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SCALE ECONOMIES AND COST SUBADDITIVITY OF PRIMARY AGRICULTURAL COOPERATIVE BANKING IN KOREA

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I. Introduction

The concerns about banking production efficiency increased in Korea as financial liberalization progressed. With given technology, producing financial services at the minimum cost level is consistent with social welfare maximization as well as the viability of financial institutions. This study was motivated from the recent issues about whether the banking sector of primary agricultural cooperatives (PACs) of Korea is efficient in the sense of production scale and the condition of rural financial markets. There is a view that rural PACs are too small to exhaust scale economies since the market area of a PAC is limited to an administrative district. Furthermore, it is argued that the market area is too small to be competitive so that rural financial institutions should be consolidated; that is, there exists natural monopoly in rural financial markets. This argument contradicts with a view that the rural financial markets should be competitive to provide rural consumers with diverse services with high quality. This study tried to test these issues by using multiproduct cost function and the concepts of scale economies and cost subadditivity of the banking of PACs.

The PACs are the most important rural financial institutions in the country, and they perform also very a diverse set of economic businesses such as marketing of farm products, purchasing farm

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inputs and consumer goods, operating cooperative insurance, etc. The banking business of PACs is recognized as a key business for the viability of PACs since it is major income source of PACs. The performance of banking business must be affected by the other activities of PACs. However, it is not easy to treat entire activities in exploring banking cost structure by using econometric method with limited sample size. Thus, the banking sector was separated from other activities by using an index as will be explained in section III.

This study follows the intermediation approach that regards deposits as outputs, which reflects a value added criterion and represents the production structure of banking. This approach measures output in the dollar value of loans and deposits rather than the number of accounts. Total costs including both operating costs and interest expenses are treated as dependent variables; thus, the input characteristics of deposits are also specified through their associated interest expenses in total costs (Triplett;Wykoff; Humphrey). This approach is known to be appropriate in analyzing the viability of a bank (Berger, Hanweck, and Humphrey, 1987).

However, when the intermediation approach is used and financial institutions treat loans that are supplied, at cheap price, by other institutions such as government or foreign institutions, measured scale economies should be carefully interpreted since interests paid on the cheap funds may hide scale efficiency of the financial institutions. The average costs of mixing funds, internally mobilized deposits and externally supplied cheap funds, become lower and approach marginal costs as dependency on the outside cheap funds increases (Park). This relationship means that the financial institution looks under no scale economies; that is, average costs are near to marginal costs. If the share of interest costs to total costs are very high, no scale economies can be appeared in wide range. Since it is not reasonable that the external funds affect scale economies through cheap interest, we need to specify the econometric model to deal with this problem. Hunter, Timme, and Yang (1989, 1990) specified their models to solve this problem by dropping the interaction terms of purchased fund prices and outputs. This method excludes only price effect of purchased funds on measured scale economies but there still remains interest payment effect of cheap purchased funds on total costs. This study tried to solve this problem by excluding the partial effect of policy loans to scale economies, which is different from Hunter, Timme, and Yang's or Berger, Hanweck, and Humphrey's specification that excludes only price term of purchased funds.

The translog cost function was used to evaluate the cost surface structure of PACs. The translog cost function is known to have many desirable properties (Caves, Christensen, and Trethway; Guilkey, Lovell and Sickles; Mester). However, the translog functional form does not allow zero output so that measuring economies of scope (SCOPE) or product specific economies (PSCE) is not appropriate. In fact, when zero output is not observed in a sample, the estimated results of SCOPE or PSCE are questionable since exploration errors cannot be avoid.

In measuring scale economies, this study used Baumol, Panzar, and Willig's ray scale economies (RSCE) and expansion path cost efficiency (EPCE) developed by the authors (Park; Park and Meyer). RSCE measures overall scale economies under the assumption that the firm increases production scale with a constant product mix. EPCE is an alternative measure of the expansion path scale economies (EPSCE) developed by Berger, Hanweck and Humphrey (1986, 1987) that measures scale economies when the firm increases the production scale with allowing the changes in product mix. It was found that the measure of EPSCE is not consistent in the general sense (Park; Park and Meyer). EPCE applies the idea of examining concavity of a function into measuring cost changes under the same assumption as EPSCE. In measuring cost subadditivity the expansion path subadditivity (EPSUB) developed by Berger, Hanweck and Humphrey (1986, 1987) was used.

In the following section, the measurements of scale economies and cost subadditivity as mentioned above will be interpreted. Interpretation of data and model specification will be presented in the third section and estimation process and results will be provided in the fourth section. In the fifth section, the limitation and policy implications of the study will be discussed as concluding remarks.

II. Measurements of Multiproduct Scale Economies and Cost Subadditivity

Berger, Hanweck, and Humphrey (1986, 1987) defined that a firm is competitively viable when its costs do not exceed the scale-adjusted cost of competitors with the same product mix. Formally it is defined as

$$C(Q) \leq 1/t\Sigma_i C(Q^i). \tag{1}$$

where Q is an output vector, C(Q) is the cost function, Q^i is any nonnegative output vector. For any positive number t, $\Sigma_i Q^i = tQ$. Competitive viability is equivalent to cost subadditivity if and only if t = 1. That is, costs are subadditive if the division of an output bundle among two or more firms cannot produce the same bundle as cheaply as one firm; thus, the firm producing Q is competitive viable.

