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An Analysis of Operating Efficiency in Senior Citizen Welfare Institutions – Application of Bounded-variable and Meta-frontier Data Envelopment Analysis

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Abstract—**This research aims at studying the operating efficiency of senior citizen welfare institutions in Taiwan. We evaluate technical efficiency (TE), technology gap ratio (TGR), and meta-frontier technical efficiency (MTE) by bounded-variable and meta-frontier data envelopment analysis. In the empirical study, we examine 91 welfare institutes for senior citizens in Taiwan. We also apply Tobit regression to study influences of relevant factors on operating efficiency.**

Keywords—Senior Citizens Welfare Institution, Operating Efficiency, Bounded- variable and Meta-frontier Data Envelopment Analysis.

I. INTRODUCTION

According to the World Health Organization, a society with a population of 7% or above of 65 years and older is categorized as an aging society. Taiwan census data shows that the percentage of the population above 65 years old has increased from 6.81% in 1992 to 11.2% in 2012. Based on the report "Population Projections for R.O.C. (Taiwan): 2012~2060", the aging population is estimated to increase to 39.4% of the total population in 2060. The elderly dependency ratio (the ratio of the number of people aged 65 and older to the number of people aged from 15 to 64) is projected to soar from the current ratio of 15% to 77.7%, while the aging index (the ratio of the number of people aged 65 and older to the number of people aged from 0 to 14) is forecasted to jump from 76.3% to 401.5% in 2060. The society is aging at a frightening rate.

Ensuring senior citizens' welfare, living standards, and health have become the major priorities in the long-term development of the country. In 2009, the Taiwanese government passed the Senior Citizens Welfare Act, which regulates the scale, area, facility, staff and scope of senior citizen welfare institutions. Article 37 of the act requires senior citizen welfare institutions to be supervised, inspected, evaluated and rewarded by the central, municipal and city governments periodically in order to ensure quality and protect the rights of senior citizens and their families.

The purpose of this research is to study the operating efficiency of senior citizen welfare institutions. We classify senior citizen welfare institutions based on two criteria: service scope (general and nursing homes) and ownership (public foundation, private foundation and private affiliate). For each classification, we adopt bounded-variable data envelopment analysis (DEA) and meta-frontier analysis to assess technical efficiency, technical gap ratio and meta-frontier efficiency for each institution. Then we apply Tobit regression to study influences of relevant factors on operating efficiencies.

This paper is organized as follows. We introduce relevant literature in Section II, present the mathematical formulations and models in Section III, and conduct an empirical study in Section IV. Conclusions are provided in Section V.

II. LITERATURE REVIEW

In this section, we summarize relevant literature on data envelopment analysis and meta-frontier analysis.

A. Data envelopment analysis

Data envelopment analysis (DEA) is a non-parametric programming method to evaluate relative efficiency of organizations with multiple outputs and inputs.

DEA analysis has been in the literature since 1978 and has been applied to many industries, including the health care sector. Nyman et al. (1990) constructed an output-oriented DEA model to study the relations among case-mix, resident accommodation rate and technical efficiency in nursing homes. Fizel & Nunnikhoven (1992) grouped nursing homes according to care intensity of residents and investigated relative efficiency among groups. Michael et al. (1995) examined 461 nursing homes in Pennsylvania and found that environmental factors such as the ownership, occupancy rate, employee salary and payment source have greater impact on operating efficiency than service quality characteristics. Chen (2002) assessed 55 chartered nursing homes in Taiwan using DEA analysis and studied the impact of ownership, scale and time length of operation. Yang (2008) incorporated environmental input and output variables in DEA to study environmental impact on efficiency.

B. Meta-frontier analysis

Meta-frontier analysis has been a very popular approach comparing the efficiency of one subject in a group with another subject in a different group. DEA mentioned above helps to compare efficiency within a group of subjects with similar characteristics. However, cross comparison allows us to examine whether the inefficiency is due to group specific characteristics. Therefore, meta production function was introduced by Hayami (1969) and Hayami & Ruttan (1970) to study agricultural production efficiency among different countries. Battese, et al. (2004) used meta production functions to study the technical efficiency and technical gap ratio across firms of different technology groups in the agriculture sector. O'Donnell et al. (2008) constructs meta-frontier model to assess efficiency across countries with different technologies. In the health care industry, Knox et al. (2007) examines nursing homes in Texas by a stochastic

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frontier function and shows that profit institutions are more efficient than non-profit institutions and that the industry has constant returns to scale.

