A Brief Verification Study on the Normalization and Translation Invariant of Measurement Data for Seaport Efficiency :DEA Approach*

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Key Words : Korean Seaports, Normalization, Unit Invariant, DEA, CCR, BCC,

Abstract

The purpose of this paper is to verify the two problems(normalization for the different inputs and outputs data, and translation invariant for the negative data) which will be occurred in measuring the seaport DEA(data envelopment analysis) efficiency. The main result is as follow: Normalization and translation invariant in the BCC model for measuring the seaport efficiency by using 26 Korean seaport data in 1995 with two inputs(berthing capacity, cargo handling capacity) and three outputs(import cargo throughput, export cargo throughput, number of ship calls) was verified. The main policy implication of this paper is that the port management authority should collect the more specific data and publish these data on the inputs and outputs in the seaports with consideration of negative(ex. accident numbers in each seaport) and positive value for analyzing the efficiency by the scholars, because normalization and translation invariant in the data was verified.

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I. Introduction

Trade volume will be increased because of the global trend of free trade agreements. Increase of trade quantity will induce the competition among the seaports for introducing the cargoes. In turn, efficient ports in terms of facilities, fees, services and so on, only can survive under this circumstances.

Korean government who has already recognized this circumstances focused on the expansion of social infrastructure including the investment of Incheon International Airport, development of New Busan Port and hinterland of the Port of Gwangyang for carrying out " North East Asia Business Hub" strategy successfully.

However, the rapid growth of Chinese ports in 2000s has threatened the cargo introduction by Korean main seaports, The Ports of Busan, Gwangyang, Incheon and Gusan.

The output quantity(amount) divided by input quantity(amount) is the efficiency of seaport. Therefore if seaport is efficient, competition power will be increased automatically and cargo introduction will be very easy.

The efficiency problem on the seaport because of importance itself interested the many scholars and has studied and verified the effectiveness. Among the previous studies, the studies which have used the DEA(Data Envelopment Analysis) method were published to many journals which introduced to Chapter II. However, there is no study in Korea except Park and ParK(2007) dealt with the normalization and translation Invariant of measurement data for seaport efficiency.

Therefore the purpose of this paper is to verify the two problems(normalization for the different inputs and outputs data, and translation invariant for the negative data) which will be occurred in measuring the seaport DEA efficiency. This paper will show the normalization[Roll and Hayuth(1993)] and unit invariant[Lovell and Pastor(1995)] by using the cross section data in the year of 1995 which comes from "Statistical Yearbook of Korean Seaports" published by Ministry of Maritime Affairs & Fisheries.

This paper consists of IV parts. After introduction of chapter I, chapter II examines the previous studies briefly. Chapter III verifies the normalization for the different inputs and outputs data, and translation invariant for the negative data. Chapter IV suggests the conclusion with brief policy suggestion.

II. Review of Previous Studies[1] and Limitation

Park(2003), and Han(2002) showed the empirical results by measuring the DEA efficiency of seaports or container ports. DEA method was originally developed by Charnes, Cooper and Rhodes(1978) for analyzing the productivity of public organization and non-profit association. Efficient DMU(Decision Making Unit) has the role as the reference set of inefficient DMU after defining the optimum envelope. Fecher et.al.(1993) and Ferrer and Lovell(1990) compared the DEA with production function method and found the positive co-relations between two methods. Y. Roll and Y. Hayuth(1993), Jose Tongzon(2001), Valentine and Gray(2002) used DEA methods for measuring the efficiency and productivity of Australian and other international ports. Recently, Wang, Cullinane and Song(2005) shows an applicability of the several DEA models for the measurement of container port efficiency by using cross-sectional and panel data.[2] Barros(2006) uses data envelopment analysis to evaluate the performance of Italian seaports from 2002 to 2003, combining operational and financial variables.

Among these studies, Roll and Hayuth(1993) showed the normalization, and Lovell and Pastor(1995) dealt with translation invariant in the negative data.

The main limitations of previous DEA studies are not to deal with the normalization and translation invariant in the negative data.