Ray Average Scale Economies (RSCE): RSCE measures overall ray scale economies under the assumption that a multiproduct firm increases scale with constant product mix. It is defined as the sum of the cost elasticity of individual output measured along a ray. Let an output vector $Q = (q_1, q_2, ..., q_n)$. Then

$$RSCE(Q) = \partial lnC(tQ)/\partial lnt\Big|_{t=1} = \Sigma_i \partial lnC(tQ)/\partial lnq_i \tag{2}$$

If RSCE(Q) = 1, there are no scale economies so that the firm is competitively viable; but if RSCE(Q) is less than or greater than one, then there are economies or diseconomies when outputs are changed equiproportionately.

Expansion Path Scale Economies (EPSCE): A firm may grow along an expansion path with a varying product mix; for instance firm A expands into firm B with different product mix from firm A. To measure the cost change effects along the expansion path AB, Berger et al. used equation (3), the elasticity of incremental cost with respect to a changing product mix as scale increases, and named this measure the expansion path scale economies (EPSCE):

$$\begin{aligned} EPSCE(Q^A, Q^B) &= \frac{\partial ln[C(Q^A + t(Q^B - Q^A) - C(Q^A)]}{\partial lnt\Big|_{t=1}} \\ &= \sum \frac{[Q_i^B - Q_i^A)/Q_i^B]}{[C(Q^B) - C(Q^A)]/C(Q^B)} * \frac{\partial lnC(Q^B)}{\partial ln Q_i} \end{aligned} \tag{3}$$

Q^A and Q^B are the output vectors of firms A and B respectively. Berger et al. interpreted that if EPSCE (Q^A, Q^B) is greater than one, then there are diseconomies on the ray AB. If firm A is competitively viable, then firm B is viable if and only if EPSCE (Q^A, Q^B) = 1. If EPSCE (Q^A, Q^B) is less than one, firm B would be driven out by a larger firm with the same product mix. RSCE is a special case of EPSCE.

However, there are problems in the application of this measurement (Park; Park and Meyer). First, the interpretation of the inequality sign given by the authors should be reversed. The term of the numerator $(q_i^B - q_i^A)/q_i^B$ represents an increasing rate of output and the term of the denominator $[C(Q^B)-C(Q^A)]/C(Q^B)$ implies an increasing rate of costs along the expansion path. Let us ignore the last term, the cost elasticity of the individual outputs, for a while. If the increasing rate of outputs is greater than that of costs, economies of scale must exist, so EPSCE(Q^A, Q^B)>1. This relationship means that Berger et al. interpreted the meaning of EPSCE in the opposite direction.

Second, EPSCE cannot consistently explore the existence of scale economies along the expansion path AB because of the weighted term, $\ln C(Q^B)/\ln q_i$, even though the inequality sign is corrected. If firm B is under scale economies, the sum of the elasticity with respect to each output, RSCE(Q^B), is less than 1. In this case, the weighted term, the cost elasticity of output, reduces the magnitude of the ratio of the increasing rate of output to that of cost. Even if the increasing rate of output is greater than that of cost, EPSCE can be less than 1 if the degree of RSCE of the larger firm is sufficiently small. That is, the measured EPSCE may imply diseconomies of scale in spite of that there exist scale economies in truth. Therefore, an alternative measure is needed to capture the cost change effect on the expansion path AB.

Expansion Path Cost Efficiency (EPCE): As the alternative measure of EPSCE, EPCE was suggested by Park and Park and Meyer. Let a cost funtion be f(Q, W) = f(x) as shown in Figure 1 and let firm A and firm B have independent variable bundles x^* and y, respectively. Then total costs will be A and B on the cost surface. We can obtain a tangent plane of point A on the cost function by taking the derivative at A with respect to the independent variables

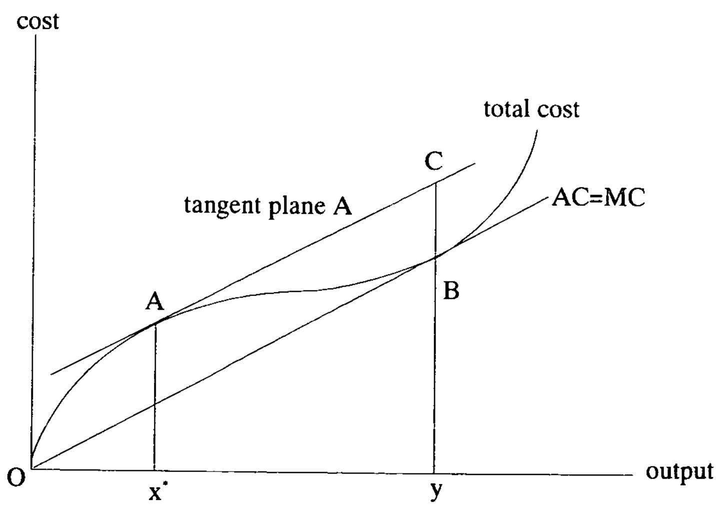
$$f(x^*) + Df(x^*)(y - x^*) \tag{4}$$

where $f(x^*)$ = predicted value of costs at point A,
x^* = a vector of independent variables at point A,

$$Df(x^*) = \left(\frac{\partial f(x^*)}{\partial x_1}, \frac{\partial f(x^*)}{\partial x_2}, \ldots, \frac{\partial f(x^*)}{\partial x_n}\right) \tag{5}$$

y = a vector of independent variables at the scale efficient point B. Equation (4) is equivalent to

$$f(x^*) + \sum_{i=1}^{n} \frac{\partial f(x^*)_*}{\partial x^*} (y_i - x_i^*)$$
$$= f(x^*) + \sum_{i=1}^{n} \frac{f(x^*)_*}{x_i^*} \frac{\partial \ln f(x^*)_*}{\partial \ln x_i^*} (y_i - x_i^*) \tag{5}$$