III. MODELS

We construct three mathematical models to study the efficiency of senior citizen welfare institutions: bounded-variable data envelopment analysis, meta-frontier analysis and Tobit regression models.

A. Bounded-variable data envelopment analysis

DEA identifies an efficiency frontier, which represents the best available technical efficiency within a group of institutions. DEA provides a simple and effective analysis to evaluate relative efficiency among institutions. However, when some of the inputs and outputs are non-discretionary, ordinary DEA does not apply. For example, in the senior citizen welfare industry, the lack of nursing personnel is a common situation in Taiwan. The number of nursing personnel is confined by the environment. Therefore, we set the number of nursing personnel at the time of data collection as a lower bound and set the lawful maximum capacity of senior citizens that each institution can accommodate as the upper bound. Thus, a bounded-variable DEA is constructed as follows.

$$\begin{aligned} &\text{Max} \quad \theta \\ &\text{s.t.} \ \theta y_0^c \geq Y^c \lambda \\ &\quad x_0^c \leq X^c \lambda \\ &\quad l_0^{N_y} \leq Y^N \lambda \leq u_0^{N_y} \\ &\quad l_0^{N_x} \leq X^N \lambda \leq u_0^{N_x} \\ &\quad L \leq \Sigma\lambda \leq U \\ &\quad \lambda \geq 0. \end{aligned} \tag{1}$$

θ : Stands for the optimal value of output-oriented bounded-variable in the DEA model.

X^c, Y^c : Represent the discretionary input and output matrix respectively.

x_0^c, y_0^c : Denote the discretionary input and output vector of correspondent respectively.

$l_0^{N_x}, u_0^{N_x}$: Indicate the lower and upper bound vector of non-discretionary inputs respectively.

$l_0^{N_y}, u_0^{N_y}$: Denote the lower and upper bound vector of non-discretionary outputs respectively.

L , U : Indicate the lower and upper bound of weighted sum ($\Sigma\lambda$) respectively.

B. Meta-frontier analysis

Meta-frontier analysis allows us to compare efficiency frontiers across groups of institutions. To obtain the meta-frontier efficiency, we propose the following steps.

1) Calculate technical efficiency (TE_i^j) for each institute by the bounded-variable DEA model, Eq.(1), where TE_i^j represents technical efficiency of institution i in group j.

2) Obtain the technical gap ratio (TGR). TGR estimates the ratio of the efficiency of an institution to the overall efficiency of all institutions. TGR is obtained by inserting TE values and the target output values obtained from Step 1 into the same bounded-variable DEA model, Eq. (1).

3) Calculate Meta-frontier efficiency by combing results from step 1 and 2 as in Eq.(2).

$$MTE_i^j = TE_i^j \times TGR_i^j \leq 1 \tag{2}$$

C. Tobit regression analysis

In order to study the impact of accommodating rates and accreditation results on efficiency measures (TE, TGR, and MTE), we apply Tobit regression. Tobit regression was introduced by Nobel prize winner James Tobin in 1958 to deal with situations where dependent variables are not linear and the ordinary least squares approach is not applicable. In our research, efficiency measures from the DEA model are between 0 and 1. If we apply the ordinary least squares regression, we might observe values greater than 1. Thus, we define dummy variables (EVA_H & EVA_M) to denote accreditation results: Excellent, A and B, and C and D. We separately formulate Tobit regression for each classification of institutions.

For service scope classification:

$$\begin{aligned} TE_i &= \alpha_0 + \alpha_1 ACR_i + \alpha_2 CAR_i + \alpha_3 EVA_H + \alpha_4 EVA_M + \varepsilon_i \\ TGR_i &= \beta_0 + \beta_1 ACR_i + \beta_2 CAR_i + \beta_3 EVA_H + \beta_4 EVA_M + \varepsilon_i \\ MTE_i &= \gamma_0 + \gamma_1 ACR_i + \gamma_2 CAR_i + \gamma_3 EVA_H + \gamma_4 EVA_M + \varepsilon_i , \end{aligned} \tag{3}$$

where

TE_i : Technical efficiency of institution i

TGR_i: Technical gap ratio of institution i

MTE_i : Meta-frontier efficiency of institution i

ACR_i : Accommodation rate of institution i

CAR_i: Dummy variable (general institution:1; nursing homes:0)

EVA_H: Dummy variable (1 for accreditation result= Excellent; 0 for otherwise)

EVA_M: Dummy variable (1 for accreditation result=A or B; 0 for otherwise)

ε_i : Residual.

