Evaluating the Operational Efficiency of Korean Public Pension Schemes: A Stochastic Cost Frontier Approach

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Abstract: Korean public pension schemes, which consist of the National Pension Scheme, the Government Employees Pension Scheme, the Military Personnel Pension Scheme and the Private School Teachers Pension Scheme, are faced with serious institutional problems such as financial instability due to the structural imbalance between low contributions and high benefits, hasty coverage expansion due to the rapid growth of aging population, opaque management of pension reserve management and managerial inefficiency.

This study measured and assessed the operational cost efficiency of Korean public pension schemes including the National Pension Scheme, the Government Employees Pension Scheme and the Private School Teachers Pension Scheme using a translog stochastic cost frontier function model for the panel data from 1988 through 1999 in order to establish a performance evaluation system for the efficient management of public pension schemes.

The empirical results show that the overall cost efficiency is 52.6%, and that there is a great difference between the cost efficiency estimates of the three pension schemes. This implies that fundamental reforms to improve the operating system of public pension systems should be carried out in a consistent and urgent way. These reforms include the
restructuring and management innovation of public pension schemes, integration of public pension schemes, private management of the pension reserve fund, and establishment of a three-pillar pension system that attaches importance to the organic and complementary functions of public pensions, corporate pensions and personal pensions.

I. Introduction

Korean public pension schemes are divided into the National Pension Scheme established in 1988 and public occupational pension schemes including three pension systems for specific occupations, which are comprised of the Government Employees Pension Scheme, the oldest public pension scheme in Korea, implemented in 1960, the Military Personnel Pension Scheme, started in 1960 as a part of the Government Employees Pension Scheme and separated from the latter in 1963, and the Private School Teachers Pension Scheme, introduced in 1973 and implemented in 1975.

Korean public pension schemes are faced with serious institutional problems such as financial instability due to the structural imbalance between low contributions and high benefits, hasty coverage expansion due to the rapid growth of the aging population, distortion of the income distribution function stemming from the incomplete means test of the self-employed with special reference to the National Pension Scheme, inequity between the National Pension Scheme and occupational pension schemes, opaque management of the pension reserve fund and managerial inefficiency.¹

Although public pension systems are capable of affording social benefits, administrative costs are necessary for managing them effectively. However, if operational expenses to maintain public pension systems are excessive relative to the benefits accruing to the insured from them, their significance will be reduced to a great extent (Kim et al. 1996: 38). Thus, options for enhancing the efficient and effective management of public pension schemes need to be searched for by measuring their managerial efficiency.

There have been a few previous studies on administrative costs of public pension schemes such as Kim et al. (1996), Mitchell et al. (1994), Mitchell (1996), James and Palacios (1995), Yoon et al. (1999a). However, the stochastic cost frontier model, which measures inefficiency as the deviation of actual cost from minimal feasible cost by using a stochastic cost function including multiple outputs and multiple input prices, has not yet been used to assess the operational efficiency of public pension schemes.

The purpose of this paper is to measure the operating cost efficiency of Korean public pension schemes using the stochastic cost frontier model, compare the managerial performance of efficient pension schemes with that of inefficient pension schemes, introduce a method to evaluate the overall performance of a set of items used to calculate efficiency with a single measure, and suggest policy and methodological implications in order to establish a performance evaluation system for the efficient management of public pension schemes in the future.

The remainder of the paper is organized as follows. Section 2 reviews prior research on administrative costs and the efficiency of public pension schemes; Section 3 describes the significance and usefulness of the stochastic cost frontier model and the theoretical method of measuring cost efficiency, and then presents the translog stochastic cost frontier model used in the article, the specification of inputs and outputs, data sources and the estimation method; Section 4 discusses the empirical results and presents policy and methodological implications for enhancing the managerial efficiency of public pension schemes; and Section 5 summarizes the empirical findings and presents the conclusions.

¹ For more details on the current state and problems of Korean public pension schemes, see World Bank (1999), OECD (2001), and Moon (2001).
II. Previous Research

1. The Concept of Operational Efficiency

The efficiency of an administrative organization means the ratio of outputs to inputs required for producing a particular service and its operational efficiency can be defined as the extent that a particular organization can achieve the missions assigned to it using minimal resources (Yoon et al., 1999a: 32).