Assuming firm A to grow to the level of firm B on the expansion path AB, if costs increase at a constant ratio as outputs and input prices change from x^* to y, the cost surface will expand along the tangent plane A. In this case, total costs will be C on the tangent plane A where the output coordinate coincides with y. However, if there is a cost saving from expanding x^* to y, total costs will be lower than point C. The distance between point C and the actual cost, point B, on the cost function, implies the degree of potential cost saving obtained by expanding firm scale and changing the product mix. The cost efficiency on the expansion path can be measured by a ratio of the distance BC to Cy. That is, the degree of EPCE is formally stated as:

$$\text{EPCE} = \frac{f(y)}{f(x^*) + Df(x^*)(y - x^*)} \tag{6}$$

EPCE is a measure of the impact of total cost changes, while the other measures such as RSCE or EPSCE depend on an analogy of average cost concepts. EPCE gives direct information about the degree of cost saving from changing the scale and product mix, while the other measures give only indirect information. For example, RSCE suggests only whether or not a firm with a specific output bundle is operating under scale economies, and does not present how much cost can be saved if a scale inefficient firm reaches the scale efficient point. Furthermore, this advantage can be used to compare the degree of cost saving experienced with scale efficiency as opposed to that achieved from removing input inefficiency, if a firm is under scale inefficiency and deviates from the cost frontier.

Expansion Path Subadditivity (EPSUB): Let firm A and B compete in a market with different scales and product mixes. For firm B to be competitively viable, it should have a competitive edge over not only firm A but also a potential competitor firm D that produces a residual output bundle, Q^D, which is equivalent to $Q^B - Q^A$. This is measured by comparing the cost sets of a pair of firms producing output vector Q^B versus the costs of the single firm B.

$$\text{EPSUB}(Q^B) = [C(Q^A) + C(Q^D) - C(Q^B)] / C(Q^B) \tag{7}$$

where $Q^A + Q^D = Q^B$. If EPSUB (Q^B) is less than zero, then firm B cannot be viable. It will be driven out of a competitive market by a combination of firms A and D. If EPSUB (Q^B) is greater than zero, there exists natural monopoly so that firm A may face inducements to expand its size and/ or acquire or merge with other firms such as firm D.

III. Data and Model Specification

1. Data

This study used the managerial performance data of PACs such as income statements (profit and loss sheets), balance sheets at the end of 1991, employee allocation sheets for 1991, a subdocument of the income statement showing a detailed classification of operating costs, and the Managerial Performance Report of PACs (MRPP) of 1992 by National Agricultural Cooperatives Federation (NACF). The employee allocation sheets offer labor allocation to individual business, extension, and administrative sectors by type of employee class. This information was used to calculate the banking portion of operating costs and capital as well as wage rates. The subdocument of the income statement enable us to precisely classify operating costs into expenses for labor and for capital. By using this information, fringe benefits, capital expenditures and other management costs can be appropriately classified. The MRPP includes the number of branches and average stock value of deposits, Mutual Credit Loans, and policy loans.

The sample were intentionally selected 206 PACs from Choongnam and Kyounggi provinces of Korea. Choongnam is a province of a typical rural area located in the west of South Korea, while Kyounggi is the suburban province of Seoul city that has many urbanized areas. The PAC in a Up (a center town of a county) or city was regarded as an urban PAC, while the PAC in a Myoun (township) was regarded as a rural PAC. Along the regional classification criterion, the sample consists of 163 rural and 43 urban PACs.

2. General Assumptions

PACs operate diverse busineses as mentioned in Introdution and it is difficult to handle econometrically the entire activities. This problem requires some strong assumptions to handle banking cost structure in addition to cost minimizer assumption for cost function analyses.

The manager of a PAC is assumed to be a cost minimizer. PACs are price takers operating under government price controls for both deposits and loans. In this situation, cost minimizing behavior must be consistent with welfare maximizing behavior on the part of PAC members. Actually, cooperative banking is similar to commercial banking. The banking services of PACs are open to non-members as well as members, which is not consistent with the general rules of cooperatives. Non-members form the predominant share of total clientele in urban PACs. In rural areas, almost all farm households are members of a PAC. PACs directly compete with other financial institutions in urban as well as rural areas. This is different from the condition that is assumed in cooperative or credit union theory based on closed membership. The assumption of cost minimization must be consistent with the reality of the banking behavior of the PACs and facilitates analysis of the PAC's cost structure based on a duality theorem, which guarantees that the cost function exactly reflects the properties of the production technology.