For ownership classification:

$$\begin{aligned} TE_i &= \delta_0 + \delta_1 ACR_i + \delta_2 OPE_1 + \delta_3 OPE_2 + \delta_4 EVA_H + \delta_5 EVA_M + e_i \\ TGR_i &= \rho_0 + \rho_1 ACR_i + \rho_2 OPE_1 + \rho_3 OPE_2 + \rho_4 EVA_H + \rho_5 EVA_M + e_i \\ MTE_i &= \theta_0 + \theta_1 ACR_i + \theta_2 OPE_1 + \theta_3 OPE_2 + \theta_4 EVA_H + \theta_5 EVA_M + e_i, \end{aligned} \tag{4}$$

where

TE_i : Technical efficiency of institution i

TGR_i: Technical gap ratio of institution i

MTE_i : Meta-frontier efficiency of institution i

ACR_i : Accommodation rate of institution i

OPE_1 : Dummy variable (1 for public institutions; 0 otherwise)

OPE_2: Dummy variable (1 for private foundations; 0 otherwise)

EVA_H: Dummy variable (1 for accreditation result= Excellent; 0 for otherwise)

EVA_M: Dummy variable (1 for accreditation result=A or B; 0 for otherwise)

ε_i : Residual.

IV. EMPIRICAL RESULTS

This section describes our data and provides empirical results for bounded-variable DEA, meta-frontier analysis and Tobit regression.

A. Data collection and descriptive statistics

Our data was collected from the 2011 Senior Citizens Welfare Institutions Accreditation Report by the Executive Yuan. After removing 36 subjects with missing data and excluding one subject that exceeds its lawful accommodation capacity, we have 91 senior citizen welfare institutions in total.

Input variables include the floor area (FLO), direct nursing personnel (DSP), indirect personnel (ISP) and accommodation capacity (PEO). Considering the lack of nursing personnel in Taiwan, we set the current nursing employment of an institution at the time of accreditation report as the lower bound and the maximum nursing employment in the database as the upper bound for direct nursing personnel. Output variables include the actual accommodation (APE) and number of government subsidized citizens (PEP). According to Senior Citizens Welfare Act of Taiwan, each institution is enforced with a maximum number of accommodations. Therefore, we set the maximum number as the upper bound for APE. Meanwhile, for institutions without any government subsidized senior citizens, we impose 0.1 on PEP instead of 0 to fit assumptions of DEA modeling. Detailed variable definitions are listed in Table I.

TABLE I. VARIABLES DEFINITONS

Variable	Notation	Unit	Definition
Input variables			
Floor area	FLO	Square meters	Area of floor for the buildings
Direct nursing personnel	DSP	People	Nursing personnel, social workers, care givers and other professionals related to the services provided
Indirect personnel	ISP	People	Administrative personnel include administration, technicians, pharmacists, sanitary personnel, etc.
Accommodation capacity	PEO	people	Maximum lawful accommodation capacity
Output variables			
Actual accommodation	APE	People	Actual accommodations at the time of accreditation report
Number of government subsidized senior citizens	PEP	People	The number of senior citizens receiving government subsidies.

In Table II, we show the summary statistics of input and output variables for ownership classification. It can be observed that the averages of input and output variables of public institutions are greater than those of the other two types of institutions. Thus, we expect to observe distinct operating efficiency. Similar to ownership classification, we also note distinct summary statistics between groups in service scope classification, shown in Table III. We expect to observe distinct efficiency of general institutions from nursing homes.

