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Cost structure and technical change in rural banking

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ABSTRACT

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Using the multi-product translog cost function, this paper examines the cost structure and technical change occurring within the novel Ghanaian rural banks. The results of the seemingly unrelated error components model indicate substantial unexploited economies of scale in individual products as well as in overall intermediation. There is presence of pairwise complementarity between loans and government securities and between deposits and government securities, but absence of pairwise complementarity between loans and deposits. Overall, capital-using and labour-saving technical change has occurred but efficiency loss in deposit mobilization outweighs the efficiency gains in government securities and lending activities; operation of agencies reinforces the overall efficiency loss. The rural banks must not be hindered from expanding, but in any growth strategy deposit mobilization should take a central position and the cost of operating agencies watched closely.

1. INTRODUCTION

Evaluations of rural credit programs based on studies of the impact of loans on rural borrowers in less developed countries (LDCs) have been criticised by proponents of the 'new view' of rural financial markets (e.g. von Pischke et al., 1983; Adams et al., 1984; Adams, 1988). The main motivation is that the fungibility property of financial assets in general, and that of money in particular, makes it very difficult to isolate the impact a

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loan has on a borrower's actions from other forces affecting borrower behaviour. The detailed data required for such an exercise can be very expensive and are generally non-existent in most LDCs. Little wonder that credit-impact studies have not been able to explain what Adams describes as "the conundrum of successful rural credit programs but failed credit institutions" (1988).

The 'new view' advocates a research focus on the issues of viability of the rural financial institutions. For efficient financial intermediation, an understanding of the cost structure and technical change within the intermediaries is of paramount importance. Estimates of scale economies can inform regulatory policy in respect of the size of the institutions; economies of scope can inform decisions on joint production of services/products; and the nature of technical change can influence the choice of growth strategy.

This paper examines the cost structure of the Ghanaian rural banks (GRBs) for the existence of economies of scale and economies of scope [1] using the multi-product translog cost function, and simultaneously attempts to characterise the interaction of technical change [2] and scale economies. Previous bank cost studies have not characterised technical change in a multi-product framework. The aim is to contribute to the understanding of the performance of LDC formal rural financial institutions producing multiple services/products.

In the rest of the paper, there is an elaboration of the institutional setting of the GRBs in Section 2. The model specification is done in Section 3, and the data used in the analyses are described in Section 4. The estimation procedures are outlined in Section 5, while the empirical results are presented in Section 6. The summary and concluding remarks are recounted in Section 7.

[1] The presence of scale economies would imply that smaller firms or entering firms that operate at a small scale would be at a cost disadvantage compared with larger, established firms. A finding of economies of scope would imply that firms that are specialised in one output/service would be at a cost disadvantage compared with those producing multiple services, and that regulations which restrict the outputs a firm is allowed to produce may lead to inefficient production.

[2] According to Hunter and Timme, "Technical change is said to result when the maximum or efficient output that can be produced from any given set of inputs increases over time due to such factors as experience, increased knowledge, new innovations, and better production techniques" (1986, p. 153).

2. INSTITUTIONAL SETTING OF THE GHANAIAN RURAL BANKS

In diverse attempts to try to meet small-farmer credit needs Ghana, like most LDCs, set up a publicly owned agricultural development bank in the 1960s. The Ghanaian Agricultural Development Bank (GADB) soon suffered the fate of most such specialised farm credit institutions: poor performance attributed to the high cost of making small loans to peasant farmers; the low interest ceilings permitted on these loans which could not cover costs; and borrowers' lack of suitable collateral plus mismanagement of loans. Even in its much-lauded "small farmer group lending program", the GADB was able to reach only 15.7% of the country's estimated small-scale farming population (Owusu and Tetteh, 1982).

The protracted nature of the problems faced by the GADB – negative real interest rates, inadequate staff and branch network that slowed down loan disbursements and curtailed the supervision and collection of loans, lack of supply of modern farm inputs to farmer clients, poor farmer-group leadership and management, and low farm incomes – prompted it to follow the practice of the existing commercial banks of locating branches mostly in the cities and semi-urban areas, and gravitating the loan portfolio towards traders and large-scale farmers who were deemed better risks than small farmers. Consequently, the credit needs of the numerous but scattered small farmers, who are responsible for the bulk of the agricultural production in the country, remained largely unmet by the GADB.

The innovation to attend to the peculiar credit needs of small farmers – small volume but high-risk loans – was the rural bank scheme. Started in 1976, the Ghanaian Rural Banks (GRBs) were designed differently to the GADB. Each rural bank is a 'locally owned and controlled' *unit bank* established for the purpose of mobilising and channelling rural savings for the economic development of its catchment area. [3] The local ownership and control is expected to foster simplified lending procedures and high loan recovery.

The GRBs are presented with both a number of 'start-up' advantages as well as a few strictures. For instance, their minimum required paid-up capital and reserves are about 13% and 90%, respectively, of that required of other banks; the central bank subscribes 33% or 50% of each rural

[3] In the beginning, it was policy to site rural banks not less than 32 km from each other and to restrict lending to clients within a 48 km radius. These restrictions have had to be relaxed as pressure mounted from various towns/villages for their own banks. This could be for reasons as simple as discontent over naming the bank after the town/village in which it is located or siting the bank in a town other than where the paramount chief resides. Sometimes name changing to reflect identification with the whole district or paramountcy was needed before the 'disgruntled' villages or towns would do business with the bank.

bank's capital as preference shares (later to be divested) and confers on itself veto powers therefrom; the GRBs are exempted from corporate tax and dividend payments during the first 5 years of operation; and to ensure broad-based ownership there are maximum ceilings for individuals and institutions with respect to the subscription of the authorised and paid-up capital. Merging of rural banks is prohibited, though a particular rural bank can open agencies within its catchment area. Interest rates were deregulated in September 1987 but, even in the deregulated era, the GRBs are required to comply with sectoral allocation guidelines in respect of their loan portfolio composition. The GRBs are precluded from engaging in foreign operations of any kind.