The second assumption is that the production processes of PACs are separable between banking and the other sectors. This separability means that resources used in a PAC are allocable between banking and its other production activities. The PACs' accounting system separates these sectors so that most resource use can be captured by accounting documents but fixed capital and managerial expenditures on materials are not. Thus, the joint goods nature of fixed capital and operating costs requires another assumption to calculate the operating costs used for banking.

The last general assumption is that banking capital-labor ratio is the same with that of other sectors in the PACs. The data describing labor allocation to each business sector are available, so we can obtain the operating costs for banking by using this assumption. In this study, a standardized banking labor ratio to total labor of the PAC was used, which is the usual index in analyzing an individual business income by

NACF. This is clearly an arbitrary assumption because PACs may have different capital structures depending on the attributes of their businesses, such as processing factories, warehouses, buildings for utilization, or supermarkets etc. However, an analysis of the entire business due to the joint good nature of fixed capital may require too many parameters to handle with a small sample size, which motivated to separate banking from the other business sectors.

3. Definition and Measurement of Variables

The definition of output follows the value added criterion that regards outputs when they incur operating expenses. Produced deposits and loans are outputs since they are responsible for the great majority of value added(Berger and Humphrey). Deposits, Mutual Credit Loans, and policy loans are specified as the banking outputs of the PACs.

Policy loans must be outputs in terms of incurring real costs for monitoring and collecting repayments. But the characteristics of policy loans are different from the characteristics of other outputs since their amounts are not internally determined. This particular feature of policy loans was reflected in the model specification and in measuring RSCE.

In contrast to treating deposits as outputs, time deposits in Mutual Credit Special Accounts (MCSA) of the NACF that are used for the management of the PACs' idle funds are not defined as outputs because they do not incur real costs. There is no risk of default or price variation in time deposits in the MCSA. Time deposits in the MCSA are just the residual of clients' deposits that are subtracted from Mutual Credit Loans. The characteristics of outputs are already reflected in clients' deposits. Borrowings, both policy loans and borrowings from MCSA, also are not specified as outputs since they entail almost no labor and physical capital operating expenses or value added. Borrowings are only input substitutes for the capital and labor used to produce deposits as a means of financing loans and other assets.

The value of outputs is measured by the average stock value in *won* (Korean money unit) in 1991 that is calculated by the NACF accounting method. The average stock value is a reasonable measurement of outputs. This measurement does not have a seasonal variation problem of the stock value on a specific date or the problem of flow values in reflecting transitory and stationary transactions.

Inputs are labor, capital, deposits, and borrowings. The labor price was obtained by dividing the sum of wages and fringe benefits by an average standardized number of banking employees in 1991. The standardized number of employees of the banking sector (SNEB) is obtained as followings:

$$SNEB = \sum_{i=1}^{7} BN_i * \frac{BS_i}{BS_4} \tag{8}$$

where BN_i is the number of ith class banking employees, BS_i is the basic salary of the ith class employee, BS_4 is the fourth class employee's basic salary, and $i = 1, \cdots, 7$. The capital price is obtained by dividing capital expenditures such as rents, depreciation, utilities, equipment, and furniture expenditure by the *won* value of deposits[1]. The deposit price is obtained by dividing interest paid to depositors by the average stock value of deposits. Even though the interest rate of every item of deposits is fixed, the interest rates at the aggregate level depend on the composition of the deposit commodities or time period of deposits. This implies that the price of aggregate deposits varies across the sample observations. The deposit price was used as an effective yield (Mullineaux; Mester; Cuevas). It may be an useful index to banking managers because actual interest costs of deposits at some aggregate level might be more helpful in decision making. Banking managers are likely to use effective yields rather than nominal interest rate of every deposit commodity. For the

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1 The measurement of capital price is a controversial issue in service industry studies. One of the methods used to obtain capital price is to use the book value of capital and capital expenditures. However, the drawback of the book value approach is clear since book value is not a market value but historical value. The book value for the machinery and equipment purchased in different years is reported in the then current capital prices. The value according to this method understates the actual value of capital purchased in previous years, so that banks with older machines appear to be more efficient. Another proxy value of capital that has been popularly used in banking studies is the rental cost of fixed assets and premises. However, the rental costs are not obtained if banks own their fixed assets, such as in Korea. The other alternative is to divide capital expenditures by the dollar value of deposits or assets (Mester; Ferrier and Lovell)

same reason, the price of borrowings is obtained as interest expense on purchased funds divided by their stock value at the end of year because of no information about average stock value. The purchased funds include policy loans and borrowings from the MCSA that are used for the cooperative's own purposes. Total costs are the dependent variable and consist of operating costs, interest expenses on both deposits and borrowings, and loan losses. The number of branches is incorporated as a control variable, with the variable measured by the number of banking offices, head office plus branches.

4. Model Specification

The model was specified for the translog cost function by using three pieces of prior information and one piece of ex-post information. It is assumed that there is no relationship between policy loans and input prices. Since policy loans are exogenousely determined by the government, there is no reason that they are related to the input prices. This information is imposed on the model by dropping the interaction terms between policy loans and the input prices. However, the interaction terms between policy loans and other outputs are included because the marginal cost of individual output is likely to be dependent on other outputs through the simultaneous use of information. Common use of information can reduce operating costs such as monitoring, evaluation, enforcing, etc.

