The Asian Journal of Shipping and Logistics 31(4) (2015) 469-476

HOSTED BY

ELSEVIER

Contents lists available at ScienceDirect

The Asian Journal of Shipping and Logistics

Journal homepage: www.elsevier.com/locate/ajsl

The Efficiency and Productivity Analysis of Large Logistics Providers Services in Korea

Hong Gyun PARK[a] , Yong Joo LEE[b]

[a] *Professor, Sunchon National University, Korea, E-mail:phg@sunchon.ac.kr (First Author)*
[b] *Associate Professor, Central Washington University, USA, E-mail:leeyj@cwu.edu (Corresponding Author)*

ARTICLE INFO

Article history:
Received 20 July 2015
Received in revised form 30 November 2015
Accepted 1 December 2015

Keywords:
DEA
Certified Logistics Providers
Efficiency
Productivity

ABSTRACT

In the fierce competition at the global logistics markets, Korean logistics providers were deemed more vulnerable than global logistics providers in terms of the quality and price competitiveness. To strengthen their competitiveness, logistics providers in Korea have focused on delivering integrated logistics services. In this regard, the Korean government has enacted the “Integrated Logistics Industry Certification Act” in 2006 to assist integrated logistics providers to offer logistics services based on their specialization and differentiation. It has been several years since the system was implemented, and the evaluation of the system implementation was necessary. Hence, in our study, we attempt to examine the efficiency and productivity of fourteen certified Korean logistics providers employing the DEA (Data Envelopment Analysis) method with a five-year panel data since the inception of the Act. Through our static and dynamic analyses, We found that Pantos Logistics and HYUNDAI Glovis are running their businesses at the highest level of efficiency and Hanjin Transportation was the most stable company in their logistics operation.

1. Introduction

The scale of the global logistics market is estimated to reach $8 trillion in 2020. Many countries have recognized the importance of value generated by global logistics providers and have implemented a wide range of policies to support their activities to spur their economic growth. To dominate the market, logistics providers attempt to establish diverse logistics strategies such as information orientation, scale expansion, and simplification. To adapt to environmental changes, logistics providers have pursued the economy of scale through activities such as M&A deals and strategic alliances. They also generated enormous profits by providing integrated logistics services based on global logistics networks.

In providing international transportation services Korean logistics providers were deemed more vulnerable than global logistics providers in terms of the quality and price competitiveness. Therefore, to strengthen their competitiveness, logistics providers in Korea have focused on delivering integrated logistics services. In this regard, the Korean government enacted the "Integrated Logistics Industry Certification Act"

http://dx.doi.org/10.1016/j.ajsl.2015.08.008
2092-5212/

in 2006 to assist integrated logistics providers to offer logistics services based on their specialization and differentiation. Eight years have passed since the enactment of the Act, and this allows for an analysis of its efficiency and productivity.

This study measures the changes in the efficiency of Korean logistics providers and verifies their reliability using the DEA/window method through dynamic analysis and examines the productivity growth that they contributed to through Malmquist analysis. The rest of this paper is organized as follows: After the introduction in Section I, Section II discusses and analyzes the productivity of integrated logistics providers. Section III provides an empirical analysis of the efficiency and productivity of integrated logistics providers, and Section IV concludes.

2. An Analysis of the Productivity of Integrated Logistics Providers

2.1. *Environmental Changes in the Productivity of Integrated Logistics Providers*

The competitiveness of the logistics industry is generally assessed based on the level of integrated-service performance in terms of the effective freight management of goods for the owner (Seo, Gim and Kim, 2004). In Korea, China, and Japan, however, an increase in trade has intensified competition to dominate the logistics network and secure long-term logistics market competitiveness.

In 2006, the Korean government introduced the "integrated logistics industry certification" system to establish a global logistics network and foster global logistics providers that can integrate logistics services. The integrated logistics industry envisioned by the Korean government aims at creating global logistics providers, and the business model pursues "diversity of services" in the long-term perspective. Therefore, Korean logistics providers (e.g., global logistics, forwarding, shipping, and trucking firms) have been providing integrated logistics services beyond simple logistic services, and their business scope has been expanded to cover overseas markets.

The Korean government's active support is expected to continue from the current promotional stage to the year 2015 to facilitate the entry of at least two or three logistics providers to the global top 20 providers and then to the year 2020 to facilitate the entry of at least one or two providers to the global top 10 providers (Jeon and Kim, 2012). The government's goal for the certification of integrated logistics providers is to foster large providers with an annual revenue exceeding KRW 3 trillion.