The organisational structure is deliberately kept simple: a Board of Directors of five to eleven members, one manager who also doubles as secretary to the Board, one accountant, one project officer, one security officer and three to seven clerical and support staff. As and when a bank is able to, it may employ more staff. There are limits to the loan sizes that the manager and the Board can approve. Loans in excess of those limits and any loan application by a Board member have to be sanctioned by the Rural Banking Department of the central bank. This is, ostensibly, to avoid concentration of the loans on a few borrowers and to deter possible abuse of membership on the Board by individuals. Board members are not paid – they receive only a nominal 'sitting allowance' and transport allowance for attending meetings. Though the GRBs are still 'small', their number, average asset size and total assets have steadily risen over the years. In December 1987 there were 107 rural banks; by November 1991 the number had increased to 122.

3. MODEL SPECIFICATION

The paper adopts the widely practised simultaneous estimation of the translog cost function augmented with cost-share equations (e.g. Murray and White, 1983; Gilligan et al., 1984; Hardwick, 1989, 1990). It is assumed that the GRBs minimise costs given input prices and predetermined output quantities. The multi-output translog cost function is given by equation (1) and the cost-share equations are given by (2):

$$\begin{aligned}\ln C = \alpha_o &+ \Sigma_i \alpha_i \ln Q_i + \Sigma_j \beta_j \ln P_j \\ &+ \tfrac{1}{2}\Sigma_i \Sigma_m \alpha_{im} \ln Q_i \ln Q_m + \tfrac{1}{2}\Sigma_j \Sigma_n \beta_{jn} \ln P_j \ln P_n \\ &+ \Sigma_i \Sigma_j \delta_{ij} \ln Q_i \ln P_j + \Theta_T \ln T + \tfrac{1}{2}\Theta_{TT}(\ln T)^2 \\ &+ \Sigma_i \Theta_{TQi} \ln T \ln Q_i + \Sigma_j \Theta_{TPj} \ln T \ln P_j \\ &+ \Sigma_i \Phi_{BQi} \ln B \ln Q_i \qquad (1)\end{aligned}$$

$$S_j = d \ln C / d \ln P_j = P_j X_j / C \qquad \text{for } i, m \text{ and } j, n = 1, 2, 3 \quad (2)$$
$$= \beta_j + \Sigma_n \beta_{jn} \ln P_n + \Sigma_i \delta_{ij} \ln Q_i + \Theta_{TPj} \ln T$$

where C is cost, Q_i's are outputs, P_j's are input prices, and T can be viewed as a proxy of the level of individual bank technology and may be interpreted as a measure of Hicks' neutral technical change; B represents number of banking offices and the $\ln B \ln Q_i$'s represent control variables included to account for other distinguishing features which could affect bank costs the omission of which could bias the analysis of the production relationships; α_o, α_i, β_j, α_{im}, β_{jn}, δ_{ij}, Θ_T, Θ_{TT}, Θ_{TQi}, Θ_{TPj} and Φ_{BQi} are the parameters to be estimated; S_j is the cost share of the jth input (the conditional factor demand function or Shephard's Lemma).

Before the Zellner-type seemingly unrelated regression equations (1) and (2) can be estimated, parameter restrictions must be imposed to ensure the regularity conditions are satisfied. When the regularity conditions – monotonicity,[4] homogeneity in input prices and quasi-concavity[5] – are imposed, estimates of economies of scale, own- and cross-price elasticities, and economies of scope obtained from a cost function should be the same as those obtained from its dual production function (Diewert, 1971; Benston et al., 1982, p. 437). Linear homogeneity in input prices is satisfied when:

$$\Sigma\beta_j = 1 \qquad \Sigma_n \beta_{jn} = 0 \qquad \text{for } j = 1, 2, 3$$
$$\Sigma_j \delta_{ij} = 0 \qquad \text{for } i = 1, 2 \quad \text{and} \quad \Sigma_j \Theta_{TPj} = 0 \qquad (3)$$

The fact that the translog function is a second-order approximation implies Slutsky's symmetry of the form:

$$\alpha_{im} = \alpha_{mi} \quad \text{and} \quad \beta_{jn} = \beta_{nj} \qquad \text{for } i, m = 1, 2 \quad \text{and} \quad j, n = 1, 2, 3 \qquad (4)$$

Imposing concavity on translog cost functions requires inequality restrictions on the parameters and non-linear estimation of the equations (Lau, 1974). Cost function concavity is met when the Hessian matrix $[d^2 \ln C / d \ln P_j \, d \ln P_n]$ or the parameter matrix $[\beta_{jn}]$ is negative semi-definite. Though such restrictions are difficult to impose using most econo-

[4] The monotonicity requirement implies that cost C cannot be negative or decrease when either output Q_i or factor price P_j or both increase in value. It also implies that when cost C is increasing, factor shares or factor demand must be non-decreasing.

[5] Concavity in the production process reflects a situation in which output increases at a decreasing rate (or decreases at an increasing rate) as the level of input is increased. In the context of economic optimisation it is only if the function is concave that input levels that maximise profit (or minimise cost) can be computed from first-order equations.

metric packages (Chalfant et al., 1991 p. 478) various procedures have been attempted. For example, Jorgenson and Fraumeni (1981) imposed negative semi-definiteness on the parameter matrix $[\beta_{jn}]$. But Diewart and Wales (1987) caution that the procedure may result in estimates of own-price elasticities of demand which are too high (in absolute value) and may destroy the flexibility property of the function (1987, p. 48). Generally, however, the price change effects are comparable for both when concavity is and is not imposed.

Humphrey, using the 'mixed estimation' procedure, utilized prior stochastic information on own-price elasticities for cost function concavity (1981a). He showed that imposing the concavity condition left his scale economy estimates and the conclusions derived from them unchanged. Thus, he concluded that the concavity condition may be more important theoretically than it is empirically.