The second information is that the price of borrowings does not affect scale economies through interaction terms with outputs. This relationship is imposed by dropping the interaction terms between outputs and the price of purchased funds, which follows Hunter et al's (1989, 1990) specification. This specification differentiates the characteristics of deposits from that of purchased funds. Deposits are specified not only as outputs, but also as inputs that affect scale economies through price effects, i.e., through the interaction terms associated with deposit price and outputs. However, it should be noted that this specification excludes only the price effect of purchased funds through cost functions. There still exists possible effect on the scale economy measure through interest paid on purchased funds already included in total costs, as discussed in the previous section. This effect can be captured by the partial output elasticity of policy loans.

The third theoretical prior information is linear homogeneity in input prices and symmetry condition. Linear homogeneity is a precondition for the existence of a duality relationship between the cost and production transformation process (Caves, Christensen, and Tretheway). Linear homogeneity is imposed by $\Sigma\beta_k = 1, \Sigma_k\beta_{kl} = 0$, $\Sigma_k\gamma_{ik} = 0$, and the symmetry restriction is $\alpha_{ij} = \alpha_{ji}$ and $\beta_{kl} = \beta_{lk}$ in equation (9).

The ex-post information is that the number of branches has a log-linear relationship with total costs. Berger et al. (1986, 1987) argued that branches can be considered as substitutes for deposit interest, because the branch provides more convenient services for clientele, thus reducing clients' transaction costs such as transportation or waiting. This argument suggests that an use of interaction terms with other variables be appropriate to represent the true cost relationship. However, the observations of this study did not show any significant interactive relationship with other output variables. That is, there is no practical advantage from such a specification to compensate for a loss of degrees of freedom.

According to the specification, the model is expressed as

$$\ln TC = \alpha_0 + \sum_{i=1}^{3} \alpha_i \ln q_i + \frac{1}{2}\sum_{i=1}^{3}\sum_{j=1}^{3}\alpha_{ij} \ln q_i \ln q_j + \sum_{k=1}^{4} \beta_k \ln w_k$$
$$+ \frac{1}{2}\sum_{k=1}^{4}\sum_{l=1}^{4}\beta_{kl} \ln w_k \ln w_l + \sum_{i=1}^{2}\sum_{k=1}^{4}\gamma_{ik} \ln q_i \ln w_k + \theta \ln BR + \varepsilon \qquad (9)$$

where TC = total costs

q_i = *won* value of output i, i = 1, 2, 3,

w_j = price of input j, j = 1, 2, 3, 4,

BR = the number of branches plus a head office,

ε = error term

IV. Estimation and Results

1. Estimation of the Cost Function

Since the sample consists of rural and urban PACs that are likely to be different from each other, the Chow test was conducted to determine whether the subsamples of both rural and urban can be pooled or not. The test did not reject the null hypothesis that the cost function of rural PACs is structurally the same as the urban one, so they were pooled.

The PACs were divided into seven classes by deposit size to evaluate the estimated cost function. The PAC at the class mean was regarded as a representative PAC for the class. The data were scaled around the geometric means of all observations to conveniently evaluate the estimated cost surface. Geometric mean scaling enables us to obtain an approximation to the true underlying cost function in the neighborhood of the scaling point (Boisvert; Akridge and Hertel). This advantage may reduce the criticism of a narrow range of approximation region where the cost function is well defined, if we move the scaling point along the sample class mean (Boisvert). This study uses this strategy to evaluate a specific point on the cost function. Another advantage is that scaling the data with the geometric mean facilitates calculation of scope and scale economy measures since the natural logarithm of one is zero. In the translog function, the examination of the estimated sign often depends on the first or second order derivatives, and scaling can provide a very simple calculation of the first and second order derivatives with respect to independent variables. In addition, for inference to be free from the arbitrary measurement of units, this can be effectively used(Cramer).

Table 1 gives the mean value of the variables in th sample data with their minimums and maximums, and Table 2 presents the product mix for each deposit size class of PACs measured at the class

TABLE 1 The Mean Value of Cost Function Variables : Aggregate Sample

Variables	Mean	Minimum	Maximum
Total Costs (million *won*)	1,433	481	6,439
Outputs (million *won*)			
Deposits	8,967	2,125	51,702
Mutual Credit Loans	6,901	1,194	29,578
Policy Loans	4,256	1,286	10,865
Input Prices			
Labor Price (thousand *won*)	1,4625	1,0405	1,8350
Capital Price (*won/won*)	0.0055	0.0027	0.0103
Deposit Price (*won/won*)	0.1150	0.0887	0.1873
Borrowing Price (*won/won*)	0.0499	0.0235	0.0761
Number of Branches per PAC	0.6585	0	6

TABLE 2 Product Mix of Deposit Size Class

Deposit Size Class (billion *won*)	Deposits		Mutual Credit Loans		Policy Loans		Sum of Outputs
	Value[a]	Share[b]	Value[a]	Share[b]	Value[a]	Share[b]	
Less than 3	2,710	0.33	2,751	0.34	2,630	0.33	8,091
3 ~ 5	4,006	0.36	3,743	0.33	3,515	0.31	11,265
5 ~ 7.5	6,181	0.38	5,502	0.34	4,607	0.28	16,291
7.5 ~ 10	9,008	0.43	7,186	0.34	4,873	0.23	21,067
10 ~ 15	11,710	0.45	8,805	0.34	5,229	0.20	25,744
15 ~ 25	19,749	0.51	14,367	0.37	4,698	0.12	38,815
Greater than 25	35,913	0.58	21,042	0.34	4,924	0.08	61,879

[a] The unit of value is one million *won*.
[b] The share is the ratio of each output to the sum of outputs.

mean. As the total deposit size increases, the deposit share of the sum of total outputs steadily increases, while the policy loan share steadily decreases. There are no big differences in product mix between neighboring classes.

