]

from our TMJCF.

The null hypothesis is accepted in Alternatives I and II, suggesting that the production structure of banks did not differ through the years considered in this study. This was expected since the three years considered are consecutive and too short to allow banks to alter their production structure. In subsequent tests, therefore, the unrestricted model without time dummies is considered as the maintained hypothesis against which restrictive models are tested.

The second hypothesis deals with the nonjointness in the production process. In the context of the TMJCF (equation (12)), the null hypothesis to be tested is

\[
(27) \quad \gamma_{ik} = 0, \quad V_j, \quad k, \quad i \neq k
\]

The null hypothesis is rejected in both alternatives, implying that the production technology of banks is not characterized by nonjointness. Thus, no output-producing department of a bank can operate on its own as if it were an independent firm since its activities influence, and are also influenced by, the activities of the other departments. This finding raises serious doubts about the validity of using simpler models, such as those proposed by Sealey and Lindley (1977) and Bell and Murphy (1968), to the Philippine case. Such models assumed nonjointness in the production process without proper verification of its validity.

Finally, the hypothesis that the bank’s underlying production technology is characterized by separability in outputs will be tested.
### Table 2 — Test Statistics for the Different Models

<table>
<thead>
<tr>
<th>Model</th>
<th>Type of Restriction</th>
<th>No. of Parameter Restrictions</th>
<th>Critical $X^2$ (5%)</th>
<th>ALT. I</th>
<th>ALT. II</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>$X^2$ Test Statistics</td>
<td>Hypothesis Outcome</td>
<td>$X^2$ Test Statistics</td>
</tr>
<tr>
<td>A</td>
<td>Unrestricted Model with Time Dummies</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>B</td>
<td>Unrestricted Model without Time Dummies</td>
<td>18</td>
<td>28.87</td>
<td>11.78</td>
<td>Accept</td>
</tr>
<tr>
<td>C</td>
<td>With Nonjointness</td>
<td>10</td>
<td>18.31</td>
<td>22.37</td>
<td>Reject</td>
</tr>
<tr>
<td>D</td>
<td>With Separability</td>
<td>15</td>
<td>25.00</td>
<td>42.44</td>
<td>Reject</td>
</tr>
</tbody>
</table>

**Note:** Model B is tested against Model A which is the Unrestricted Model with Time Dummies while Model C and Model D are tested against Model B.
It means that we have to test the null hypothesis that

\[(28) \quad \theta_{ij} = 0, \quad V_{i,j}\]

Again, this hypothesis is strongly rejected in both alternatives indicating that models of bank behavior which assume a single homogeneous output must be rejected.

If the technology is separable, the ratio of any two marginal costs, or under perfect competition, the ratio of any two output prices is dependent on the output mix but independent of factor prices or factor intensities. The result showing that separability is decisively rejected implies that the ratios of any two marginal costs are also sensitive to factor prices or factor intensities. Thus, a bank optimization decision depends simultaneously on output and input mix. With this finding, it may be said that the practice of managing simultaneously both outputs and inputs stands out well in contrast to the practice of managing the outputs independently of the inputs. In other words, the decision-making process done at the bank level is still centralized.

The Cobb-Douglas is even more restrictive than any of the models tested since it requires that all second order parameters \(\lambda_{js}, \theta_{ij}\) be zero. Since the model with separability restriction (the most restrictive among the models considered) is rejected, the Cobb-Douglas form will most likely be rejected. This, therefore, seriously limits the claim of Richard and Villanueva (1978) that a Cobb-Douglas function is the underlying technology of the entire banking system. Since they were analyzing only the rural and private development banks of the Philippines, their conclusions could not be extended to the commercial banks.

5. Concluding Remarks

On the basis of the results, we may conclude that the unrestricted model (which does not allow for differences in the structure of production during the period 1977 to 1979) is the model that best describes the production technology of banks. Such model underscores jointness in the production process and centralized decision-making. In other words, banks produce the different financial products jointly, and their choice of output mix is dependent on the input mix.

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14 They were actually using a Cobb-Douglas profit function which is not fitted to the Cobb-Douglas production function.
The determination of the underlying production technology is just the initial stage of the analysis of bank behavior. The production technology contains information which may be utilized to answer important questions, like:

1) How much is the additional cost of producing an extra P1 M of a particular financial product?
2) Can banks realize some savings in costs by expanding their scale of operation (existence of economies of scale)?
3) Can banks realize some savings in costs by expanding the number of financial products produced (existence of economies of scope)?
4) How strong are banks' responses to changes in the prices of their factor inputs, such as deposits and funds borrowed from the Central Bank and from the money market (price elasticities of the demand for factor inputs)?

However, we do not intend to answer them here for lack of space.\(^5\)

\(^5\) These questions are dealt with in Lamberte (1982).
REFERENCES


 Lau, Lawrence J., Lin, Wuu-Tong and Yotopoulos, Pan A. (1974), *Microeconomic Output Supply and Factor Demand Functions in the Agriculture of the Province of Taiwan,* Discussion Paper No. 193 (July), Stanford University, Stanford, California.