A necessary condition for cost function concavity is that, for all inputs the Allen–Uzawa own-price elasticities of demand should be non-positive (Humphrey, 1981a, pp. 159, 161) or, equivalently, the own-elasticity of substitution should be negative (Bothwell and Cooley, 1982, p. 982). This opens up an alternative approach to the direct imposition of concavity on the estimating equations. Typically, parameters estimated without the concavity condition are inspected to see whether or not the necessary condition for concavity is captured in the data (e.g. Humphrey, 1981b; Hardwick, 1989, 1990). This is the approach followed in this study. It was found that concavity was achieved in 65 out of the 68 observations in the sample.

The other structural restrictions associated with separable, homothetic, homogeneous and/or unitary elastic (Cobb–Douglas) production functions are left as testable hypotheses.

Separability and homotheticity [6] are imposed when:

$$\delta_{ij} = 0 \quad \text{and} \quad \Theta_T = \Theta_{TT} = \Theta_{TQi} = \Theta_{TPj} = 0 \quad \text{for all } i, j \tag{5}$$

By setting:

$$\alpha_{im} = 0 \quad \text{for all } i, m \tag{6}$$

in addition to (5), we can make the production function homogeneous of

[6] Separability and homotheticity would imply: (a) consistent aggregation/indexation of the outputs or of the inputs; (b) independence between the marginal rates of substitution between inputs and levels of the outputs; and (c) independence between measures of economies of scale and scope and the levels of inputs and outputs. A priori, however, economy of scale is a function of both the levels and mix of outputs.

degree $\tau = \Sigma \alpha_i$. If $\tau = 1$, that would imply a Cobb–Douglas type of production function. If in addition we set:

$$\beta_{jn} = 0 \quad \text{for all } j, n \tag{7}$$

the production function will have unitary elasticities of substitution for all pairs of inputs.

To avoid singular disturbance covariance matrix during the actual estimation one of the share equations is dropped. From the system estimates, we can calculate the cost elasticity of the ith output:

$$\begin{aligned} K_i &= \text{d} \ln C / \text{d} \ln Q_i \\ &= \alpha_i + \Sigma_m \alpha_{im} \ln Q_m + \Sigma_j \delta_{ij} \ln P_j + \Theta_{TQi} \ln T + \Phi_{BQi} \ln B \end{aligned} \tag{8}$$

as the 'partial' economies of scale (PES). This is one way [7] of indicating the returns to scale with respect to a single output holding all other outputs constant (Bothwell and Cooley, 1982; Cuevas, 1988; Noulas et al., 1990). There are increasing, decreasing or constant returns to scale with respect to output i as K_i is less than, greater than or equal to 1, respectively. A measure of 'overall' economies of scale (OES) at any particular output combination is given by the elasticity of total cost with respect to composite output:

$$\begin{aligned} \text{OES} &= \Sigma K_i = \Sigma \ \text{d} \ln C / \text{d} \ln Q_i \\ &= \Sigma \alpha_i + \Sigma_i (\Sigma_m \alpha_{im}) \ln Q_i + \Sigma_j (\Sigma_i \delta_{ij}) \ln P_j \\ &\quad + (\Sigma_i \Theta_{TQi}) \ln T + (\Sigma_i \Phi_{BQi}) \ln B \qquad \text{for} \quad i, j, m = 1, 2, 3 \end{aligned} \tag{9}$$

There are increasing, constant and decreasing ray scale economies as OES is less than 1, equal to 1 or greater than 1, respectively. It is assumed that the product mix remains unchanged.

For a translog cost function, cost complementarities (i.e. economies of scope) between the two products Q_i and Q_m can be approximated by:

$$\alpha_i \alpha_m + \alpha_{im} < 0 \tag{10}$$

where $i \neq m$ (Denny and Pinto, 1978; Murray and White, 1983, p. 890; Le Compte and Smith, 1990, p. 1340). [8]

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[7] The alternative indicator, 'product-specific' returns to scale, requires the calculation of the proportion of total cost attributed to output i or the 'incremental cost' of output i. Data limitation precluded the utilization of product-specific measures.

[8] Mester (1987) has argued against this approach to examining scope economies if the cost function is estimated using ordinary least squares (OLS). Le Compte and Smith counter-argue that their qualitative conclusions do not appear to be sensitive to this specification because the results of their 1983 study are consistent with those obtained by Mester using a more general test statistic.

The Allen–Uzawa partial elasticities of substitution can be written as:

$$\sigma_{jn} = \left(\beta_{jn} + S_j S_n\right)/S_j S_n \qquad j \neq n \tag{11}$$

and the own-elasticities of substitution are given by:

$$\sigma_{jj} = \left(\beta_{jj} + S_j(S_j - 1)\right)/S_j^2 \qquad \text{for} \quad j = 1, 2, 3 \tag{12}$$

where the variables are as defined earlier. Additionally, the own-and cross-price elasticities of demand for the inputs (μ_{jj} and μ_{jn}) are calculated using the estimated values of σ_{jn} and σ_{jj} and the factor shares S_j and S_n:

– own-price elasticity $\mu_{jj} = \sigma_{jj} S_j$ (13)

$j \neq n$ for $j, n = 1, 2, 3$

– cross-price elasticity $\mu_{jn} = \sigma_{jn} S_n$ (14)

Following the specification by Hunter and Timme (1986), technical change may be measured by:

$$\begin{aligned} \text{TD} &= \text{d} \ln C/\text{d} \ln T \\ &= \Theta_T + \Theta_{TT} \ln T + \Sigma_i \Theta_{TQi} \ln Q_i + \Sigma_j \Theta_{TPj} \ln P_j \end{aligned} \tag{15}$$

If TD < 0, the same level of output can be produced for a lower level of aggregate costs, i.e. there has been an efficiency gain over time; the converse is true.

The input-use bias in technical change is given by the signs of Θ_{TPj}. If $\Theta_{TPj} > 0$, then share of factor j has increased, so technical change has been factor j-using; $\Theta_{TPj} < 0$ implies factor j-saving bias.