The estimated cost function is presented in Table 3. The fitness of the estimated function is good and the portion of the estimates that are statistically significant is very high; that is, eighteen of thirty one parameters (58.1 %) are significant at the 1 percent level. The marginal costs of outputs are positive, which is reasonable. The regularity conditions of the cost function are satisfied at least around the geometric means: The condition of homogeneous degree one in input prices was parametrically imposed. The concavity condition is satisfied around the geometric means of the observations, although it cannot be imposed. Therefore, these results suggest that the estimated function is reasonable.

2. Ray Scale Economies

Table 4 presents the results for the estimated scale economies as a PAC expands production scale with a constant product mix. RSC2 in the table refers to the overall ray scale economies when policy loans are regarded as outputs such as deposits and Mutual Credit Loans. RSC2 shows that

TABLE 3 Estimated Cost Function

Coefficients (Variable)	Estimate	Standard Error	t value
α_0 (intercept)	-0.0474**	0.0051	-9.3556
α_1 ($\ln q_1$, deposits)	0.5444**	0.0207	26.315
α_2($\ln q_2$, Mutual Credit Loans)	0.3032**	0.0228	13.3130
α_3($\ln q_3$, policy loans)	0.1394**	0.0092	15.1130
α_{11} (($\ln q_1 \ln q_1$)/2)	0.7282**	0.0814	8.9442
α_{22} (((($\ln q_2 \ln q_2$)/2)	0.4781**	0.0565	8.4590
α_{33} (($\ln q_3 \ln q_3$)/2)	0.1090**	0.0174	6.2685
α_{12} (($\ln q_1 \ln q_2$)/2)	-0.5645**	0.0662	-8.5296
α_{13} (($\ln q_1 \ln q_3$)/2)	-0.1116**	0.0327	-3.4142
α_{23} (($\ln q_2 \ln q_3$)/2)0.0349		0.0448	0.7788
β_1 ($\ln w_1$, price of labor)	0.1258**	0.0317	3.9633
β_2($\ln w_2$, price of capital)	0.1129**	0.0148	7.6424
β_3($\ln w_3$, price of deposits)	0.6052**	0.0244	24.7660
β_4 ($\ln w_4$, price of borrowings)	0.1561**	0.0187	8.3566
β_{11} (($\ln w_1 \ln w_1$)/2)	0.9287**	0.3198	2.9038
β_{22} (($\ln w_2 \ln w_2$)/2)	0.0370	0.0967	0.3829
β_{33} (($\ln w_3 \ln w_3$)/2)	0.2756	0.2499	1.1028
β_{44} (($\ln w_4 \ln w_4$)/2)	0.2800**	0.1072	2.6124
β_{12} (($\ln w_1 \ln w_2$)/2)	-0.1631	0.1227	-1.3297
β_{13} (($\ln w_1 \ln w_3$)/2)	-0.3272	0.2289	-1.4293
β_{14} (($\ln w_1 \ln w_4$)/2)	-0.4384**	0.1555	-2.8184
β_{23} (($\ln w_2 \ln w_3$)/2)	0.0096	0.1151	0.8370
β_{24} (($\ln w_2 \ln w_4$)/2)	0.1164	0.0630	1.8474
β_{34} (($\ln w_3 \ln w_4$)/2)	0.0419	0.1343	0.3120
γ_{11} ($\ln q_1 \ln w_1$)	-0.0367	0.2537	-0.1445
γ_{12} ($\ln q_1 \ln w_2$)	0.0004	0.0829	0.4796
γ_{13} ($\ln q_1 \ln w_3$)	0.6108**	0.1664	3.6703
γ_{21} ($\ln q_2 \ln w_1$)	0.0367	0.2537	0.1445
γ_{22} ($\ln q_2 \ln w_2$)	-0.0004	0.0829	-0.4796
γ_{23} ($\ln q_2 \ln w_3$)	-0.6108**	0.1664	-3.6703
θ (lnBR, branches)	0.0046	0.0082	0.5616
R^2 = 0.9960		Adjusted R^2 = 0.9955	

* ; significant at 5 % level, ** ; significant at 1 % level

the PACs exhaust scale economies in earlier stages on the cost surface. RSC2 is not significantly different from 1 for the overall sample mean and for the average of the urban PACs, but for the average rural PAC. Considering the different deposit size classes, RSC2 consistently increases as the deposit class increases, showing changes from slight