The operational efficiency of a public pension scheme indicates the ability of a public pension corporation to obtain maximal outputs from a given set of inputs or to minimize a set of inputs, given the level of outputs. Basically, operational efficiency is based on Farrell’s (1957) productive efficiency that is composed of technical efficiency, which reflects the ability of a firm to obtain maximal outputs from a given set of inputs, and allocative efficiency, which reflects the ability of a firm to use the inputs in optimal proportions, given their respective prices and the production technology. If the stochastic production frontier model is used, operational efficiency is calculated by technical efficiency, while if the stochastic cost frontier is employed, it is measured by cost efficiency, as will be seen later. Generally speaking, a public pension corporation is likely to aim at minimizing input costs to accomplish the given level of outputs by restructuring its organization, replacing human resources, and utilizing physical capital in a more efficient manner. If a public pension corporation has excessive personnel or spends too much overhead expenses relative to the optimal size of its services, its managerial efficiency is reduced. Cost efficiency needs to be enhanced by minimizing input costs necessary for producing a given amount of outputs in order to improve operational efficiency (Kim et al., 1996: 40).

This study focuses on the cost minimization of inputs to be used for producing a given level of outputs of a public pension corporation and measures the operational cost efficiency of public pension schemes including the National Pension Scheme, the Government Employees Pension Scheme and the Private School Teachers Pension Scheme. Here the deviation of observed cost from minimal feasible cost is regarded as cost inefficiency and cost efficiency is measured by the ratio of minimal feasible cost to actual cost.

2. Literature Review

The major previous research on administrative costs of public pension schemes includes Kim et al. (1996), Mitchell et al. (1994), Mitchell (1996), James and Palacios (1995), and Yoon et al. (1999a). Kim et al. (1996) analyzed the economies of scale and scope in the Medical Insurance, the National Pension, and the Industrial Accident Compensation Insurance in Korea using 1996 budget data on these social insurances. They estimated the economies of scale in social insurances with the log-linear regression model that relates a dependent variable, total cost proxied by general administrative expenses covering personnel and overhead expenses, to an independent variable, the size of operation proxied by the number of insured persons or establishments. The empirical results showed that all social insurances such as the National Pension, the Medical Insurance, and the Industrial Accident Compensation Insurance in Korea using 1996 budget data on these social insurances. They estimated the economies of scale in social insurances with the log-linear regression model that relates a dependent variable, total cost proxied by general administrative expenses covering personnel and overhead expenses, to an independent variable, the size of operation proxied by the number of insured persons or establishments. The empirical results showed that all social insurances such as the National Pension, the Medical Insurance, and the Industrial Accident Compensation Insurance all have economies of scale, regardless of whether the size variable is the number of insured persons or the number of establishments, suggesting that the coverage of local offices in each social insurance needs to be

2. Farrell (1957) made use of the work of Debreu (1951), where Farrell’s technical efficiency is similar to Debreu’s coefficient of resource utilization, and Koopmans (1957) to define a simple measure of firm efficiency that could account for multiple inputs, and used the term price efficiency in place of allocative efficiency and the term overall efficiency, which is equal to the product of the technical and price efficiencies, instead of economic efficiency. However, allocative efficiency as well as productive or economic efficiency has been used most often in recent literature. On the other hand, for ease of exposition, Farrell’s efficiency measures were developed primarily in terms of the efficiency of a firm, but they were intended to be quite general, applicable to any productive organization from a workshop to a whole economy (Farrell, 1957: 254). For more detailed explanations of modern efficiency measurement, see Färe et al. (1985, 1994), Lovell (1993), and Coelli et al. (1998), and for more details on efficiency measurement in the public sector, see Barrow and Waggstaff (1989), Mayston and Smith (1987), Diamond (1990), and Ganley and Cubbin (1992).
They also assessed the economies of scope using a translog cost function with relation to the cash and medical care benefit affairs of the Industrial Accident Compensation Insurance, the benefit and collection affairs of the Industrial Accident Compensation Insurance, the benefit and workers management affairs of the Industrial Accident Compensation Insurance, and the individually and workplace-based insured persons management affairs of the National Pension. The empirical results indicated that there are no economies of scope for all affairs of the Industrial Accident Compensation Insurance, while there are economies of scope for those of the National Pension.

Mitchell et al. (1994) examined administrative costs as a percentage of social security benefit expenditures around the world from almost fifty developed and developing countries, finding that their mean of countries in the Organization for Economic Cooperation and Development (OECD) is 3.12%, whereas that of the developing nations of the Latin American and Caribbean region (LAC) is 27.78%. This implies that there is a great difference between administrative costs of OECD and LAC countries.

Mitchell (1996) compared administrative costs associated with the US public and private retirement systems with data from national systems in other countries, finding that administrative costs of publicly-run social security systems vary a great deal across countries and institutional settings. She also suggested that a key factor affecting public old-age program costs is the system’s scale.