III. Empirical Verification on the Normalization and Translation Invariant of the Data for Measuring the Efficiency of Seaports

1. Analysis Object, Data and Input-Output Variables

Analysis object is 26 Korean export and import seaports, and analysis year is in the year of 1995. Main reason for using cross-section data(year of 1995) is that the purpose of this paper is just only to show the analysis method and verify the normalization and translation invariant in the negative data empirically in brief. And also, if another paper follows our method, the time series data including multi-years could be easily applicable.

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1) Park(2003),p.37. For more detailed literatures, refer to Barros(2006, pp.352-353)

2) Park(2006),p.61-62.

Input variables are berthing capacity, and cargo handling capacity. Output variables are export cargo throughput, import cargo throughput, and number of ship calls. For verifying the translation invariant, accidents numbers in the seaport are added as the output variable because they have the negative character even though regarded as output variable.

<Table 1> Original Data for Verification of Normalization and Translation Invariant (1995)

Ports/ Variables	Birthing Capacity (1000DWT)	Cargo Handling Capacity (1000 DWT)	Export Cargo Throughput (1000R/T)	Import Cargo Throughput(1000R/T)	No. of Ship Calls(Number)
Incheon	1669	39081	13058	92119	39611
Pyungtag	250	1368	236	21583	8741
Daesan	785	5649	3475	9667	4737
Boryung	250	9715	0	8242	346
Janghang	16	663	8	583	904
Gusan	190	3523	856	7584	7948
Mogpo	107	2536	175	3505	11852
Wando	33	707	67	313	2982
Yeasu	30	2663	8586	10496	4090
Gwangyang	2238	51369	29215	79194	32932
Jeju	34	1353	175	2170	6340
Seoguipo	14	716	212	320	2202
Samcheonpo	172	5984	33	6320	2626
Tongyoung	6	321	34	115	3588
Gohyun	11	531	44	792	1983
Ogpo	20	389	44	582	1529
Masan	299	8340	2608	8394	12009
Jinhae	65	1039	422	2239	1844
Busan	1790	54836	38782	53656	61387
Woolsan	2095	18119	45028	82261	41251
Pohang	915	38864	4694	37533	12429
Samcheog	26	7002	5915	12	1849
Donghae	256	14148	11552	5953	4927
Mookho	40	5925	3275	485	3903
Oggae	85	2797	2781	969	1305
Sogcho	18	843	0	29	176
Sum	11414	278481	171275	435116	273491
Average	439	10710.81	6587.5	16735.23	10518.88

Data: The Statistical Yearbook of Maritime Affairs and Fisheries in 1995, Ministry of Maritime Affairs and Fisheries

2. Theoretical Approach to DEA, Normalization, Translation Invariant for DEA Data

DEA models mainly consist of CCR model by Charnes, Cooper & Rhodes(1978) and BCC model by Banker, Charnes & Cooper(1984). Following Farrell(1957), CCR(1978) first introduced the term DEA to describe a mathematical programming approach to the construction of production frontiers and the efficiency measurement of the constructed frontiers. They proposed a model that had an input orientation and assumed constant returns-to-scale(CRS). the model is known as the CCR model. Later studies considered alternative sets of assumptions. BCC(1984) first introduced th assumption of variable returns-to-scale(VRS). Theis model is known as the BCC mode l.[3] However, CCR model does not classify between scale efficiency and pure technical efficiency. BCC model overcomes above limitation.

In this paper, data normalization means that because original data usually have the different units and numerical values, that is to say, variation among the input and output variables is so large, original data should be uniformed in terms of units and values by using the concept of average value of each variable.

Translation invariant means that if there are negative values in the input and output values, because of the fundamental property of an efficiency measure embedded in a DEA model, measuring the efficiency score is impossible. Therefore to translate the negative data into positive data, the biggest numerical value among the input variables or output variables should be added to variables of all DMUs. This property, which we refer to as translation invariance, is critical when the data contain zero or negative values, and must be translated prior to analysis with available software package [Lovell and Pastor(1995), p.147].