TABLE II. SUMMARY STATISTICS: OWNERSHIP CLASSIFICATION

	Statistics	Public	Private foundation	Affiliate Foundation	Total
FLO	Average	3.539	0.835	1.582	1.482
	Maximum	6.200	5.082	10.500	10.500
	Minimum	0.357	0.023	0.050	0.023
	Standard Deviation	1.887	1.182	2.375	2.028
DSP	Average	58.273	31.585	36.103	36.747
	Maximum	117.000	114.000	117.000	117.000
	Minimum	10.000	7.000	8.000	7.000
	Standard Deviation	38.092	22.431	24.073	26.429
ISP	Average	22.182	8.854	9.667	10.813
	Maximum	67.000	33.000	31.000	67.000
	Minimum	2.000	1.000	3.000	1.000
	Standard Deviation	18.904	7.087	5.555	9.653
PEO	Average	300.636	124.098	166.744	163.714
	Maximum	544.00	403.000	512.000	544.000
	Minimum	34.000	20.000	25.000	20.000
	Standard Deviation	149.210	85.301	124.061	123.355
APE	Average	237.273	95.049	115.103	120.835
	Maximum	481.000	384.000	414.000	481.000
	Minimum	10.000	17.000	21.000	10.000
	Standard Deviation	142.475	69.261	92.377	99.824
PEP	Average	133.564	22.468	21.864	35.638
	Maximum	481.000	257.000	149.000	481.000
	Minimum	0.100	0.100	0.100	0.100
	Standard Deviation	145.696	41.514	37.545	71.084

TABLE III. SUMMARY STATISTICS: SERVICE SCOPE CLASSIFICATION

Variable	Statistics	General	Nursing homes	Total
FLO	Average	2.228	0.487	1.482
	Maximum	10.500	4.580	10.500
	Minimum	0.109	0.023	0.023
	Standard Deviation	2.327	0.833	2.028
DSP	Average	42.596	28.949	36.747
	Maximum	117.000	114.000	117.000
	Minimum	8.000	7.000	7.000
	Standard Deviation	29.417	19.586	26.429
ISP	Average	13.385	7.385	10.813
	Maximum	67.000	26.000	67.000
	Minimum	2.000	1.000	1.000
	Standard Deviation	11.264	5.413	9.653
PEO	Average	208.962	103.385	163.714
	Maximum	544.000	250.000	544.000
	Minimum	34.000	20.000	20.000
	Standard Deviation	137.650	63.813	123.355
APE	Average	152.712	78.333	120.835
	Maximum	481.000	179.000	481.000
	Minimum	10.00	17.000	10.000
	Standard Deviation	116.589	45.969	99.824
PEP	Average	45.681	22.249	35.638
	Maximum	481.000	149.000	481.000
	Minimum	0.100	0.100	0.100
	Standard Deviation	88.958	32.014	71.084

Table IV shows the correlation coefficient between input and output variables. We observe that most of the inputs and outputs are positively correlated in both classifications; in

particular, accommodating capacity is highly correlated with actual accommodation.

TABLE IV. CORRELATION OF COEFFICIENT

Service scope				
General				
	FLO	DSP	ISP	PEO
APE	0.387	0.838	0.608	0.875
	(2.970***)	(10.853***)	(5.422***)	(12.771***)
PEP	0.153	0.464	0.653	0.515
	(1.093)	(3.704***)	(6.103***)	(4.250***)
Nursing homes				
	FLO	DSP	ISP	PEO
APE	0.436	0.659	0.362	0.935
	(2.943***)	(5.326***)	(2.360**)	(15.979***)
PEP	0.158	0.364	0.175	0.475
	(0.975)	(2.373**)	(1.081)	(3.287***)
Ownership				
Public				
	FLO	DSP	ISP	PEO
APE	-0.156	0.853	0.714	0.912
	(-0.474)	(4.911***)	(3.057**)	(6.678***)
PEP	-0.079	0.589	0.763	0.685
	(-0.237)	(2.188**)	(3.543***)	(2.823**)
Private Foundation				
	FLO	DSP	ISP	PEO
APE	0.548	0.663	0.517	0.930
	(4.096***)	(5.536***)	(3.772***)	(15.759***)
PEP	0.339	0.440	0.304	0.619
	(2.249**)	(3.061***)	(1.991**)	(4.921***)
Affiliate Foundation				
	FLO	DSP	ISP	PEO
APE	0.504	0.840	0.403	0.838
	(3.552***)	(9.426***)	(2.676***)	(9.348***)
PEP	-0.082	0.067	-0.106	0.055
	(-0.500)	(0.408)	(-0.649)	(0.338)

( ):T VALUES. *, ** AND *** REPRESENTS 10, 5, AND 1% LEVEL OF SIGNIFICANCE.

B. Operating efficiency results

This section shows our findings of the technical efficiency, technical gap ratio, and meta-frontier efficiency of 91 senior citizen welfare institutions in Taiwan.

1) Technical efficiency

This section presents the empirical results for the bounded-variable DEA model in Eq.(1). We select the floor area (FLO), direct nursing personnel (DSP), indirect personnel (ISP) and accommodation capacity (PEO) as input variables, and the actual accommodation (APE) and number of government subsidized senior citizens (PEP) as output variables. Empirical results of the constant returns to scale bounded-variable DEA are shown in Table V and Table VI.