James and Palacios (1995) found that external factors, such as the country’s per capita income and the number of workers covered by pension plans, are major determinants of administrative costs, suggesting that even though private decentralized pension plans are sometimes more expensive to administer than centralized public pensions, the resulting benefits, in terms of improved quality and higher investment returns, may outweigh the costs.

Yoon et al. (1999a) used a pooled time series analysis for the panel data from 1989 to 1998 to analyze the determinants of administrative costs in public pension schemes including the National Pension, the Government Employees Pension and the Private School Teachers Pension. They used the log-linear model that regresses a dependent variable, administrative costs, on independent variables such as the number of insured persons, the number of beneficiaries, the number of cases for paying benefits, contributions, benefit expenditures, the number of workplaces, the number of individually insured persons, the amount of the pension reserve fund, and the number of employees. In addition, to control for the impact of the size of each public pension system on administrative costs they adopted administrative costs relative to contributions, benefit expenditures, the sum of contributions and benefit expenditures, the number of insured persons, and the number of beneficiaries, respectively, as a dependent variable.

The empirical results showed that the random effects model is accepted against the fixed effects model on the basis of the Hausman test, and that factors influencing administrative costs are the number of insured persons, the number of cases for paying benefits, contributions, benefit expenditures, the amount of the pension reserve fund, and the number of employees. They also found that administrative costs of the three public pension schemes are inclined to increase over time.

As mentioned earlier, prior studies have been conducted with reference to the economies of scale and scope in social insurances, the administrative costs associated with public and private retirement systems, the ratio of administrative costs to social security benefit expenditures, and the determinants of administrative costs in public pension schemes. As far as we know, research that focuses on measuring the managerial efficiency of public pension schemes and assessing its differences across public pension schemes has not been carried out yet. Hence we need to measure the operating cost efficiency of Korean public pension schemes using the stochastic cost frontier model that is one of the advanced efficiency measurement methods, compare the managerial performance of efficient pension schemes with that of inefficient pension schemes, introduce a method to evaluate the overall performance of several items used to calculate efficiency with a single measure, and further establish a performance evaluation system for the efficient management of public pension schemes.
III. Model and Data

1. The Significance and Usefulness of the Stochastic Cost Frontier Function Model

Stochastic frontier analysis (SFA) used in this paper is an econometric model for measuring the managerial efficiency of decision-making units (DMUs) and has been applied in various fields. This method compares the best performance, i.e., the production frontier or the cost frontier with the actual level of achievement and measures the difference between the frontier and the observed level as inefficiency.

Since this technique measures the observed level of achievement relative to the maximal levels, it is different from regression analysis which compares the actual levels with the average levels, or ratio analysis as measured by output per input. Also it has the merit of measuring the operational inefficiency of a decision-making unit more accurately than data envelopment analysis (DEA), because the latter treats total errors, i.e., the difference between the frontier and the observed level of achievement as operational inefficiencies, while the former divides total errors into random errors and inefficiency effects and then measures only pure inefficiency effects. However, since data envelopment analysis has the features of requiring no price data as well as suggesting reference groups and then provides inefficient organizational units with useful management information for benchmarking the efficient organizations, it can be usefully applied to the efficiency measurement of the public sector together with stochastic frontier analysis.

The majority of prior studies using stochastic frontier analysis have applied the stochastic production frontier function to the efficiency measurement, but it has the limitation of dealing with a single output. Hence as for the public sector characteristic of multiple outputs, the stochastic cost frontier function model needs to be used rather than the stochastic production frontier function model, because the former can deal with multiple outputs as well as multiple inputs.

2. Cost Efficiency

The basic model of a stochastic cost frontier analysis as proposed by Aigner et al. (1977) assumes that total cost deviates from the optimal cost, i.e., the cost frontier by a random noise \( v_{it} \) and an inefficiency component \( u_{it} \) (Aigner et al., 1977; Allen and Rai, 1996). Thus, the panel data cost frontier model of the cost function as specified in the panel data form is given as equation (1):

\[
\ln C_{it} = \ln C(y_{it}, p_{it}; \beta) + v_{it} + u_{it}, \quad i = 1, 2, \ldots, N; t = 1, 2, \ldots, T
\] (1)