3. Normalization Verification of DEA Data

<Table 2> shows the efficiency scores by using the raw data listed to <Table 1> under input-oriented CCR model and BCC model. A range of DEA models have been developed that measure efficiency and capacity in different ways. These largely fall into the categories of being either input-oriented or output-oriented models.[4]

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3) Barros(2006), p.351, p.354.

4) With input-oriented DEA, the linear programming model is configured so as to determine how much the input use of a firm could contract if used efficiently in order to achieve the same output level. Modifications to the traditional input-oriented DEA model, however, could be done such that it would be possible to determine the reduction in the levels of the variable inputs conditional on fixed outputs and a desired output level. In contrast, with output-oriented DEA, the linear programme is configured to determine a firm's potential output given its inputs

<Table 2> shows the followings.

First, under CCR model, efficient ports are The Ports of Pyungtag, Yeasu, Tongyoung. The Port of Sogcho shows the lowest efficiency, Ports of Mogpo, Jeju, Gohyun, Okpo are in middle level, and Samcheog and Uoolsan are in 80% and 90 efficiency.

Second, under BCC model, efficient ports are The Ports of Incheon, Pyungtag, Mogpo, Yeasu, Jeju, Tongyoung, Busan, and Uoolsan. Gohyun and Okpo, and Samcheog Ports are in over 80% efficiency. The Port of Boryung shows the lowest efficiency score.

To verify the normalization compared to the results of <Table 2>, Roll and Hayuth(1993, p.156) introduced the following procedure.

First, calculate the sum of each input and output variables in <Table 1>.

Second, calculate the average of each input and output variable by dividing 26, because 26 seaports are included in the sample.

Third, calculate the ratio by dividing the value which comes from second step.

Fourth, to calculate the percentage ratio, multiply 100 by the value which comes from the third step. For example, normalization value of birthing capacity of The Port of Incheon will be (1669/439)X100 =380.1822.

Fifth, CCR and BCC efficiency were measured by using the input and output value which come from the above-mentioned procedure.

Sixth, compare efficiency scores, reference set, shadow price with the result of <Table 2> for examining whether the change in value has occurred.

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if it operated efficiently as firms along the best practice frontier. This is more analogous to the SPF approach, which estimated the potential output for a given set of inputs and measured capacity utilization as the ratio of the actual to potential output, and is consistent with the illustration of the method in Figure D.1. Output-oriented models are "...very much in the spirit of neo-classical production functions defined as the maximum achievable output given input quantities" (Färe, Grosskopf and Lowell, 1994, p. 95).
http://www.fao.org/DOCREP/006/Y5027E/y5027e0e.htm

<Table 2> Efficiency Measurement Results(CCR and BCC Model):1995

Port/Model	CCR Model		BCC Model	
	Efficiency Score	Reference Set and Shadow Price*	Efficiency Score	Reference Set and Shadow Price
Incheon	0.39042	a:2.036, b:4.580, c:0.858	1.0	d:1.0
Pyungtag	1.0	a:1.0	1.0	a:1.0
Daesan	0.26267	a:0.254, b:0.397, c:0.250	0.26810	a:0.253, b:0.396, c:0.350
Boryung	0.17174	a:0.103, b:0.574	0.18076	a:0.105, b:0.566, c:0.329
Janghang	0.26022	a:0.008, b:0.038, c:0.190	0.57909	a:0.011, b:0.022, c:0.967
Gusan	0.38779	a:0.234, b:0.225, c:1.387	0.51192	a:0.211, e:0.248, b:0.118, h:0.423
Mogpo	0.47895	a:0.130, b:0.034, c:2.947	1.0	e:1.0
Wando	0.39829	a:0.008, b:0.004, c:0.806	0.47725	a:0.007, b:0.004, c:0.989
Yeasu	1.0	b:1.0	1.0	b:1.0
Gwangyang	0.25157	a:1.775, b:3.890, c:0.419	0.77442	d:0.386, b:0.096, g:0.519
Jeju	0.63440	a:0.035, b:0.118, c:1.547	1.0	h:1.0
Seoguipo	0.34752	a:0.001, b:0.022, c:0.586	0.51641	b:0.021, c:0.979
Samcheonpo	0.20677	a:0.092, b:0.413, c:0.038	0.22671	a:0.096, b:0.399, c:0.505
Tongyoung	1.0	c:1.0	1.0	c:1.0
Gohyun	0.57902	a:0.008, b:0.055, c:0.472	0.83327	a:0.008, b:0.048, c:0.944
Ogpo	0.40684	a:0.023, b:0.003, c:0.365	0.88687	a:0.021, b:0.001, c:0.978
Masan	0.24696	a:0.191, b:0.380, c:2.448	0.55851	d:0.034, e:0.773, b:0.180, f:0.012
Jinhae	0.33325	a:0.073, b:0.060, c:0.267	0.48556	a:0.078, b:0.044, c:0.879
Busan	0.28990	a:0.254, b;4.465, c:11.401	1.0	f:1.0
Woolsan	0.90394	a:1.270, b:5.200, c:2.477	1.0	g:1.0
Pohang	0.20167	a:0.410, b:2.732	0.62440	d:0.250, a:0.600, b:0.150
Samcheog	0.79490	b:0.689	0.86555	b:0.688, c:0.312
Donghae	0.25325	b:1.345	0.77371	b:0.919, g:0.081
Mookho	0.38252	b:0.379, c:0.656	0.40876	b:0.378, h:0.045, c:0.576
Oggae	0.30838	b:0.324,	0.38372	b:0.321, c:0.679
Sogcho	0.02304	a:0.00, b:0.002, c:0.046	0.38078	c:1.0