The sign of the coefficient of $\ln T \ln Q_i$ can shed some light on whether or not there has been efficiency gain or loss in producing individual output Q_i. When $\Theta_{TQi} < 0$, then there has been efficiency gain in product Q_i; the converse is true.

On the issue of interaction between technical change and scale economies, Hunter and Timme note (1986, p. 155) that technical change may be associated with production processes that alter extant scale economies. In other words, the scale economy measure given by equation (4) is responsive to technical change. The response of scale economies to changes in technology is measured by:

$$\text{OESD} = \Sigma_i\left(\text{d}^2 \ln C/\text{d} \ln Q_i \ \text{d} \ln T\right) = \Theta_{TQ1} + \Theta_{TQ2} + \Theta_{TQ3} \tag{16}$$

If OESD < 0, then changes in technology increase scale economies i.e., a leftward movement on the (ray) average cost curve. Conversely, if OESD > 0, scale economies are decreased, i.e. a rightward movement on the (ray) average cost curve.

4. THE DATA

In multi-product bank cost studies, theoretical and empirical controversy surrounds the measurement of outputs and cost. On the output metric, the controversy relates to the treatment of deposits as outputs or inputs. Given the theory of production and cost at depository financial institutions advanced by Sealey and Lindley (1977), the view is taken that, deposits, to the extent that their production causes operating expenses, are *technical outputs*. Hence, deposits are considered as outputs in this study.

With regard to cost, some studies utilize operating cost, while others utilize total cost (i.e. operating cost plus interest costs). Benston et al. (1982) explain that employing operating cost implies investigating a bank's ability to produce and service deposits and earning assets using internal resources and management. Using total cost implies that externally purchased funds are significant and an analyst is interested in investigating the relative costs of producing and servicing deposits with internal resources and with external resources. [9] Since the concern in this study is in investigating the rural banks' ability to produce and service deposits and earning assets using internal resources and management, and since a capital market where purchased funds can be obtained by the GRBs is non-existent, it seems inappropriate to use total cost. Rather, operating cost is used in this study.

The data used were extracted from audited annual accounts of 17 rural banks for the years 1984–87. The records were obtained from the central bank. The variables utilized in the analyses are:

(1) *Cost.* The total non-interest operating expenses nett of depreciation and provisions for bad debt (Cuevas, 1988).

(2) *Outputs.* Three outputs (Q_1, Q_2 and Q_3) are utilised in this study. Following Cuevas (1988), Q_1 and Q_2 are used to represent, respectively, the total amount of deposit balances outstanding as of the 31st December of each year and the total value of loans granted during the year. Historically (i.e. 1976–87), government securities (all of short-term duration) have averaged 21% of GRB assets. Q_3 represents the total amount of government securities outstanding as of 31st December of each year.

(3) *Factor prices.* Three inputs were assumed in this study: labour, capital and 'management'. Following the practice in previous studies (e.g. Benston et al., 1982; Hunter and Timme, 1986; Cuevas, 1988), the price for labour, P_1, was defined as the total remuneration and benefits for the staff

[9] Where banks fund a large proportion of their earning assets with non-deposit accounts, using only the operating cost may lead to over-estimation of the economies of scale.

(minus the manager) divided by their total number. The unit price of capital services, P_2, is proxied by the ratio of "depreciation plus rents paid" to "the total value of loans plus deposit balances" (Cuevas, 1988).

P_3 was used to represent cost of management and was proxied by the total expense on the Board of Directors plus the manager's remuneration. One of the most important outputs or performance variables is amount of deposits mobilized. In this, all staff and Board members participate one way or the other. It is of particular interest to estimate the price responsiveness of the manager and Board members (as a group) in order to inform the policy of using monetary incentives to elicit from those people greater output in general and expanded deposit mobilization activities in particular.

(4) *Level of technology.* Technology, represented by T, was specified in two different ways to see how the results might depend on the specification. In one instance, T was proxied by the age of the bank (Bothwell and Cooley, 1982). In an alternative specification, T was assigned the values 1, 2, 3, 4 for the years 1984 to 1987 as the 'trend term' (Hunter and Timme, 1986).

(5) *Control variables.* The often-used control variables in empirical studies include: number of branches; average loan size; average deposit size; and, to a lesser extent, portfolio risk and growth in total assets. Data constraints [10] allowed the use of only number of branches, which is proxied by number of banking offices, variable B. Multiple bank offices, or the operation of agencies, presumably lead to increases in individual outputs. Hence, the variable B enters the cost function in interactive form with the output levels as $\ln B \ln Q_1$, $\ln B \ln Q_2$ and $\ln B \ln Q_3$. The implication is that both the measure of scale economies and marginal costs of production depend on the number of banking offices. This method of incorporating B in the analysis (rather than expanding it as done with the output and input price variables, Q_is and P_js, respectively, in the translog function) conserves degrees of freedom. Because the net effect of the variable B through a particular output Q_i could either be cost-decreasing or cost-increasing, there are no a priori expectations concerning the signs of the coefficients.

The summary statistics of the data are reported in Table 1. The monetary values are in millions of cedis at 1987 prices.

[10] All the loan and deposit accounts are generically small in size, thus minimizing bias in the results due to size-related transactions costs. Besides, some of the banks did not record the numbers of accounts for some of the years, and not all the banks itemized the allowance for 'bad debt' for all the years.

TABLE 1

Summary statistics of the data

Variable	Mean	SD	Minimum	Maximum
C (operating costs)	2.929	2.586	0.459	16.432
Q_1 (deposits)	30.531	18.148	5.723	76.750
Q_2 (loans)	15.324	12.238	0.903	53.725
Q_3 (government securities)	6.552	5.773	0.001	23.800
P_1 (price of labour)	0.094	0.091	0.017	0.580
P_2 (price of capital)	0.012	0.009	0.001	0.041
P_3 (management costs)	0.139	0.227	0.014	1.164
AGE	4.5	2.668	1.0	11.0
T	2.5	1.126	1.0	4.0
S_1	0.433	0.101	0.192	0.598
S_3	0.042	0.027	0.011	0.142
B	1.985	1.140	1.0	5.0

Monetary variables are in millions of constant cedis.
AGE = age of bank in years.
T = 'time-trend' within the time series data set.
S_1 = share of labour in operating costs.
S_3 = share of management in operating costs.
B = number of banking offices.