TABLE 4 Ray Scale Economies of Banking

Deposit Size Class (billion *won*) or Region	Number of Observations	Partial Elasticity			Scale Economies	
		Deposit	MCL[a]	PL[b]	RSC1[c]	RSC2[d]
Less than 3	7	0.4263	0.3632	0.1714	0.7895**	0.9609*
3 ~ 5	77	0.4609	0.3481	0.1664	0.8090**	0.9754*
5 ~ 7.5	48	0.4996	0.3260	0.1620	0.8256**	0.9876
7.5 ~ 10	25	0.5664	0.2966	0.1306	0.8630**	0.9936
10 ~ 15	21	0.6327	0.2479	0.1183	0.8806**	0.9989
15 ~ 25	16	0.7291	0.2086	0.0575	0.9377**	0.9952
Greater than 25	12	0.8870	0.1026	0.0175	0.9896	1.0071
Rural PACs	163	0.4986	0.3292	0.1551	0.8278**	0.9829*
Urban PACs	43	0.7183	0.2018	0.0797	0.9201**	0.9998
All	206	0.5441	0.3032	0.1394	0.8473**	0.9867

[a] Mutual Credit loans
[b] Policy loans
[c] RSC1 is the ray scale economies when only deposits and Mutual Credit Loans are considered as outputs.
[d] RSC2 measures the ray scale economies including policy loans as outputs
[e] The asterisks mean that the measured ray scale economies are significantly different from 1 at the respective significance levels which are based on the Wald χ^2 test statistic: *, 10 %; **, 1 % significance level.

economies to slight diseconomies of scale. The existence of scale economies is statistically supported only in the smallest two classes with a low significance level, but the RSC2 for the other classes are not significantly different from 1 (no scale economies). This result implies that about a half of the rural PACs cannot save costs by expanding the scale of banking production, and most urban PACs are also operating under no scale economies.

However, RSC2 may not give relevant information about scale economies due to the cheap interest cost effects of policy loans and the substantially different shares of the policy loans across observations. The cheap policy loans affect total average costs - including interest expenses on deposits and on borrowings - which are lowered by mixing funds. Thus, since the shares of policy loans increase as banking size decreases, the smaller the bank size, the greater the effect of lowering total average costs. Consequently, the total average costs of small PACs with a large share of policy loans becomes lower, which likely flattens the total average cost curve over the considerable range of observations. For this situation, overall scale economies cannot be observed in the range. This relationship means that even scale inefficient PAC may appear as efficient even if the internally determined production scale is not large enough to be efficient. Therefore, excluding the policy loan effects may be a more relevant measure for policy implications based on scale economies.

RSC1 represents the overall ray scale economies when the policy loans are regarded as a control variable instead of output so that only deposits and Mutual Credit Loans are regarded as outputs. Since the concept of outputs is meaningful when they are internally controlled by the firm, we may regard the policy loans as a control variable given outside of the PACs. RSC1 results in a substantially different implication from the results of RSC2. The estimates of RSC1 for all classes of PACs, except for the largest class, suggest they are operating under significant economies of scale and that the degree of scale economies consistently decreases as deposit size increases. That is, the PACs except for the largest class PAC can save substantial costs by increasing the scale of production up to the largest class of PACs. The estimates of RSC1 are 0.8473, 0.8278 and 0.9201, at the overall, rural and urban sample means, respectively. In all cases except for the largest class, the value of RSC1 is different from 1 at the 1 percent significance level and only the largest class PAC exhausts scale economies. This suggests that the largest class can be an effective standard to be used as the scale efficient class.

3. Expansion Path Cost Efficiency

Expansion path cost efficiency (EPCE) measures the potential cost savings that could be obtained by changing the scale of production and/ or product mix. There were substantial differences in product mixes between the smaller size rural PACs and the larger urban PACs, but no large differences in product mixes between the neighboring size classes as shown in Table 2. This suggests that it will not be a relevant strategy for a small PAC to increase the scale of production while holding product mix constant. Therefore, in a more practical sense, the EPCE that allows for the effects on costs of changes in both scale and product mix can give valuable information about cost structure to the manager of a small PAC. But the EPCE has a drawback in treating the effects of policy loans. The EPCE is not developed enough to measure the effect of a partial change like RSC1 in the previous section, so the degree of cost changes along the expansion path independent of policy loans was not analyzed in this study. The following evaluation results, therefore, are based on the specification of all three outputs - deposits, Mutual Credit loans, and policy loans.

Table 5 presents the degree of cost saving when the small size classes change both their scale and product mix to that of the largest class. The results show that the smallest three size classes can save costs if the scale of production and product mix reach those of the largest class, but the large size classes with deposits greater than 7.5 billion *won* do not realize any significant cost saving. The measured EPCE suggests that if the smallest class reached the largest class, total costs would be reduced by 15 percent, while for the second and third classes the total costs saved reach 8 and 7 percent, respectively. However, the larger three classes would save less than 0.5 percent, which is meaningless. Therefore, a PAC that belongs to the deposit size class over 7.5 billion *won* is competitively viable while the smaller ones are not.