* a: The Port of Pyungtag, b: The Port of Yeasu, c: The Port of Tongyoung, d: The Port of Incheon, e: The Port of Mogpo, f: The Port of Busan, g: The Port of Woolsan, h: The Port of Jeju

<Table 3> Normalized Data for Verification

Seaport/Variables	Birthing Capacity	Cargo Handling Capacity	Export Cargo Throughput	Import Cargo Throughput	Number of Ship Calls
Incheon	380.1822000	364.874400	198.223900	550.449600	376.570500
Pyungtag	56.9476100	12.772140	3.582543	128.967500	83.098200
Daesan	178.815500	52.741110	52.751420	57.764370	45.033310
Boryung	56.947610	90.702760	0	49.249400	3.289324
Janghang	3.644647	6.190008	0.121442	3.483669	8.594071
Gusan	43.280180	32.892000	12.994310	45.317570	75.559380
Mogpo	24.373580	23.677010	2.656546	20.943840	112.673600
Wando	7.517084	6.600808	1.017078	1.870360	28.349030
Yeasu	6.833700	24.862730	130.337800	62.717990	38.882470
Gwangyang	509.795000	479.599600	443.491500	473.217300	313.075200
Jeju	7.744875	12.632100	2.656546	12.966660	60.272580
Seoguipo	3.189066	6.684835	3.218216	1.912134	20.933790
Samcheonpo	39.179950	55.868790	0.500949	37.764640	24.964640
Tongyoung	1.366743	2.996972	0.516129	0.687173	34.110100
Gohyun	2.505695	4.957608	0.667932	4.732531	18.851820
Ogpo	4.555809	3.631845	0.667932	3.477693	14.535770
Masan	68.109340	77.865260	39.590130	50.157660	114.166100
Jinhae	14.806380	9.700480	6.406072	13.378960	17.530380
Busan	407.744900	511.968700	588.721100	320.617000	583.588700
Woolsan	477.221000	169.165500	683.537000	491.543900	392.161500
Pohang	208.428200	362.848400	71.256170	224.275400	118.159000
Samcheog	5.922551	65.373210	89.791270	0.071705	17.577920
Donghae	58.314350	132.090900	175.362400	35.571670	46.839590
Mookho	9.111617	55.317950	49.715370	2.898078	37.104710
Oggae	19.362190	26.113800	42.216320	5.790180	12.406260
Sogcho	4.100228	7.870553	0	0.173287	1.673182
Sum	2600	2600	2600	2600	2600
Average	100	100	100	100	100

When normalized data in <Table 3> are used for measuring efficiency, the results are exactly the same that of <Table 2>.
In conclusion, the efficiency results are same when original data is used or normalized data is used.