5. ESTIMATION PROCEDURES

The pooled cross-sectional and time series data may contain significant bank differences as well as time differences in input mixes, output mixes and production efficiency. Should that be the case, the disturbances in the model would have an *error components structure* that needs to be allowed for in the estimation process. Avery's (1977) seemingly unrelated error components model allows the error term of each of the equations in the system to be decomposed into three stochastically independent and additive components: the bank-specific, the time-specific and the bank-time interactive components. For the tth observation on bank b, the error terms are given by:

$$u_{bt} = \mu_b + v_t + w_{bt} \qquad b = 1, \ldots, 17 \quad t = 1, \ldots, 4 \tag{17}$$

where $\mu_b \approx N(0, \sigma_\mu^2)$, $v_t \approx N(0, \sigma_v^2)$, $w_{bt} \approx N(0, \sigma_w^2)$. The variance components are assumed independent of one another as well as temporally and cross-sectionally independent. The procedure advanced by Amemiya (1971) was used to estimate the variance components and Baltagi's (1980) estimator of the coefficient vector was employed. The analysis was done with and without control variables, [11] yielding four models:

[11] The analyses were done using matrix manipulation commands of the SHAZAM computer program on the Mainframe at the University of New England's Computer Centre.

TABLE 2

Estimated coefficients of the translog cost function

Parameter		Model Ia		Model Ib		Model IIa		Model IIb	
		Coef.	*t*-ratio	Coef.	*t*-ratio	Coef.	*t*-ratio	Coef.	*t*-ratio
α_0	intercept	2.171	*3.14*	4.001	*5.48*	9.718	*1.58*	0.305	*0.08*
α_1	$\ln Q_1$	1.491	*2.82*	−1.034	*−1.82*	0.570	*0.97*	−0.791	*−1.27*
α_2	$\ln Q_2$	0.244	*1.48*	−0.361	*−2.60*	0.144	*0.80*	−0.192	*−1.26*
α_3	$\ln Q_3$	−0.473	*−2.46*	0.959	*4.56*	−0.003	*−0.01*	1.023	*4.17*
β_1	$\ln P_1$	0.471	*6.60*	0.726	*11.40*	0.571	*7.44*	0.718	*11.63*
β_2	$\ln P_2$	0.170	*2.50*	0.251	*3.97*	0.095	*1.47*	0.256	*4.28*
β_3	$\ln P_3$	0.359	*12.24*	0.022	*1.34*	0.334	*10.03*	0.026	*1.61*
α_{11}	$(\ln Q_1)^2$	−0.751	*−3.21*	0.308	*1.23*	−0.308	*−1.20*	0.345	*1.27*
α_{22}	$(\ln Q_2)^2$	0.241	*3.53*	0.010	*0.12*	0.166	*2.19*	−0.087	*−0.91*
α_{33}	$(\ln Q_3)^2$	−0.014	*−0.89*	0.127	*7.29*	0.018	*0.96*	0.123	*6.07*
α_{12}	$\ln Q_1 \ln Q_2$	−0.122	*−1.54*	0.074	*0.99*	−0.074	*−0.85*	0.108	*1.32*
α_{13}	$\ln Q_1 \ln Q_3$	0.201	*2.39*	−0.353	*−3.90*	0.023	*0.24*	−0.393	*−3.89*
α_{23}	$\ln Q_2 \ln Q_3$	−0.015	*−0.83*	0.048	*2.52*	−0.010	*−0.52*	0.059	*3.15*
β_{11}	$(\ln P_1)^2$	0.059	*5.71*	0.072	*6.70*	0.045	*4.14*	0.067	*6.22*
β_{22}	$(\ln P_2)^2$	0.031	*2.81*	0.054	*5.25*	0.029	*2.82*	0.056	*5.61*
β_{33}	$(\ln P_3)^2$	0.032	*11.76*	0.033	*12.56*	0.027	*10.16*	0.036	*13.78*
β_{12}	$\ln P_1 \ln P_2$	−0.029	*−2.82*	−0.047	*−4.57*	−0.024	*−2.31*	−0.044	*−4.34*
β_{13}	$\ln P_1 \ln P_3$	−0.030	*−9.05*	−0.025	*−7.87*	−0.021	*−7.81*	−0.023	*−7.71*
β_{23}	$\ln P_2 \ln P_3$	−0.002	*−0.63*	−0.007	*−3.00*	−0.006	*−2.48*	−0.013	*−5.56*
δ_{11}	$\ln Q_1 \ln P_1$	0.031	*1.30*	0.006	*0.25*	−0.009	*−0.40*	−0.028	*−1.21*
δ_{12}	$\ln Q_1 \ln P_2$	−0.039	*−1.53*	−0.011	*−0.45*	−0.005	*−0.24*	0.026	*1.12*
δ_{13}	$\ln Q_1 \ln P_3$	0.007	*1.15*	0.005	*0.82*	0.014	*2.43*	0.001	*0.23*
δ_{21}	$\ln Q_2 \ln P_1$	0.009	*0.61*	0.004	*0.26*	−0.008	*−0.51*	−0.024	*−1.45*
δ_{22}	$\ln Q_2 \ln P_2$	−0.003	*−0.17*	0.003	*0.22*	0.014	*0.83*	0.030	*1.76*
δ_{23}	$\ln Q_2 \ln P_3$	−0.007	*−1.61*	−0.008	*−1.97*	−0.006	*−1.37*	−0.006	*−1.42*
δ_{31}	$\ln Q_3 \ln P_1$	0.016	*3.46*	0.019	*4.25*	0.013	*2.78*	0.017	*3.87*
δ_{32}	$\ln Q_3 \ln P_2$	−0.016	*−3.31*	−0.020	*−4.18*	−0.012	*−2.56*	−0.018	*−3.81*
δ_{33}	$\ln Q_3 \ln P_3$	0.0002	*0.15*	0.0005	*0.42*	−0.0005	*−0.42*	0.0005	*0.42*
θ_T	$\ln T$	0.010	*0.04*	0.538	*2.06*	−12.76	*−1.58*	0.794	*0.18*
θ_{TT}	$(\ln T)^2$	−0.283	*−2.65*	−0.260	*−1.27*	7.014	*1.75*	1.653	*0.56*
θ_{TQ1}	$\ln T \ln Q_1$	0.203	*1.68*	0.291	*2.22*	0.203	*2.04*	0.173	*1.45*
θ_{TQ2}	$\ln T \ln Q_2$	−0.115	*−2.08*	−0.110	*−1.47*	−0.097	*−1.66*	−0.262	*−3.62*
θ_{TQ3}	$\ln T \ln Q_3$	−0.087	*−1.59*	−0.217	*−3.41*	−0.070	*−1.85*	−0.014	*−0.28*
θ_{TP1}	$\ln T \ln P_1$	−0.071	*−3.10*	−0.141	*−5.46*	−0.013	*−0.61*	−0.102	*−5.02*
θ_{TP2}	$\ln T \ln P_2$	0.078	*3.34*	0.135	*5.41*	0.011	*0.63*	0.096	*5.81*
θ_{TP3}	$\ln T \ln P_3$	−0.007	*−1.00*	0.006	*0.93*	0.002	*0.20*	0.006	*0.66*
Φ_{BQ1}	$\ln B \ln Q_1$			−0.265	*−3.28*			−0.300	*−3.40*
Φ_{BQ2}	$\ln B \ln Q_2$			0.148	*1.67*			0.299	*3.30*
Φ_{BQ3}	$\ln B \ln Q_3$			0.373	*5.76*			0.241	*3.16*
Goodness of fit									
McElroy's R^2		0.622		0.682		0.993		0.521	
McElroy's F		5.11		6.13		430.33		3.12	
d.f.		49; 152		52; 149		49; 152		52; 149	
Chi-square (5%)		1.44		1.44		1.44		1.44	