Some cases of integrated logistics providers in other counties are now discussed. Singapore has implemented a VAT (value-added tax) exemption policy for third-party value-added logistics occurring in Singapore based on its certification system of "Approved Third-Party Logistics Company Scheme." The purpose of this government-assisted system is to enforce Singapore's role as an Asian hub. Japan has implemented a project to promote third-party logistics providers.

The Industrial Structure Council subcommittee highlighted in 1996 the third-party logistics industry among 15 new growth areas in "the program for the reform and creation of economic structure." This emphasis is in conjunction with measures for promoting large enterprises and strengthening the competitiveness of small to medium-sized enterprises. In the U.S., the keyword in the integrated logistics industry is M&A (mergers and acquisitions) activity, particularly in the last few years (Seo and Han, 2004).

Korea's Integrated Logistics Industry Act defines integrated logistics providers as firms with more than one type of logistics operation and substantial sales. Among transportation (roads, airways, and maritime routes), logistics facilities (warehouses and terminals), forwarding, and logistics services, more than one type of business type is required displayed in Fig. 1.

In addition, each firm's sales must exceed 3% of total sales of logistics business or KRW 3 billion, and sales of third-party logistics providers must exceed 40% of total sales or KRW 400 billion.

A		B		C
Transportation (land/marine/flights/pipelines to one more operation)	+	Management of logistics facility operations (warehouses/terminals/ to one more operation)	+	Logistics services (handling/forwarding/equipment lending/information processing/consulting/ to one more operation)

Fig. 1. Impact of different end-haulage operations on cost competitiveness

Those firms not satisfying the requirements under the Act can obtain entry into the integrated logistics industry by establishing strategic alliances with other firms. The operational requirements for such strategic alliances include five or fewer partners, the use of co-brands, and the joint operation of information systems and logistics networks. In a partnership configuration, the exchange of both contracts and shares is allowed, and the partnership is valid for more than three years.

Korean integrated logistics providers handle mainly their affiliates' supply and thus are generally associated with their parent firms (Lee, 2013). In this regard, they try to enter global logistics networks but are limited in terms of their market entry because of their dependence on their parent firms, which makes them vulnerable in terms of their management. As of 2011, Hyundai Glovis operated a total of 20 overseas subsidiaries mainly from overseas subsidiaries of Hyundai and Kia. As of 2011, 60% of the total volume handled by Pantos Logistics Co., Ltd. was from LG Group's logistics volume. As of 2013, Pantos had a total of 29 overseas subsidiaries indicated in Table 1.

Table 1
The global status of major logistics providers in Korea

Provider	Global region
Pantos Logistics	Overseas: 5 continents, 29 countries (e.g., India, Brazil, Australia, the U.S., and Germany)
CJ GLS	Overseas: 3 continents, 11 countries (e.g., China, Mexico, the U.S., and the Netherlands)
Sinokor	Overseas: 3 continents, 10 countries (e.g., China, Brazil, and South Africa)
Hanjin Transportation	Overseas: 2 continents, 5 countries (the U.S., China, and Vietnam)
HYUNDAI Glovis	Overseas: 5 continents, 12 countries (the U.S., Germany, Russia, Australia, and Brazil)
HYUNDAI LOGISTICS	Overseas: 3 continents, 6 countries (China, Germany, and the U.S.)

Data: The Ministry of Land, Transport, and Maritime Affairs report (June,17, 2012)

Since the global financial crisis in 2008, leading integrated logistics providers in Korea, including Glovis, CJ Korea Express, Pantos, and Dongbu Express, generated significantly lower revenues than DHL and UPS, and their operating profit rates are lower than that of UPS.

Table 2
A comparison of revenues, operating profits, and operating profit rates between Korean and global logistics providers (2011)

Major Provider	Revenue	Operating profit	Operating profit rate
DP DHL	KRW 75.7 trillion	KRW 3 trillion KRW 491.1 billion	4.6%
UPS	KRW 59.2	KRW 6 trillion	11.4%

	trillion	KRW 784.2 billion	
HYUNDAI Glovis	KRW 7.5 trillion	KRW 339.6 billion	4.5%
CJ	KRW 2.6 trillion	KRW 122.8 billion	4.7%
Pantos Logistics	KRW 1.3 trillion	KRW 39.2 billion	3.1%
Dongbu Express	KRW 0.6 trillion	KRW 20.7 billion	3.3%