In the stochastic cost frontier model, the entire excess of observed cost over minimal feasible cost, i.e., the cost frontier is attributed to cost inefficiency, and the measure of cost efficiency \( CE_{it} \) is given by the ratio of minimal cost to observed cost. If the cost frontier is specified as being stochastic, the appropriate measure of cost efficiency is defined as equation (2):

\[
CE_{it} = \frac{C(y_{it}, p_{it}; \beta) \exp\{v_{it}\}}{C_{it}} = \exp\{-u_{it}\}
\] (2)

where \( C_{it} \) is the observed cost of production for the \( i \)-th organization at the \( t \)-th time period; \( y_{it} \) is a vector of the output quantity for the \( i \)-th organization at the \( t \)-th time period; \( p_{it} \) is a vector of the input prices for the \( i \)-th organization at the \( t \)-th time period; \( \beta \) is a vector of unknown parameters to be estimated; \( v_{it} \) is a random error, assumed to be independent and identically distributed and has \( N(0, \sigma^2) \) distribution, independent of the \( u_{it} \); \( u_{it} \) is a non-negative cost inefficiency effect which is often assumed to have an independent and identically distributed half-normal or truncated-normal distribution. \( [C(y_{it}, p_{it}; \beta) \exp\{v_{it}\}] \) is the stochastic cost frontier, which is composed of a deterministic part \( C(y_{it}, p_{it}; \beta) \) common to all organizations and an organization-specific random part \( \exp\{v_{it}\} \) capturing the effects of random shocks on each organization. Equation (2) defines cost efficiency as the ratio of minimal cost attainable in an environment characterized by \( \exp\{v_{i}\} \) to actual cost or expenditure. \( CE_{it} \) is bounded.
between zero and one, with \( CE_u = 1 \) if, and only if, \( CE_u = C(y_{it}, p_{it}; \beta) \exp(u_i) \).

The minimum squared error predictor of time-varying cost efficiency in the half-normal distribution is given as equation (3) (Battese and Coelli, 1988; Kumbhakar and Lovell, 2000).\(^3\)

\[
CE_u = E(\exp(-u_i) | \varepsilon_u) = E(\exp(-\beta_i u_i) | \varepsilon_u) = \frac{1 - \Phi(\beta_i \mu_i - \sigma_i / \sigma_i) \exp(-\beta_i \mu_i + \frac{1}{2} \beta_i^2 \sigma_i^2)}{1 - \Phi(-\mu_i / \sigma_i)} \exp(\beta_i \mu_i + \frac{1}{2} \beta_i^2 \sigma_i^2) \tag{3}
\]

where \( \mu_i = \sum_{t=1}^{T} \beta_i \varepsilon_{it} / (\alpha_i^2 + \sum_{t=1}^{T} \beta_i^2) \), \( \sigma_i^2 = \alpha_i^2 / (\alpha_i^2 + \sum_{t=1}^{T} \beta_i^2) \), and \( \Phi(.) \) is the cumulative distribution function of standard normal random variables. The Battese and Coelli (1988, 1992) point estimator can give results different from the Jondrow et al. (1982) point estimator.\(^4\) However, the former is superior to the latter, because the latter is a first-order approximation to the former in Taylor’s expansion (Kumbhakar & Lovell, 2000: 142).

3. Model Specification

The nonhomothetic translog cost function used to measure the cost efficiency of public pension schemes can be envisioned as a second-order Taylor’s series approximation in logarithms to an arbitrary cost function. Nonhomothetic functions are very general, since their ratios of cost-minimizing input demands are allowed to rely on the level of output, whereas with homothetic functions, relative input demands are independent of the level of output (Berndt, 1991: 469). The nonhomothetic translog stochastic cost frontier model is specified as equation (4):

\[
\ln C_i = \alpha_i + \gamma_i y_{it} + \beta_i \ln \pi_{it} + \frac{1}{2} \sum_{m=1}^{q} \sum_{j=1}^{p} \gamma_{jm} \ln y_{jm} \ln \pi_{m} + v_{it} + u_i
\tag{4}
\]

where \( \ln C_i \) is the natural logarithm of total cost for the \( i \)-th public pension scheme at the \( t \)-th time period; \( y_{it} \) is the natural logarithm of the \( j \)-th output for the \( i \)-th public pension scheme at the \( t \)-th time period; \( \ln \pi_{it} \) is the natural logarithm of the \( k \)-th input price for the \( i \)-th public pension scheme at the \( t \)-th time period; \( v_{it} \) is the two-sided noise component of the composed error term, which is assumed to be independent and identically distributed and has \( N(0, \sigma^2) \) distribution, independent of the \( u_i \); and \( u_i \) is the non-negative cost inefficiency component of the composed error term, which is often assumed to be independent and identically distributed, and captures the composite cost of input-oriented technical and allocative inefficiency. Here cost inefficiency means the operational inefficiency of public pension schemes.