According to Table V, TE values of general and nursing institutions do not differ significantly from each other. The overall room for TE improvement in service scope classification is around 55.3~64.4%. Primary and target averages of all input and output variables of general institutions are significantly higher than those of nursing homes. In ownership classification as displayed in Table VI, public institutions are the most efficient institutions, with the highest TE, among all three types of ownership. Room for TE improvement in the ownership classification is ranged from 24.7% to 66.5% depending on the ownership types. The primary and target averages of all input and output data of public institutions are higher than those of private institutions.

TABLE V. TECHNICAL EFFICIENCY RESULTS OF SERVICE SCOPE CLASSIFICATION

		General	Nursing homes	T test
TE	Average	0.356	0.447	-1.075
	Maximum	1.000	1.000	
	Minimum	2.8E-04	8.7E-04	
	Standard deviation	0.393	0.409	
	Number of efficient institutions	9	10	
	Number of inefficient institutions	43	29	
FLO	Primary average	2.228	0.487	4.459***
	Target average	1.550	0.136	4.741***
	Gap of improvement	-18.190%	-39.116%	3.012***
DSP	Primary average	42.596	28.949	2.508**
	Target average	47.236	30.622	3.127***
	Gap of improvement	23.612%	8.539%	1.851*
ISP	Primary average	13.385	7.385	3.068***
	Target average	12.692	4.489	4.464***
	Gap of improvement	-3.720%	-28.780%	-6.043***
PEO	Primary average	208.962	103.385	4.441***
	Target average	200.044	103.385	4.227***
	Gap of improvement	-3.246%	0%	-2.085**
APE	Primary average	152.712	78.333	3.766***
	Target average	166.115	95.895	3.705***
	Gap of improvement	28.984%	20.969%	0.717
PEP	Primary average	45.681	22.249	1.569
	Target average	118.432	67.869	2.987***
	Gap of improvement	508.829%	414.000%	1.016

*, ** AND *** REPRESENTS 10, 5 AND 1% LEVEL OF SIGNIFICANCE

TABLE VI. TECHNICAL EFFICIENCY RESULTS OF OWNERSHIP CLASSIFICATION

		Public	Private foundation	Affiliate foundation	F test
TE	Average	0.753	0.405	0.335	4.724**
	Maximum	1.000	1.000	1.000	
	Minimum	6.68E-0.4	7.77E-04	2.68E-04	
	Standard deviation	0.384	0.400	0.403	
	Number of efficient institutions	7	9	7	
	Number of inefficient institutions	4	32	32	
FLO	Primary average	3.539	0.835	1.582	9.216***
	Target average	2.424	0.358	0.548	11.229***
	Gap of improvement	-20.491%	-40.079%	-49.541%	2.592*
DSP	Primary average	58.273	31.585	36.103	4.819*
	Target average	60.764	40.129	38.957	3.504**
	Gap of improvement	11.064%	41.797%	17.887%	2.669*
ISP	Primary average	22.182	8.854	9.667	10.619***
	Target average	22.182	6.101	6.541	20.807***
	Gap of improvement	0%	-19.715%	28.770%	5.523***
PEO	Primary average	300.636	124.098	166.744	10.852***
	Target average	289.817	124.098	156.665	10.747***
	Gap of improvement	-2.862%	0%	-2.565%	1.289
APE	Primary average	237.273	95.049	115.103	10.871***

	Target average	230.6001	117.534	142.977	6.282***
	Gap of improvement	17.965%	26.429%	36.331%	0.630
PEP	Primary average	133.564	22.468	21.864	15.771***
	Target average	168.444	67.914	97.333	7.508***
	Gap of improvement	147.207%	442.436%	555.412%	3.870**

*, ** AND *** REPRESENTS 10, 5 AND 1% LEVEL OF SIGNIFICANCE

2) Technical gap ratio

To obtain the technical gap ratio, we refer to Section III. B. (2. for details. Table VII illustrates the results for service scope classification. We observe that the average TGR of nursing homes is higher than that of general institutions. Furthermore, the maximum TGR is 1 and minimum is 0.906, indicating the efficient frontier of nursing homes is very close to meta-frontier. It can be seen that in Table VIII three types of institutions in the ownership classification are close to the meta-frontier. In particular, the efficient frontier of private foundation institutions, with a maximum of 1 and a minimum of 0.918, is the closest to the meta-frontier.