Note: KRW: Korean Won
Data: KMI (2012), CEO Forum for Global Logistics Provider

Table 3
Status of certification screening for Korean integrated logistics providers (2006 - 2012)

Classification		2006	2007	2008	2009	2010	2011	2012	2013
New certification judgment	Number of application providers	22 (43)	10 (25)	4 (11)	1 (2)	1 (1)	1 (1)	4 (4)	5 (3)
	Number of certification providers	21 (42)	7 (18)	4 (11)	1 (2)	1 (1)	1 (1)	4 (4)	5 (3)
Periodical inspection	Number of object providers		10 (20)	11 (22)	16 (32)	13 (30)	16 (32)	10 (20)	
Prn inspection	Number of object providers						2 (4)		
Total		22 (43)	20 (45)	15 (33)	17 (34)	14 (31)	19 (37)	14 (24)	5 (3)

Note: Figure indicates number of firms certified.
Figure in parentheses indicates number of providers.
Data: The Korea Transport Institute, Certified Integrated Logistics Provider Center (2013).

Up to 2012, a total of 43 affiliated groups applied, and 39 received this certification. Through regular inspections, the Center for Certified Integrated Logistics Company canceled the certification of one group in 2007, two in 2009, two in 2010, four in 2011, and six in 2012 and announced names of newly certified firms as well as cancelled firms in July 2013. The cancellation was due to firms not meeting the criteria for strategic alliances or other certification standards. KCTC Co., Ltd., Dongwon Industries Co, Ltd., and Chunil Cargo Transportation were recently certified, and the certification of several alliance groups was revoked, including the group with KCTC Co., Ltd. and KCTC International, that with Dongwon Industries Co, Ltd., Joyang Logistics International Co., Ltd., and Dongyeong Cold Plaza, and that with Chunil Cargo Transportation and CMF Co., Ltd. Table 4 shows the composition of integrated logistics providers considered in this study. As of 2012, there were 23 certified groups (including newly certified ones).

Table 4
The composition of integrated logistics providers

Individual	Alliance
Sunkwang	CK LINE (CK LINE, CK Ocean, and Dongjin)
	Heung-A Logistics (Heung-A Shipping, and KUKBO)
Pantos Logistics	Everways (Han Express, Kukdongtls, Sunjin Shipping & Air Cargo, and Haewoogls)
DONGBANG TRANSPORT LOGISTICS	Sinoko (Sinokor and Pyeong Taek Container Terminal)
Hanjin Transportation	LogisALL (Korea Pallet Pool, Korea Container Pool, and Korea Logistics Pool)
HYUNDAI Glovis	EUNSAN LOGIS (Eunsan Shipping and Aircargo and Eunsan Container Terminal)
HYUNDAI LOGISTICS	
Hansol CSN	

2.2. *A Literature Review and the Need for an Analysis*

Previous studies have examined the efficiency of logistics providers' service processes by using the DEA method. Poli and Scheraga (2000), and Min and Joo (2006) analyzed the service performance of logistics providers of road transportation service in the U.S. market, and also Scheraga (2004) investigated the service performance of airline firms' efficiency in the context of international airports. Zhou et al., (2008) analyzed the efficiency of third-party logistics providers in China.

For the benchmarking of logistics providers, Min et al. (2009) examined the efficiency of major global logistics providers' financial structures, focusing on the financial efficiency of third-party logistics providers ranked 12 and higher in the U.S. over a three-year period to evaluate their strengths and weaknesses, and found finance to be a core determinant of efficiency with the expansion of the management scope and large-scale investment.

Lieb and Lieb (2010) conducted two-year surveys of CEOs of third-party logistics providers in 40 leading countries in North America, Europe, and the Asia-Pacific region and addressed the issues of sustainability and environmental damage for these providers.

Kumar and Singh (2012) used the fuzzy AHP method and TOPSIS and verified that the most important criteria for global third-party logistics are service quality and logistics costs.

Min et al., (2013) employed the DEA method to conduct a long-term efficiency analysis to analyze branch roles of third-party logistics providers. In their study, for management effectiveness, specific markets, negative-element management, and competitiveness enforcement methods have been suggested. Lately, Park and Kang (2013) designed connecting logistics service to FTA for Gwangyang hinterland.