Since for a cost function to be well behaved, the duality theorem requires that it must be linearly homogeneous in input prices, the following restrictions on the parameters in equation (4) should be imposed (Berndt, 1991; Allen and Rai, 1996; Resti, 1997; Marco Gual and Moya Clemente, 1999):

\[
\sum_{k=1}^{q} \beta_{k} = 1
\]

\[
\sum_{k=1}^{q} \beta_{k} = 0
\]

Further, since Young’s theorem requires that the symmetry restrictions be imposed (Kumbhakar and Lovell, 2000: 144), the second-order parameters of the cost function in equation (4) must be symmetric as given in (6):

\[
\sum_{k=1}^{q} \beta_{k} = 0
\]
\[ \alpha_{jm} = \alpha_{mj} \]
\[ \beta_{jm} = \beta_{mj} \] (6)

The linear homogeneity conditions are imposed by normalizing total cost and input prices by dividing them all by one of input prices (Coelli et al., 1998; Berndt, 1991; Allen and Rai, 1996; Resti, 1997). Hence the translog stochastic cost frontier model to estimate the cost efficiency of public pension schemes must be reformulated as equation (7) by normalizing total cost and the price of labor using the price of physical capital (\( p_i \)) as a numeraire:

\[
\ln(C_{it}/p_{it}) = \alpha_o + \sum_{j=1}^{n} \alpha_j \ln(y_{ijt}) + \beta_1 \ln(p_{it}/p_{pt}) + \sum_{m=1}^{k} \sum_{j=1}^{n} \alpha_{jm} \ln(y_{jm}) \ln(y_{jm}) + \frac{1}{2} \beta_{1m} \ln(p_{it}/p_{pt})^2 + \sum_{j=1}^{n} \beta_j \ln(y_{jt}) \ln(p_{it}/p_{pt}) + u_{it} + u_{it} 
\] (7)

When the symmetry conditions are imposed, the final estimation model is specified as the following equation (8):

\[
\ln(C_{it}/p_{it}) = \alpha_o + \alpha_1 \ln(y_{it}) + \alpha_2 \ln(y_{i2t}) + \beta_1 \ln(p_{it}/p_{pt}) + \frac{1}{2} \alpha_1 (\ln(y_{i1t}))^2 + \frac{1}{2} \beta_1 (\ln(p_{it}/p_{pt}))^2 + \gamma_1 \ln(y_{it}) \ln(p_{it}/p_{pt}) + \gamma_2 \ln(y_{i2t}) \ln(p_{it}/p_{pt}) + u_{it} + u_{it}
\] (8)

4. Specification of Inputs and Outputs, and Data Sources

For the definition of inputs and outputs we use the systems model where inputs are used to produce outputs. Two outputs are the number of insured persons \( y_i \) and the number of beneficiaries \( y_b \).\(^5\) The two inputs are labor and physical capital. The unit price of labor \( p_i \) is proxied by the annual average of personnel expenses divided by the number of full-time equivalent employees. The unit price of physical capital \( p_{pt} \) is constructed as the annual average of overhead expenses divided by net tangible fixed assets. Overhead expenses include computing business expenses, equipment maintenance expenses and real estate working expenses. Net tangible fixed assets are calculated by including land, buildings, structures, machinery, vehicles and transportation equipment, and tools, furniture and fixtures, while excluding accumulated depreciation and construction in-progress (construction suspense account). In addition, personnel and overhead expenses and net tangible fixed assets are deflated by the Korean gross national product (GDP) at 1995 prices.

Total cost \( C \) is the annual average of all expenditure on labor and physical capital including the pension and fund sectors of public pension schemes as a proxy variable for total cost.

Considering the consistency and availability of data during the period of analysis, we chose three public pension schemes, such as the National Pension Scheme, the Government Employees Pension Scheme, and the Private School Teachers Pension Scheme. The settlement-based panel data for the period from 1988 through 1999 were used.

Data on outputs were taken from the “National Pension Statistical Yearbook” published by the National Pension Corporation, “Government Employees Pension Statistics” published by the Government Employees Pension Corporation, and “Private School Teachers Pension Statistical Yearbook” published by the Private School Teachers Pension Corporation. Data on personnel and overhead expenses and tangible fixed assets were based on the income statement and balance sheet of “Settlement Report” filed by the National Pension Corporation, “Settlement Report” filed by the Government Employees Pension Corporation, and “Settlement Report” filed by the Private School Teachers Pension Corporation, respectively. The definitions of the relevant variables and sources of data are given in Table 1.

\(^5\) The number of cases for paying benefits can be used as another output. However, since there is a high correlation between the number of beneficiaries and the number of cases for paying benefits, and a serious problem with the degree of freedom due to the application of a translog stochastic cost frontier function to a small sample of 36 may occur, the number of cases for paying benefits is excluded.
The mean, the standard deviation, the maximum, and the minimum of the number of insured persons (\(y_1\)) are showed to be 2,399,100 persons, 2,877,700 persons, 10,749,000 persons, and 141,310 persons, respectively, while the mean, the standard deviation, the maximum, and the minimum of the number of beneficiaries (\(y_2\)) are 239,890 persons, 389,800 persons, 1,269,000 persons, and 783 persons, respectively.