4. Verification of Translation Invariant on the Measurement Data for Seaport Efficiency

If we assume that whole or part of output variables is negative value(minus value) in the <Table 4>, because accidents in the ocean or port will be undesirable outputs.

To get solution of linear programming will be impossible, because of the fundamental assumption that all the numerical value should be positive(plus value) in the analysis of DEA. Therefore the negative value should be changed into plus value before measuring the efficiency. The most easy way to change the negative value into positive value will be that one unit larger plus value than the largest minus value is added. <Table 4> shows the accidents of 2001 in the port instead of 1995 data which are not obtainable for using the measurement of translation invariant. 24 accidnents in the Ports of Woolsan and Pohang are the largest number. Therefore, 25 is added to all the ports for making the minus value into plus value. By this way, plus value is done.

<Table 4> Original Data for Measuring Translation Invariant of Seaport Efficiency (1995)

Ports/Variables	Birthing Capacity	Cargo Handling Capacity	Export Cargo Throughput	Import Cargo Throughput	Number of Ship Calls	Number of Accidents(건수) Original Data	Number of Accidents(건수) Translated Data(25 is added to the original data)
Incheon	1669	39081	13058	92119	39611	-16	9
Pyungtag	250	1368	236	21583	8741	0	25
Daesan	785	5649	3475	9667	4737	0	25
Boryung	250	9715	0	8242	346	0	25
Janghang	16	663	8	583	904	-7	18
Gusan	190	3523	856	7584	7948	-7	18
Mogpo	107	2536	175	3505	11852	-2	23
Wando	33	707	67	313	2982	0	25
Yeasu	30	2663	8586	10496	4090	-5	20
Gwangyang	2238	51369	29215	79194	32932	-5	20
Jeju	34	1353	175	2170	6340	0	25
Seoguipo	14	716	212	320	2202	0	25
Samcheonpo	172	5984	33	6320	2626	-20	5
Tongyoung	6	321	34	115	3588	-20	5
Gohyun	11	531	44	792	1983	0	25
Ogpo	20	389	44	582	1529	-7	18
Masan	299	8340	2608	8394	12009	-3	22
Jinhae	65	1039	422	2239	1844	-3	22
Busan	1790	54836	38782	53656	61387	-16	9
Woolsan	2095	18119	45028	82261	41251	-24	1
Pohang	915	38864	4694	37533	12429	-24	1
Samcheog	26	7002	5915	12	1849	-7	18
Donghae	256	14148	11552	5953	4927	-7	18
Mookho	40	5925	3275	485	3903	0	25
Oggae	85	2797	2781	969	1305	0	25
Sogcho	18	843	0	29	176	-7	18
Sum	11414	278481	171275	435116	273491	-178	470
Average	439	10710.81	6587.5	16735.23	10518.88	-6.84615	18.07692

<Table 5> Normalized and Translated Data after adding the Number of Accidents in the Seaport for Measuring Translation Invariant of Seaport Efficiency