The logistics industry is a high-cost industry requiring large-scale investment for things such as logistics facilities. Despite recent increases in logistics volume, the efficiency of branch operations has decreased. The indirect cost is considered a key element in deciding the efficiency of logistics operations. To foster global logistics providers, the Korean government has introduced the Integrated Logistics Industry Certification System in 2006.

The goal of the system is to establish a global logistics network, provide integrated logistics services, and achieve competitiveness in global markets. Therefore, based on this certification system as a specific industrial policy to construct new business models, a more accurate analysis of efficiency and productivity is required.

3. Theoretical Background

DEA(Data Envelopment Analysis), developed by Charnes et al. (1978) is a non-parametric method used widely to measure the productivity of a set of a comparable entities called DMUs (Decision Making Unit) with multiple inputs and outputs in character, and its applications span a wide variety of settings. The method suggests the best performance frontier, or called reference set and relative inefficiency scores of each unit. The model pursues maximization of the ratio of virtual output and virtual input computed to be less than or equal to 1 by optimally assigning weights of the inputs and outputs for DMUs individually under non-negativity constraint. This non-linear fractional programming problem was then transformed into an equivalent linear programing format in the model of Charnes et al (Called CCR model). The CCR model is contrasted with the BCC model, developed by Banker et al. (1984) afterwards in that the first is constructed under the assumption of constant return scale, whereas the latter was under the assumption of variable returns to scale; a) increasing return to scale, b) decreasing return to scale, and c) constant return to scale. Mathematical notations of primal and dual forms for CCR-input and BCC-input model are expressed as follows:

CCR-input model

Primal:

$$\max_{v,u} uy_0$$
$$\text{s.t.}$$
$$vx_0 = 1$$
$$-vX + uY \le 0$$
$$v \ge 0, u \ge 0$$

Dual:

$$\min_{\theta,\lambda} \theta$$
$$\text{s.t.}$$
$$\theta x_0 - X\lambda \ge 0$$
$$Y\lambda \ge y_0$$
$$\lambda \ge 0$$

BCC-input model

Primal:

$$\min_{\theta_B,\lambda} \theta_B$$
$$\text{s.t.}$$
$$\theta x_0 - X\lambda \ge 0$$
$$Y\lambda \ge y_0$$
$$e\lambda = 1$$
$$\lambda \ge 0$$

Dual:

$$\max_{u,v,u_0} z = uy_0 - u_0$$
$$\text{s.t.}$$
$$vx_0 = 1$$
$$-vX + uY - u_0 e \le 0$$
$$v \ge 0, u \ge 0, u_0 \; free\ in\ sign$$

There are many articles on the CCR model and the BCC model. Readers are advised to refer to Charnes et al. (1978) and Banker et al. (1984) for further insight on the original formulation of the two models.

4. An Empirical Analysis

4.1 *Analysis Resources*

Logistics providers offer high quality logistics services utilizing all their assets. The operational capacity of logistics services denotes "how effectively the logistics service can be utilized" to satisfy the shipper. The input elements used in this study includes capital, assets, the number of employees, and total revenue was used for the output element.

To conduct the efficiency and productivity analyses, balanced panel data from "Five Years (2007-2011) of the Integrated Logistics Industry in 2012" by the Korea Transport Institute were employed. The logistics providers considered in the analysis included Sunkwang Co., Ltd., Intergis Co., Ltd. (previously International Express), Pantos Logistics Co., Ltd., DONGBANG TRANSPORT LOGISTICS CO., LTD., Hanjin Transportation Co., Ltd., HYUNDAI Glovis Co. Ltd., HYUNDAI LOGISTICS CO, LTD., Hansol CSN Co., Ltd., CK LINE Co., Ltd. (CK LINE Co., Ltd., CK Ocean Co., Ltd., and Dongjin Co., Ltd.), Heung-A Logistics (Heung-A Shipping Co., Ltd. and KUKBO Corporation), Everways (Han Express, Kukdongtls, Sunjin Shipping & Air Cargo Co., Ltd., and Haewoogls), Sinoko (Sinokor and Pyeong Taek Container Terminal), LogisALL (Korea Pallet Pool Co., Ltd., Korea Container Pool Co., Ltd., and Korea Logistics Pool Co., Ltd.), EUNSAN LOGIS (Eunsan Shipping, Aircargo Co., Ltd., and Eunsan Container Terminal Co., Ltd.).