The input prices are 20.046 million won for labor (\(p_1\)) with the respective values of the standard deviation, the maximum, and the minimum being 12.494 million won, 57.617 million won and 6.743 million won, and 0.726 million won for physical capital (\(p_2\)) with the respective values of the standard deviation, the maximum, and the minimum being 1.633 million won, 7.142 million won and 0.018 million won.

5. Estimation Method

The parameters of the translog stochastic cost frontier function in equation (8) are estimated using the maximum-likelihood method. The appeal of maximum-likelihood estimation is that it should produce more efficient parameter estimates than either the fixed effects estimator or the random effects estimator, since it exploits distributional information that the other estimators do not (Kumbhakar and Lovell, 2000: 168).

To sum up the procedures of maximum-likelihood estimation briefly, the ordinary least squares estimates are used as starting values in the iterative process to obtain the maximum-likelihood estimates. First, a grid search over values of \(\gamma\) between 0 and 1 is conducted, and the value of \(\gamma\) which gives the largest value of the log-likelihood function is chosen.\(^6\) The next step involves using these estimates as starting values in an iterative maximization routine which obtains the maximum-likelihood estimates when the likelihood function attains its global maximum (Coelli, 1996).

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6. \(\gamma\) is the ratio of the variance of the cost inefficiency effects (\(\sigma_u^2\)) to the total residual variance (\(\sigma^2\)).
IV. Empirical Results and Implications

1. Empirical Results and Discussions

In this study, since managerial inefficiency of public pension schemes is measured by cost inefficiency, cost efficiency means managerial efficiency.

<table>
<thead>
<tr>
<th>Coefficients</th>
<th>Variables</th>
<th>Estimates</th>
<th>Standard error</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha_1$</td>
<td>constant</td>
<td>-30.714</td>
<td>35.329</td>
<td>-0.869</td>
</tr>
<tr>
<td>$\alpha_2$</td>
<td>$\ln y_1$</td>
<td>1.627</td>
<td>6.296</td>
<td>0.258</td>
</tr>
<tr>
<td>$\alpha_3$</td>
<td>$\ln y_2$</td>
<td>5.847</td>
<td>2.660</td>
<td>2.198*</td>
</tr>
<tr>
<td>$\beta_1$</td>
<td>$\ln(p_1/p_2)$</td>
<td>-0.617</td>
<td>2.505</td>
<td>0.246</td>
</tr>
<tr>
<td>$\alpha_2$</td>
<td>$1/2\ln y_1^2$</td>
<td>0.124</td>
<td>0.546</td>
<td>0.227</td>
</tr>
<tr>
<td>$\alpha_3$</td>
<td>$1/2\ln y_2^2$</td>
<td>-0.430</td>
<td>0.219</td>
<td>-1.960*</td>
</tr>
<tr>
<td>$\beta_1$</td>
<td>$1/2\ln(p_1/p_2)^2$</td>
<td>0.098</td>
<td>0.108</td>
<td>0.903</td>
</tr>
<tr>
<td>$\gamma_1$</td>
<td>$\ln y_1\ln y_2$</td>
<td>0.374</td>
<td>0.223</td>
<td>1.675*</td>
</tr>
<tr>
<td>$\gamma_2$</td>
<td>$\ln y_1\ln(p_1/p_2)$</td>
<td>-0.279</td>
<td>0.105</td>
<td>-2.664**</td>
</tr>
</tbody>
</table>

$log$-likelihood function $-0.359$

likelihood-ratio test statistic $20.078**$

* $p<0.05$, ** $p<0.01$.

The one-sided generalized likelihood-ratio tests for testing the null hypothesis, $H_0: \gamma=\eta=0$, which specifies that the stochastic frontier has time-invariant inefficiency effects with no cost inefficiency effects in the half-normal model, against the alternative hypothesis, $H_1: \gamma>0$, $\eta\neq0$, which specifies that there are time-varying inefficiency effects with half-normal distribution, provides a statistic of 20.078. This value is significant, because it exceeds the critical value for the mixed chi-square distribution at the 1% level of significance, 8.273, which is obtained from Table 1 of Kodde and Palm (1986) for the degrees of freedom equal to 3. Thus, the null hypothesis that there is a time-invariant cost inefficiency is rejected and instead the alternative hypothesis that there is a time-variant cost inefficiency is accepted. This indicates that the traditional average response function, which does not consider cost inefficiency effects, is not an adequate representation of the data.