Seaports/Variables	Birthing Capacity	Cargo Handling Capacity	Export Cargo Throughput	Import Cargo Throughput	Number of Ship Calls	Number of Accident
Incheon	380.1822000	364.874400	198.223900	550.449600	376.570500	49.78724
Pyungtag	56.9476100	12.772140	3.582543	128.967500	83.098200	138.29790
Daesan	178.815500	52.741110	52.751420	57.764370	45.033310	138.29790
Boryung	56.947610	90.702760	0	49.249400	3.289324	138.29790
Janghang	3.644647	6.190008	0.121442	3.483669	8.594071	99.57449
Gusan	43.280180	32.892000	12.994310	45.317570	75.559380	99.57449
Mogpo	24.373580	23.677010	2.656546	20.943840	112.673600	127.23410
Wando	7.517084	6.600808	1.017078	1.870360	28.349030	138.29790
Yeasu	6.833700	24.862730	130.337800	62.717990	38.882470	110.63830
Gwangyang	509.795000	479.599600	443.491500	473.217300	313.075200	110.63830
Jeju	7.744875	12.632100	2.656546	12.966660	60.272580	138.29790
Seoguipo	3.189066	6.684835	3.218216	1.912134	20.933790	138.29790
Samcheonpo	39.179950	55.868790	0.500949	37.764640	24.964640	27.65958
Tongyoung	1.366743	2.996972	0.516129	0.687173	34.110100	27.65958
Gohyun	2.505695	4.957608	0.667932	4.732531	18.851820	138.29790
Ogpo	4.555809	3.631845	0.667932	3.477693	14.535770	99.57449
Masan	68.109340	77.865260	39.590130	50.157660	114.166100	121.70210
Jinhae	14.806380	9.700480	6.406072	13.378960	17.530380	121.70210
Busan	407.744900	511.968700	588.721100	320.617000	583.588700	49.78724
Woolsan	477.221000	169.165500	683.537000	491.543900	392.161500	5.531916
Pohang	208.428200	362.848400	71.256170	224.275400	118.159000	5.531916
Samcheog	5.922551	65.373210	89.791270	0.071705	17.577920	99.57449
Donghae	58.314350	132.090900	175.362400	35.571670	46.839590	99.57449
Mookho	9.111617	55.317950	49.715370	2.898078	37.104710	138.29790
Oggae	19.362190	26.113800	42.216320	5.790180	12.406260	138.29790
Sogcho	4.100228	7.870553	0	0.173287	1.673182	99.57449
Sum	2600	2600	2600	2600	2600	2600
Average	100	100	100	100	100	100

Empirical results by using data on <Table 5> under the input and output-oriented BCC model are shown to <Table 6> which verify the Theorem 4 by Lovell and Pastor(1995, p.150). The content of Theorem 4 is as follow.

Theorem 4: The input oriented normalized weighted BCC DEA model is units invariant, and translation invariant with respect to outputs only. The output oriented normalized weighted BCC DEA model is units invariant, and translation invariant with respect to inputs only.

<Table 6> Efficiency Scores by Using Normalized and Translated Data after Adding Accidents for Verification of Translation Invariant of Seaport Efficiency

Seaports/Models	Input oriented and Normalized BCC Model		Output oriented and Normalized BCC Model	
	Efficiency Score	Reference Set and Shadow Price*	Efficiency Score	Reference Port and Shadow Price
Incheon	1.0	d:1.0	1.0	d:1.0
Pyungtag	1.0	a:1.0	1.0	a:1.0
Daesan	1.0	r:1.0	1.0	r:1.0
Boryung	0.38656	a:0.358, g:0.642	1.0	a:0.358, g:0.642,
Janghang	0.67878	a:0.001,c:0.307,g:0.569, k:0.123	1.0	a:0.001, g:0.999
Gusan	0.51192	a:0.211, b:0.118, e:0.248, l:0.423	1.0	a:0.408, e:0.346, f:0.024 l:0.222,
Mogpo	1.0	e:1.0	1.0	e:1.0
Wando	0.96972	a:0.077, g0.813, l:0.109,	1.0	a:0.079, g:0.811, l:0.107, o:0.002,
Yeasu	1.0	b:1.0	1.0	b:1.0
Gwangyang	1.0	p:1.0	1.0	p:1.0
Jeju	1.0	l:1.0	1.0	l:1.0
Seoguipo	1.0	q:1.0	1.0	q:1.0
Samcheonpo	0.22671	a:0.096, b:0.399, c:0.505	0.36254	d:0.086, b:0.901, e:0.012,
Tongyoung	1.0	c:1.0	1.0	c:1.0
Gohyun	1.0	m: 1.0	1.0	m:1.0
Ogpo	1.0	k:1.0	1.0	k:1.0
Masan	0.56131	a:0.042, b:0.166, d:0.023,e:0.750, f:0.019	0.93831	a:0.603, f:0.067, e:0.245, l:0.085,
Jinhae	0.58815	a:0.054, b:0.043, g0.506, k:0.398	0.88000	a:0.084, g0.769, h:0.033, i:0.114
Busan	1.0	f:1.0	1.0	f:1.0
Woolsan	1.0	j:1.0	1.0	j:1.0
Pohang	0.62440	a:0.600, b:0.150, d:0.250,	0.68703	a:0.466, b:0.057, d:0.477,
Samcheog	0.89124	b:0.688, c:0.178, m:0.134	0.86739	b:0.793, c:0.014, m:0.193
Donghae	0.77371	b:0.919, j:0.081	0.95252	b:0.811, f:0.128, h:0.061
Mookho	1.0	h:1.0	1.0	h:1.0
Oggae	1.0	i:1.0	1.0	i:1.0
Sogcho	0.53925	c:0.335, g:0.622, k:0.042	0.72000	g:1.0