- Model Ia: $T=$ age of bank, no control variables
- Model Ib: $T=$ age of bank, with control variables
- Model IIa: $T=$'time trend', no control variables
- Model IIb: $T=$'time trend', with control variables.

6. EMPIRICAL RESULTS

6.1 *Regression coefficients*

The estimates of the coefficients and their t-ratios from the four models are reported in Table 2. Fifty-six percent, 62%, 36% and 51% of the coefficients in Models Ia, Ib, IIa and IIb, respectively, are significant. Different specifications of T and/or inclusion/non-inclusion of control variables lead to inconsistent signs for some of the coefficients. However, the implications will be relegated to the section dealing with discussion of results.

Estimates of McElroy's (1977) system R^2 and F statistics for restricted error components model are reported for each of the models. (The results for Model IIa seem inexplicably high.) The F-statistics lead to the rejection of the null hypothesis that all the coefficients, with the exception of the intercept, are zero in each of the models.

A test of significance of the variance components with Breusch and Pagan's (1980) LM statistic (Table 3) indicates significant error components structure in each of the models. In Table 3, the LM statistics to test for separability and homotheticity, homogeneous production function, and unitary elasticity of substitution lead to the rejection of those hypotheses in all the models. These results buttress the choice of flexible functional form to model financial firms.

6.2 *Economies of scale and scope*

The estimated measures of overall economies of scale (OES) and partial economies of scale (PES) for the 'average', and 'large' banks are reported in Table 4. The average bank is characterised by the mean values of the variables. Following Mester (1987), the large bank is characterised by the sample maximum values of the outputs and the mean values of the other variables. [12] Since the OES values for all the models are less than 1 (and

[12] Characterizing the 'small' bank with the sample minimum values of the outputs and the mean values of the other variables led to perverse results, so the 'small' bank is ignored in subsequent discussions.

TABLE 3

Test statistics of various hypotheses

Hypothesis and test statistic used	Model			
	Ia	Ib	IIa	IIb
Variance components (Ho: $\sigma_\mu^2 = \sigma_\upsilon^2 = 0$)				
Breusch and Pagan's LM statistic	68.18	480.80	540.34	610.98
Critical chi-square (2 d.f., 5%)	5.99	5.99	5.99	5.99
Separability and homotheticity				
LM statistic	60.60	170.92	112.89	102.94
Degrees of freedom	15	18	15	18
Critical chi-square (5%)	25.00	28.87	25.00	28.87
Homogeneous production function				
LM statistic	98.52	301.47	126.16	182.36
Degrees of freedom	20	23	20	23
Critical chi-square (5%)	31.41	35.17	31.41	35.17
Unit elasticity of substitution				
LM statistic	358.58	567.22	388.30	482.66
Degrees of freedom	25	28	25	28
Critical chi-square (5%)	37.65	41.34	37.65	41.34

some are negative) for the average and large banks, there is unanimity among the models that there are substantial economies of scale in overall financial intermediation. A negative (positive) value of OES or of PES implies marginal costs are decreasing (increasing). As Bothwell and Cooley note, decreasing marginal costs are not inconsistent with increasing returns to scale (1982, p. 981). The overall result is that all the banks from the sample are so small in size that they represent points only on the downward-sloping portion of an expected U-shaped average cost surface.

The PES value for each of the three outputs is less than 1 in all the models for the two bank sizes, indicating increasing returns to scale in individual outputs. The specification of T does not seem to have much impact on the scale measure. The picture that emerges is that there are substantial economies of scale in individual activities as well as in overall intermediation. On the basis of cost reduction, the GRBs can gain from getting bigger or from consolidation so they must not be hindered from expanding.