TABLE VII. TECHNICAL GAP RATIO RESULTS OF SERVICE SCOPE CLASSIFICATION

		General	Nursing homes	T test
TGR	Average	0.756	0.972	5.224***
	Maximum	1.000	1.000	
	Minimum	0.001	0.906	
	Standard deviation	0.257	0.072	
FLO	Primary average	2.228	0.487	4.459***
	Target average	0.453	0.191	4.057***
	Gap of improvement	-57.875%	-26.873%	4.626***
DSP	Primary average	42.596	28.949	2.508**
	Target average	46.770	30.604	3.103***
	Gap of improvement	21.863%	8.448%	1.934*
ISP	Primary average	13.385	6.529	3.068***
	Target average	12.969	4.489	3.429***
	Gap of improvement	-1.900%	-6.870%	1.820*
PEO	Primary average	208.962	103.385	4.441***
	Target average	193.373	103.385	4.211***
	Gap of improvement	-3.782%	0%	1.878*
APE	Primary average	152.712	78.333	3.766***
	Target average	176.263	94.544	4.190***
	Gap of improvement	7.367%	-1.836%	5.338***
PEP	Primary average	45.681	22.249	1.569
	Target average	145.644	70.089	4.334***
	Gap of improvement	91.013%	2.935%	2.361**

*, ** AND *** REPRESENTS 10, 5 AND 1% LEVEL OF SIGNIFICANCE

TABLE VIII. TECHNICAL GAP RATIO RESULTS OF OWNERSHIP CLASSIFICATION

		Public	Private foundation	Affiliate foundation	F test
TGR	Average	0.871	0.983	0.968	9.910**
	Maximum	1.000	1.000	1.000	
	Minimum	0.317	0.918	0.822	
	Standard deviation	0.201	0.027	0.039	
FLO	Primary average	3.539	0.835	1.582	9.216***
	Target average	0.776	0.245	0.318	15.007***
	Gap of improvement	-72.892%	-37.488%	-44.069%	4.810***
DSP	Primary average	58.273	31.585	36.103	4.819*
	Target average	65.744	33.765	38.924	7.744***
	Gap of improvement	24.190%	12.415%	17.724%	0.619
ISP	Primary average	22.182	8.854	9.667	10.619***
	Target average	22.182	8.127	9.022	13.026***
	Gap of improvement	0%	-4.284%	-4.900%	0.614
PEO	Primary average	300.636	124.098	166.744	10.852***
	Target average	286.758	124.350	153.813	12.497***
	Gap of improvement	-3.353%	-1.182%	-2.854%	0.391
APE	Primary average	237.273	95.049	115.103	10.871***
	Target average	258.724	120.251	147.260	9.063***
	Gap of improvement	32.483%	1.776%	3.736%	8.464***
PEP	Primary average	133.564	22.468	21.864	15.771***
	Target average	212.790	74.465	102.762	14.773***
	Gap of improvement	126.420%	9.408%	46.645%	2.636*

*, ** AND *** REPRESENTS 10, 5 AND 1% LEVEL OF SIGNIFICANCE

3) Meta-frontier efficiency

In order to compare efficiency between groups of institutions with distinct characteristics, we compute meta-frontier efficiency by Eq. (2). Table IX and X display the results for the service scope and ownership classification respectively. We also compare meta-frontier with pooled efficiency frontier in Table XI.

In Table IX, the average TE, TGR and MTE of nursing homes are all greater than those of general institutions. From TE values, we remark a room of 55.3~64.4% for improvement in efficiency. The Average TGR values, both close to 1, show that the two types of institutions are close to the meta-frontier. In terms of MTE, we find a 56.1~76.1% room for improvement.

TABLE IX. MTE RESULTS OF SERVICE SCOPE CLASSIFICATION

		General	Nursing homes	T test
TE	Average	0.356	0.447	1.075
TGR	Average	0.769	0.972	5.224***
MTE	Average	0.239	0.439	2.675***

*** REPRESENTS 1% LEVEL OF SIGNIFICANCE

The average TE of public institutions in ownership classification is significantly greater than that of other two types of institutions as displayed in Table X. Average TGRs of all three types of institutions show that their efficiency frontiers are close to the meta-frontier. MTE values are between 0.324~0.649, indicating a 35.1~67.6% room for improvement.