* a: The Port of Pyungtag, b: The Port of Yeasu, c: The Port of Tongyoung, d: The Port of Incheon, e: The Port of Mogpo, f: The Port of Busan, g: The Port of Gohyun, h: The Port of Moogho, i; The Port of Oggae , j: The Port of Woolsan, k: The Port of Ogpo, l: The Port of Jeju, m: The Port of Gohyun, o: The Port of Boryung, p: The Port of Gwangyang, q: The Port of Seoguipo, r: The Port of Daesan

5. Empirical Results on the Normalization and Translation Invariant for the Efficiency Measurement Data for Seaports

Following conclusions are derived from <Table 2> to <Table 6>.

First, normalization and translation invariant of data for measuring seaport efficiency are verified.

Second, translation invariant for negative(-) data is verified in the input and output oriented BCC model.

IV. Conclusion

This paper has examined two problems, when we use DEA method, which have occurred in measuring seaport efficiency(firts, normalization problem of all the different units, second, translation problem of input and output data which have minus value) by empirically verifying above-mentioned problems with using 26 Korean seaports data.

The empirical main results are as follows. First, normalization by Roll and Hayuth (1993) and translation invariant by Lovell and Pastor(1995) was clearly founded in the Korean seaport case. Second, translation invariant was confirmed in the case of input and output oriented BCC model.

According to the above empirical results, the following policy implication is suggested.

It is necessary for seaport manager and policy planner to collect, arrange, and publish the specific seaport statistics after considering the data normalization and translation. For example, seaport accident should be published after classifying it not each ocean but each seaport separately and specifically with the support in terms of policy.

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< 요 약 >

항만효율성 측정 자료의 정규성과 변환 불변성 검증소고: DEA접근

박 노 경

본 논문에서는 항만효율성 측정 시 문제가 되었던 두 가지 문제점(첫째, 각기 상이한 기본단위를 갖는 투입변수와 산출변수의 정규화문제, 둘째, DEA분석의 기본가정인 비음수조건에 벗어난 자료, 즉, 음수를 갖는 투입-산출자료의 변환불변성)를 해결하기 위해서 국내 26개항만의 자료를 이용하여 실증분석을 한 후에 검증을 함으로써 항만효율성 측정방법을 부분적으로 확장시켰다.

본 논문의 실증분석의 핵심적인 결과는 다음과 같다. 첫째, 항만효율성 측정 시 사용되는 자료의 정규성과 변환불변성은 실증분석 결과 분명하게 있는 것으로 검증되었다. 둘째, 항만효율성 측정 시 사용되는 자료가 마이너스(-)인 경우에 가장 큰 음수보다 더 큰 양수를 더해 주는 이른바 자료의 변환를 검증하는 변환불변성은 투입지향-산출지향 BCC 모형에서 확인되었다.

위와 같은 실증분석 결과는 다음과 같은 정책적인 함의를 갖고 있다. 즉, 효율성 측정 시 사용되는 자료의 정규성과 변환불변성이 실증적으로 검증되었으므로, 국내 항만의 정책입안가들은 항만효율성 측정 시 이용되는 자료의 정규성과 변환불변성과 같은 사항을 고려하여 보다 세부적인 항만통계자료를 수집·정리·공표하는 것이 매우 필요하다. 예를 들면 항만사고와 같은 통계도 해역별이 아닌 항만별로 세부적으로 통계를 발행하도록 관련된 정책적인 지원이 필요하다.

□ 주제어: 항만효율성, 측정자료, 정규성, 변환불변성, 검증, BCC, CCR, DEA