With regard to cost complementarity, the measures of economies of scope estimated with equation (5) for various output pairs in all the models are also reported in Table 4. Contrary to expectation, all the models indicate deposits and loans to be substitutes and loans and government securities to be complements. The combined implication is that there are no cost savings from jointly mobilizing deposits and extending loans but

TABLE 4

Estimates of economies and elasticities [a]

	Model Ia		Model Ib		Model IIa		Model IIb	
Economies of scale								
'Average' bank								
Partial – Q_1	−0.644	*−5.39*	−0.161	*−1.05*	−0.323	*−2.28*	−0.054	*−0.30*
Partial – Q_2	0.284	*4.18*	−0.067	*−0.78*	0.148	*1.80*	−0.202	*−2.01*
Partial – Q_3	0.051	*0.81*	0.092	*1.55*	0.0006	*0.01*	0.253	*3.75*
Overall (OES)	−0.309	*−4.17*	−0.136	*−1.59*	−0.175	*−1.67*	−0.003	*−0.03*
'Large' bank								
Partial – Q_1	−1.230	*−6.28*	−0.240	*−0.96*	−0.672	*−2.93*	−0.107	*−0.38*
Partial – Q_2	0.454	*4.14*	0.075	*0.53*	0.275	*2.20*	−0.135	*−0.81*
Partial – Q_3	0.199	*2.02*	−0.010	*−0.10*	0.033	*0.29*	0.123	*1.04*
Overall (OES)	−0.578	*−4.15*	−0.175	*−1.27*	−0.364	*−2.09*	−0.119	*−0.68*
Economies of scope								
Q_1 Q_2	0.242	*0.76*	0.447	*1.69*	0.008	*0.05*	0.259	*1.41*
Q_1 Q_3	−0.504	*−1.34*	−1.344	*−2.08*	0.021	*0.27*	−1.202	*−1.64*
Q_2 Q_3	−0.131	*−1.30*	−0.299	*−1.95*	−0.010	*−0.31*	−0.137	*−0.85*
Elasticity of substitution								
Lab. & Cap.	0.241		0.219		0.247		0.223	
Lab. & Manage.	−0.001		−0.0007		−0.0003		−0.0005	
Cap. & Manage.	0.002		0.001		0.001		0.0007	
Lab. ['own']	−0.186		−0.173		−0.201		−0.179	
Cap. ['own']	−0.219		−0.195		−0.220		−0.193	
Manage. ['own']	−0.008		−0.007		−0.014		−0.004	
Own-price elasticity								
Labour	−0.081		−0.075		−0.087		−0.077	
Capital	−0.115		−0.102		−0.116		−0.101	
Management	−0.0004		−0.0003		−0.0006		−0.0002	
Cross-price elasticity								
Lab. w.r.t. Cap.	0.126		0.115		0.130		0.117	
Cap. w.r.t. Lab.	0.104		0.095		0.107		0.096	
Lab. w.r.t. Manage.	−0.00005		−0.00003		−0.00001		−0.0002	
Manage w.r.t. Lab.	−0.0005		−0.0003		−0.0001		−0.002	
Cap. w.r.t. Mgt.	0.00007		0.00005		0.00006		0.00003	
Manage. w.r.t. Cap.	0.0009		0.0006		0.0007		0.0004	

[a] *t*-ratios for the scale measures are shown in italics. Q_1 = deposits; Q_2 = loans; Q_3 = government securities.

there are cost savings from jointly producing loans and government securities.

The absence of pairwise complementarity between deposits and loans suggests that it is not the consideration of cost savings that motivates their joint production. The lack of cost savings from the joint production of deposits and loans would seemingly undermine the desirability of 'de-specializing' rural financial institutions of LDCs. This finding then prompts a scrutiny of the efficiency of deposit mobilization and lending activities before any recommendation can be made. This is done in the next section.

The cost savings from the joint production of loans and government securities may stem from the risk reduction possible from diversifying between government securities (with near-zero default risk) and loans (which are characterised by greater-than-zero default risk). Concerning deposits and government securities, all the models except Model IIa gave the expected verdict of cost complementarity. [13] Ignoring the result from Model IIa, we can conclude that cost savings from the joint production of deposits and government securities are warranted.

6.3 *Technical change and multiple offices*

The solution values of equation (15) or TD values for Models Ia, Ib, IIa and IIb at the mean values of the variables were calculated to be -0.362, 0.158, -6.057 and 1.963, respectively. The meaning of the alternating signs is that, when number of banking offices are incorporated as interactive variables in the estimations, the conclusion about technical change switches from overall efficiency gain to overall efficiency loss. This happens whether technology is proxied by age of bank or the term trend. An examination of the constituent parameters should throw more light on this phenomenon.

With respect to the input-use bias of technical change, the signs of the Θ_{TPj}'s in all the models indicate that the technical change is labour-saving and capital-using (significant in all the models except in IIa) and neutral with respect to management.

With respect to the efficiency gain/loss in the production of individual products, the signs of the Θ_{TQi}'s (with no discernible pattern to their statistical significance) in all the models indicate there has been efficiency gain in lending activities (Q_2) and government securities (Q_3) but efficiency loss in deposit-taking activities (Q_1). Herein lies a plausible explanation of the absence of pairwise complementarity between deposits and loans observed in Section 6.2. Apparently, the loss in efficiency in deposit mobilization outweighs the efficiency gain in lending. Attention is therefore drawn to the relative slack in deposit mobilization by the rural banks. A

[13] This discrepant result of Model IIa perhaps underscores a potential problem with that particular model. It will be recalled that only 36% of the estimated coefficients in that model are significant yet the McElroy system R^2 is uncharacteristically high. This observation prompts the caveat that the results of a model using 'time-trend' without control variables must be treated with extra caution.

contervailing feature, however, is that the efficiency gain in government securities seems to outweigh the efficiency loss in deposit mobilization.

Overall, however, when the number of banking offices is not taken into account the analyses indicate that there has been an efficiency gain. A closer scrutiny of the parameters reveals that this comes about because the efficiency gains in loans and government securities outweigh the efficiency loss in deposit mobilization.