The estimate of $\gamma$ is 0.984 and significant, because the t-value with the estimated standard error of 0.016 is much greater than the critical value. These results are consistent with the conclusion that the true $\gamma$-value is concluded to be greater than zero. In addition, the $\gamma$-estimate is not significantly different from one, which means that the vast majority of residual variation is due to the inefficiency effect and that the random error is approximately zero. Hence the stochastic frontier model may not be significantly different from the deterministic frontier, in which there are no random errors in the cost function.

Inefficiency decreases over time if $\eta$ is positive, increases if $\eta$ is negative, and keeps steady if $\eta$ is zero (Resti, 1997: 228). The value of $\eta$ is negative and significant at the 1% level of significance. This indicates that the operational inefficiency of public pension schemes has increased by 21.2% per year.

The cost efficiency estimates of the three public pensions in 1988 show that the cost efficiency of public pension A, B, C is 0.762, 0.944, 0.980, respectively. This means that as for public pension B, for exam-

7. For the critical values of a mixed chi-square distribution to test jointly for the equality and inequality restrictions, see Table 1 of Kodde & Palm (1986: 1246).
8. Referring to a time-varying technical inefficiency model as proposed by Battese and Coelli(1992), a time-varying model for the cost inefficiency effects in the stochastic cost frontier function for panel data is specified as follows:

$$u_t = \exp(\gamma(T-t))u_t^{(t)}, \quad t=1,2,\ldots,T$$

where if the parameter, $\eta_t$, is positive, then $\eta_t(T-t)\eta(T-t)$ is non-negative and so $\exp(-\eta(T-t))$ is no smaller than one, which means that $u_t\geq u_t$. On the contrary, if $\eta<0$, then $\eta(T-t)\leq 0$ and so $u_t\leq u_t$. In addition, when $\eta=0$, the time-varying inefficiency model is reduced to the time-invariant model, which is a special case of the former.
The annual operating efficiencies of public pension C have the respective ratings of 0.980 in 1988, 0.964 in 1991, 0.933 in 1994, 0.876 in 1997, and 0.816 in 1999, which implies that its efficiencies decrease over time, but are inclined to decrease to the smallest extent of the three public pensions.

The total annual averages of managerial efficiencies of the three public pension systems are revealed to be 0.885 in 1988, 0.786 in 1991, 0.609 in 1994, 0.341 in 1997, and 0.156 in 1999, which indicates that their efficiencies tend to decrease over time. Here it is noted that managerial inefficiencies are likely to increase 21.2% per year. This may be due to the inefficient use of inputs given outputs of public pension schemes. That is, personnel restructuring seems to be deterred and tangible fixed assets are excessive relative to the optimal size.

As can be seen in Table 4, the annual managerial efficiencies of public pension A show the respective values of 0.762 in 1988, 0.600 in 1991, 0.381 in 1994, 0.161 in 1997, and 0.062 in 1999, and its cost efficiencies are likely to decrease to the greatest extent of the three public pensions.

The annual operational efficiencies of public pension B have the respective estimates of 0.944 in 1988, 0.898 in 1991, 0.816 in 1994, 0.680 in 1997, and 0.553 in 1999, which suggests that its efficiencies decrease over time, but are inclined to decrease to an intermediate extent of the three public pensions.

The total annual averages of managerial efficiencies of the three public pension systems are revealed to be 0.885 in 1988, 0.786 in 1991, 0.609 in 1994, 0.341 in 1997, and 0.156 in 1999, which indicates that their efficiencies tend to decrease over time. Here it is noted that managerial efficiencies are likely to increase 21.2% per year. This may be due to the inefficient use of inputs given outputs of public pension schemes. That is, personnel restructuring seems to be deterred and tangible fixed assets are excessive relative to the optimal size.

The averages of managerial efficiencies from 1988 to 1999 in the three public pension systems show that public pension C has the highest efficiency of 0.922, followed by public pension B with the efficiency of 0.789, while public pension A has the lowest level of 0.326. The great difference between managerial efficiencies of the three public pension systems might stem from operating cost inefficiency immanent in the different history of each public pension.

In sum, overall managerial efficiency is estimated to be 52.6%, indicating that on average the three public pension schemes could produce the current levels of outputs with 47.4% less operating costs. Corporation-specific operating cost efficiency estimates show a considerable level of efficiency dispersion among public pension schemes, which is suggestive of the diversity of the operating environments and performance among them. This implies that imminent efforts for improving the management of public pension schemes are needed.