TABLE 5 Expansion Path Cost Efficiency to Scale Efficient Class

Deposit Size Class (billion *won*)		Expansion Path
Lower end	Higher end	Cost Efficiency
Less than 3	Greater than 25	0.8519486
3 ~ 5	Greater than 25	0.9153974
5 ~ 7.5	Greater than 25	0.9324724
7.5 ~ 10	Greater than 25	0.9949096
10 ~ 15	Greater than 25	0.9977796
15 ~ 25	Greater than 25	0.9960276

4. Expansion Path Subadditivity

The evaluation result of the EPSUB as reported in table 6 shows that it is not efficient, over all classes, to divide a representative PAC into two smaller PACs, i.e., a PAC in the next smallest size class and a separate potential PAC which produces the residual or complementary output bundle[2]. Therefore, all size classes of PACs are competitively

TABLE 6 Expansion Path Subadditivity (EPSUB) by Deposit Size Class

Deposit Size Class (billion won)		EPSUB
Higher Class	Lower Class	
3 ~ 5	Less than 3	0.0384
5 ~ 7.5	3 ~ 5	0.0168
7.5 ~ 10	5 ~ 7.5	0.0570
10 ~ 15	7.5 ~ 10	0.0289
15 ~ 25	10 ~ 15	0.0790
Greater than 25	15 ~ 25	0.2092

viable against the smaller PACs. The degree of diseconomies obtained by dividing the representative PAC in a class into two smaller PACs shows a relatively large variation from 2 to 21 percent. Dividing the largest two size classes of PACs into smaller PACs will lead to a substantial increase in costs. For the largest class PAC (greater than 25 billion won), the cost advantage of maintaining one multiproduct PAC rather than two smaller PACs is about 21 percent of the current

[2] A problem for obtaining EPSUB concerns how to deal with the input price variables and the branch variable. There are two sets of input price variables (for smaller and larger class representative PACs) and the number of offices at the class mean may not be an integer. By following Berger et al.'s method (1986), the input prices of the next higher class PAC were used and the number of offices was treated as one if the office number of the higher class PAC minus that of the smaller class PAC was less than one. Actually, the difference in the number of offices between two class PACs was less than one, so that every potential entrant (PAC) was assumed to have only one office (no branches).

production costs, while dividing the second largest PAC will increase cost by 8 percent.

Since the largest two size classes of PACs are urban, the evaluation result of EPSUB implies that urban financial markets are more favorable to the large multiproduct PACs than are rural financial markets. This finding supports the existence of large banking institutions in urban areas. Furthermore, the impact of financial liberalization will be substantial for urban PACs. On the other hand, the class of 7.5 ~ 10 billion *won* is the largest class of rural PACs that shows the highest degree of diseconomies (6 %) as a result of dividing it into smaller PACs. That is, rural PACs also will be affected by the entrance in the rural financial markets of large banking institutions.

However, the estimated EPSUB of this study should be carefully interpreted. EPSUB refers a sufficient condition of natural monopoly, which needs entire information of financial institutions in a market. Since the PAC is only one of the financial institutions in the market, the estimated EPSUB cannot avoid the problems caused by excluding information about the other institutions. The PAC in a rural financial market can be a representative financial institution so that the information loss of other financial institutions may not be big, but the PAC in an urban financial market is a small institution so that the information loss must be big.

V. Conclusion

This paper presented the test results for scale economies of PAC banking and existence of natural monopoly, by using the intermediation approach, in rural financial markets in Korea. Measuring scale economies was conducted by RSCE depending on the assumption of constant product mix and EPCE depending on the assumption of varying product mix. The study adopted new specification in measuring RSCE related to policy loans determined outside of PACs and a new measure for scale economies with varying product mix. The new specification and measurement resulted in reasonable implications and showed consistency. The test results for scale economies and cost subadditivity suggested that most PACs need to expand scale and change product mix to reduce costs. This suggestion is related to restrictive rural financial markets that are not large enough to be competitive markets.

Since cheap funds supplied by the government may hide the existence of scale economies by lowering average costs, the policy loans were treated by both ways of normal output and only a control variable, in measuring RSCE. When the policy loans were treated as normal output, measured RSCE statistically supported that only small rural PACs are under scale economies. But when the policy loans are treated as a control variable, RSCE statistically supported that all class PACs except the largest class are under scale economies. This fact implies that most PACs should expand banking production scale to reach minimum cost level, assuming that the PACs increase scale with constant product mix.

Under the assumption of varying product mix as scale increases, the cost change effect was measured by using the new measure EPCE developed by the authors and treating the policy loans as normal output. The result was consistent with RSC2, ray scale economy measure treating policy loans as normal outputs, and suggested that small rural PACs can save substantial costs by expanding scale and changing product mix as the level of the largest class of PACs. The measured EPSUB suggested the natural monopoly in rural financial markets so that one PAC can be more efficient rather than two or more financial institutions compete in the market.

On the other hand, some limitations of this study require careful explanation when interpreting the analysis results. This study used the strong assumption of separability between the banking sector and the other business sectors of a PAC in order to apply the econometric model. This assumption excludes a priori the effects of other businesses on the banking business, and these effects may be substantial considering the competitive edge of multibusinesses. Furthermore, the labor allocation index that was used to separate the banking and non-banking portions of operating costs may not be an exact measure of resource allocation; therefore, the results cannot avoid a possible bias due to the use of this index. In addition, this study focused only on cost advantages to the PACs themselves without considering the cost benefits for PAC clients that may be an important competitive edge of the PACs. In other words, a PAC may appear inefficient in utilizing inputs, in operating scale, or in combining product mix, but if we consider the total transaction costs of both the PAC and its clients, the PAC may be evaluated as efficient (Berger et al., 1986, 1987; Hunter et al., 1989,1990).

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