TABLE X. MTE RESULTS OF OWNERSHIP CLASSIFICATION

		Public	Private foundation	Public	Affiliate foundation	Private foundation	Affiliate foundation
TE	Average	0.753	0.405	0.753	0.335	0.405	0.335
	T test	(2.583**)		(3.065***)		(0.777)	
	F test	(4.724***)					
TGR	Average	0.871	0.983	0.871	0.968	0.983	0.968
	T test	(-3.546***)		(-2.883**)		(2.095**)	
	F test	(9.910**)					
MTE	Average	0.649	0.399	0.649	0.324	0.399	0.324
	T test	(1.889*)		(2.469**)		(0.857)	
	F test	(2.977**)					

*, ** AND *** REPRESENTS 10, 5 AND 1% LEVEL OF SIGNIFICANCE

In Table XI, we observe that the pooled efficiency frontier is lower than the meta-frontier in both classifications. It indicates that the former tends to underestimate efficiency.

TABLE XI. COMPARISON OF POOLED AND META FRONTIER FRONTIERS

		Pooled frontier	Meta-frontier	T test
Service scope	Average	0.267	0.325	1.170
Ownership	Average	0.267	0.397	2.482***

*** REPRESENTS 1% LEVEL OF SIGNIFICANCE

C. Tobit regression

We apply censored Tobit regression as in Eq.(3&4). TE, TGR and MTE are explained variables while the accreditation result, type of institution and accommodation rate of each institution are explanatory variables. Results for service scope and ownership classifications are shown in Table XII.

TABLE XII. TOBIT REGRESSION RESULTS

Service scope					
	Residual	ACR	CAR	EVA_H	EVA_M
TE	0.120 (0.520)	0.007 (2.850***)	-0.029 (-0.281)	-0.047 (-0.230)	-0.276 (-1.870*)
TGR	1.185 (10.735***)	-0.006 (-0.528)	-0.268 (-5.534***)	-0.200 (-2.020**)	-0.108 (-1.475)
MTE	0.280 (1.477)	0.005 (2.558***)	-0.165 (-1.994**)	-0.225 (-1.363)	-0.289 (-2.418**)

Ownership						
	Residual	ACR	OPE_1	OPE_2	EVA_H	EVA_M
TE	0.136 (0.588)	0.008 (2.944***)	0.659 (3.652***)	0.040 (0.366)	-0.125 (-0.549)	-0.421 (-2.776***)
TGR	0.892 (17.352***)	0.001 (2.240**)	-0.099 (-2.957***)	0.061 (2.383**)	-0.015 (-0.323)	-0.008 (0.241)
MTE	0.070 (0.356)	0.008 (3.600***)	0.359 (2.610***)	0.024 (0.262)	-0.232 (-1.245)	-0.375 (-2.942***)

( ):Z values. *, ** And *** Represents 10, 5 And 1% Level Of Significance

In the service scope classification, ACR has a positive impact on TE. However, accreditation result=A or B (EVA_M) has a negative influence on TE. General institution (CAR) and accreditation result= Excellent (EVA_H) have a negative impact on TGR. ACR is positively related to MTE, whereas general institution (CAR) and accreditation result=A or B (EVA_M) are negatively correlated to MTE.

In the ownership classification, for TE regression, we confirm several similar patterns as in service scope classification. For example, ACR is positive related to TE and accreditation result= A or B (EVA_M) is negatively related to TE. Nevertheless, public institution (OPE_1) has a positive impact on TE. ACR and private foundation (OPE_2) are positively related to TGR. However, public institutions (OPE_1) decrease TGR. With respect to MTE, ACR and (OPE_1) have a positive impact and accreditation result= A or B (EVA_M) has a negative impact on meta-frontier efficiency.

V. CONCLUSIONS

The aim of this research is to study the operating efficiency of senior citizen welfare institutions in Taiwan. We observe that senior citizen welfare institutions display distinct differences in operating efficiency based on the service scope and ownership type. The accommodation rate helps to improve operating efficiency. The higher the accommodation rate is, the more efficient an institution is. Our findings also suggest that accreditation results have a negative impact on efficiency. This is because, to rank higher in the accreditation report, institutions tend to purchase more facilities or hire more personnel to support operations. However, there is a maximum accommodation capacity regulated by law. Thus, idle facilities or personnel appear which, in turn, lowers the operating efficiency of an institution.

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