If the incorporation of the variable B evinces overall efficiency loss the inescapable deduction is that when the number of banking offices is taken into account the efficiency loss in deposit mobilization outweighs the efficiency gains in loans and government securities. It seems that the operation of agencies leads to cost increases in deposit mobilization that eclipse the concurrent cost savings in lending activities and government securities. This is borne out by the signs of the coefficients of the control variables (i.e., the Φ_{BQi}'s) in Models Ib and IIb (Table 2). When the coefficient of a control variable takes on a positive (negative) sign it means banks with agencies have experienced efficiency gain (loss) with respect to the relevant output compared to banks with no agencies operating at the same cost. The results indicate that having or opening agencies simultaneously reinforces the previously observed efficiency loss in deposits (Q_1) more intensively than the combined efficiency gains in loans (Q_2) and government securities (Q_3).

This raises two broad issues. Firstly, the criteria for opening and evaluation (if any) of performance of agencies with regard to deposit mobilization are called into question. On the basis of the cost findings, this study would urge rationalization of existing agencies and for the central bank to tighten the criteria for opening agencies. Second, the number of banking offices as a variable in bank modelling has been shown to be of such critical importance that it cannot be ignored or over-emphasized.

The second point is further underscored by the estimated responses of scale economies to changes in technology. For instance, the solution values of equation (16) or the OESD values for Models Ia, Ib, IIa and IIb are 0.001, -0.036, 0.036 and -0.103, respectively. It is of some worth to indicate that in this study technology, whether proxied by age of bank or time-trend, is basically a *time* concept. The positive OESD values imply that changes in production processes over time have led to a rightward movement on an (imaginary) average (ray) cost curve. In other words, the GRBs have been getting bigger in real (constant) prices and have been able to exploit the inherent scale economies or that their rate of growth in deposits exceeded the rate of inflation during the study period. These conclusions are drawn from the models that do not contain the 'number of banking offices' variable, i.e., Models Ia and IIa. The OESD values for Models Ib and IIb are negative, implying a reversal of the sanguine conclusions about the interaction of technical change and scale economies when the 'number of banking offices' variable is incorporated in the analysis. Inflation in Ghana for the study period averaged 40% per annum. Growth in real deposits *did not* exceed the rate of inflation so, in constant prices, the GRBs have been getting smaller. Leaving out the number of banking offices leads to erroneous characterization of the interaction between technical change and scale economies.

6.4 *Elasticities of factor demand and substitution*

The set of Allen–Uzawa elasticities of substitution and own- and cross-price elasticities of demand for the inputs are presented in Table 4. The own-price elasticities of demand and the own-elasticity of substitution for the three inputs are negative in all the models. Thus, the necessary condition for concavity of the cost function in input prices is satisfied (see Section 3).

The models reveal that demand for each input is inelastic. However, capital is comparatively the most price-responsive and management the least price-responsive. All the models indicate labour and capital to be substitutes, [14] capital and management also to be substitutes but labour and management to be complements. The observed capital-using technical change (Section 6.3), the relative price responsiveness of capital combined with the substitutability between capital and labour or management (though weak) augur well for the future. The Ghanaian rural banks (GRBs) are manifesting a propensity for increasing utilization of modern facilities used in banking, e.g. calculators, computers and other communication facilities.

In all the models the cross-price elasticities of demand took signs consistent with the partial elasticities of substitution. The signs of the parameters are consistent with a priori expectations but the magnitudes are rather low, indicating the relationships are weak. This may be partly due to the simple nature and restricted set of financial services/products that these novel banks are capable of offering. A notable policy implication of this is that factor-price adjustment can only have paltry impact on levels and combinations of factor utilization.

[14] Rounding to 1 decimal place, the estimate of the Allen–Uzawa elasticity of substitution between labour and capital comes to 0.2 in all the models. The only available published comparable figure is 0.6 that Cuevas estimated for Honduran agricultural development banks. Cuevas commented that his estimate was low but did not have any other to compare it with.

7. SUMMARY AND CONCLUDING REMARKS

Very few formal rural financial institutions in LDCs were designed originally to mobilise savings and operate without concessionary interest rates. In this paper, a multi-output translog cost function with error-components structure estimated simultaneously with derived input cost-share equations has been used to examine cost-output relationships and characterise technical change for a sample of such institutions – the Ghanaian rural banks.

Estimated measures of economies of scale indicate the existence of substantial unexploited economies of scale in deposits, government securities and loans as well as in overall financial intermediation. The rural banks must not be hindered from expanding. Demand for each input is inelastic, with capital being relatively the most price-responsive and 'management' the least price-responsive. Substitutability between inputs is quite weak, suggesting that factor-price adjustment may be inconsequential to the levels and combinations of labour, capital and 'management' utilization.

On the issue of the desirability of rural financial institutions producing multiple services rather than specializing in lending, this study reports of cost complementarity between loans and government securities. This means there are cost savings from the joint production of those two products. The absence of pairwise complementarity observed between deposits and loans indicates that non-cost motivations such as the fostering of financial intermediation/development, customer convenience and diversification to reduce risk may be more important in explaining the joint production of loans and deposits.

The empirical results further indicate that capital-using and labour-saving technical change affecting government securities and lending activities has occurred. Concurrently, there has been efficiency loss in deposit mobilization though, nominally, deposits have grown. Perhaps, this is due more to the growth in deposits lagging behind the rate of inflation. The operation of agencies reinforces both the efficiency gains in government securities and lending activities and the efficiency loss in deposit-taking activities. The net effect is overall efficiency loss. In any growth strategy, emphasis must primarily be placed on deposit mobilisation ahead of loans and government securities. There is an apparent need to tighten the criteria for approving opening of agencies. Costs can be saved if the agencies already in operation are re-appraised critically with a view to shutting down the 'unviable' ones. Finally, the importance of integrating the number of banking offices/branches as an explanatory variable in bank cost modelling is emphasized. These conclusions are drawn with due recognition of the smallness of the sample size.

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