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9. In consideration of the historical characteristic and prestige of each public pension scheme, this paper keeps anonymity.
stochastic cost frontier function, different input price data by organizational unit are required, but in a lot of cases organizational units may have the same price data, or even if there are different input prices, it is very difficult to obtain them. Since public enterprises have the responsibility of reporting financial statements such as a balance sheet and income statement, input price data is obtainable without many difficulties, while it is almost impossible to get price data on the inputs of general governments. These problems would be overcome if the budget accounting information system based on the accrual basis could be established in the near future, because the accrual basis accounting includes financial statements such as a balance sheet and income statement.

Considering that the stochastic frontier model has great difficulty in obtaining input prices data, whereas the data envelopment method has the advantage of providing inefficient decision-making units with useful management information to benchmark the efficient organizations through the identification of reference groups, we had better use the stochastic cost frontier analysis and data envelopment analysis complementarily in evaluating the performance of the public sector.

V. Concluding Remarks

Korean public pension schemes, which consist of the National Pension Scheme, the Government Employees Pension Scheme, the Military Personnel Pension Scheme, and the Private School Teachers Pension Scheme, are faced with serious institutional problems such as financial instability due to the structural imbalance between low contributions and high benefits, hasty coverage expansion due to the rapid growth of the aging population, opaque management of the pension reserve management, and managerial inefficiency.

This study measured and evaluated the cost efficiency of Korean public pension schemes including the National Pension Scheme, the Government Employees Pension Scheme, and the Private School Teachers Pension Scheme using a translog stochastic cost frontier function model for

2. Implications

The implications derived from the above-mentioned empirical results are divided into two parts, which are composed of policy and methodological implications. As for policy implications, first, the personnel and maintenance expenses of public pension corporations need to be reduced much more than the current levels with the rationalization of the management system in public pension schemes. Second, the management system of public pension schemes should be integrated, but the operation of finance and funds needs to be separated. Third, functional linkage and integration should be considered by integrating the coverage, imposition and collection functions disconnected with each social insurance. Fourth, the management style needs to be changed from the viewpoint of consumers rather than suppliers. Fifth, to enhance the organic linkage functions among social insurances tentatively named the ‘Pension Insurance Corporation’ dealing with public pension, health insurance, industrial accident compensation insurance and employment insurance, or the ‘Welfare Insurance Corporation’ coping with public pension and health insurance should be established. Finally, the linkage system between public and private pensions should be established by introducing private pensions to the pension system dependent on public pensions excessively.

Next, methodological implications are that since the stochastic frontier analysis measures only the inefficiency effects separated from the error terms, which are made up of random errors and cost inefficiency effects, it measures the operational inefficiency of organizations more accurately than data envelopment analysis.

However, the stochastic frontier analysis has some problems as well. First, there is no a priori justification for the selection of any particular distributional form for the cost inefficiency effects. Second, when using a translog stochastic cost frontier function, different input price data by organizational unit are required, but in a lot of cases organizational units may have the same price data, or even if there are different input prices, it is very difficult to obtain them. Since public enterprises have the responsibility of reporting financial statements such as a balance sheet and income statement, input price data is obtainable without many difficulties, while it is almost impossible to get price data on the inputs of general governments. These problems would be overcome if the budget accounting information system based on the accrual basis could be established in the near future, because the accrual basis accounting includes financial statements such as a balance sheet and income statement.

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10. Bang et al. (1999) also proposed options similar to those suggested in this paper.
11. For more detailed explanations of pension reform proposed by the World Bank and International Labour Office (ILO), see Holzman (2000) and Gillion (2000). In addition, for options for the balanced development of public and private pensions, see Yoon et al. (1999b).
the panel data from 1988 through 1999 in order to establish an evaluation system for the efficient management of public pension systems by comparing their relative operational efficiency and to determine their overall management performance with a single measure.

The empirical results show that the overall cost efficiency of the three public pension schemes is 52.6%, which means that their inefficiency amounts to 47.4%, and that there is a great difference between the operational efficiency of the three pensions with their respective cost efficiency estimates of 32.6%, 78.9%, and 92.2%. This implies that fundamental reforms to improve the operating system of public pension systems should be carried out in a consistent and urgent way.

Policy implications are that policy actions such as restructuring and management innovation of public pension schemes, integration of public pension schemes, private management of the pension reserve fund, establishment of a three-pillar pension system that attaches importance to the organic and complementary functions of public pensions, corporate pensions and personal pensions, should be implemented as soon as possible.

Methodological implications are that both a stochastic frontier analysis and a data envelopment analysis need to be used complementarily in measuring and assessing the performance of the public sector, because even if the former measures the cost inefficiency effects separated from the error term, it has the limitation of getting the input price data of the public sector, while the latter has the merit of suggesting useful management information of input and output slacks, and reference groups for benchmarking.

References