Table 5 shows the descriptive statistics of the firms by year. For the volume of assets except for 2010, the coefficient of variation increased consistently with a decrease in volatility, whereas for capital and the number of employees, they decreased consistently with a decrease in volatility except for 2011. The increase in the coefficient of variation for total revenue was much larger with a consistent increase in volatility than that for other factors.

Table 5
Descriptive statistics of data

		Assets (hundred million won)	Capital(hundred million won)	Number of employees	Total revenue (hundred million won)
2007	Maximum	10,614	610	2,145	25,102
	Minimum	330	14	160	850
	Average	3,405	190	616	5,287
	S.D.	2,997	186	482	6,093
	C.V.	0.880	0.978	0.783	1.153
2008	Maximum	12,617	610	2,049	30,652
	Minimum	572	14	165	1,241
	Average	4,295	199	605	6,422
	S.D.	3,794	182	460	7,428
	C.V.	0.884	0.915	0.761	1.157
2009	Maximum	16,610	610	2,006	31,928
	Minimum	566	24	165	1,038
	Average	4,894	220	620	6,366
	S.D.	4,658	187	441	7,718
	C.V.	0.952	0.848	0.712	1.212
2010	Maximum	19,220	610	2,054	58,340
	Minimum	677	30	165	1,333
	Average	5,640	225	678	9,108
	S.D.	5,327	183	457	14,133
	C.V.	0.945	0.813	0.674	1.552
2011	Maximum	31,896	913	2,275	75,477
	Minimum	1,026	30	201	1,258
	Average	6,972	247	690	10,511
	S.D.	8,046	235	507	18,345
	C.V.	1.154	0.954	0.735	1.745

Note: S.D: Standard deviation, C.V.: Coefficient of variation.

4.2 *A Static Efficiency Analysis*

After obtaining yearly CCR (Charnes, Cooper, and Rhodes) efficiency (TE: Technical Efficiency) and BCC (Banker, Charnes, and Cooper) efficiency (PTE: Pure Technical Efficiency), we first computed scale efficiency by dividing the CCR score by the BCC score as displayed in Table 6.

For the CCR index, it was highest in 2011 and lowest in 2010. CCR efficiency decreased slightly from 2007 to 2008, showing a sharp decrease from 2009 to 2010, and a sharp increase from 2010 to 2011.

The BCC index shows a similar trend to the CCR index; the efficiency was highest in 2011 and lowest in 2010. It also displays slight decreases from 2007 to 2008, sharp decreases from 2009 to 2010, and sharp increases from 2010 to 2011 as are observed in the CCR index.

Scale efficiencies showed a tendency of consistent increase that they were 0.671 in 2008, 0.676 in 2009, and 0.694 in 2010, and 0.702 in 2011. This increasing tendency indicates that the scale of the integrated logistics providers has been converging to the optimal level as time passed.

The result of variability analysis shows that pure technical efficiency was most instable and scale efficiency was most stable in terms of efficiency standard deviation. The coefficient of variation that considers both average and standard deviation denotes that it was most stable in scale efficiency and most instable in pure technical efficiency. As the scale efficiency turns out to be stable, it is highly likely that technical

efficiency will improve in the future among the firms in the logistics industry.

During the periods of 2007-2011, integrated logistics providers generated inefficiency of 53% through 60%, 32% through 42%, 28% through 33%, based on CCR index, BCC index, and scale index, respectively, accounting for overinvestment of the firms to receive the certification.

Table 6
The annual efficiency of integrated logistics providers

	2007	2008	2009	2010	2011	5 year average	5 year standard deviation	Coefficient of variation
CCR	0.458	0.421	0.445	0.401	0.476	0.440	0.027	0.060
BCC	0.636	0.627	0.658	0.578	0.678	0.635	0.034	0.053
SCALE	0.720	0.671	0.676	0.694	0.702	0.693	0.018	0.026

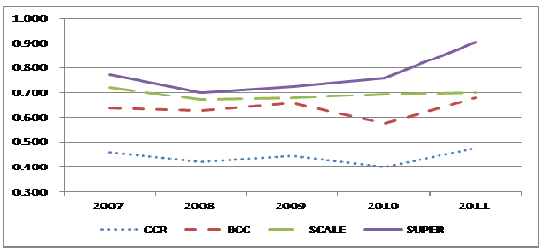

Fig. 2. Annual efficiencies of integrated logistics providers

Table 7 exhibits technical efficiency, pure technical efficiency, scale efficiency, and causes of inefficiency by DMU. The table indicates that Pantos Logistics and HYUNDAI Glovis are the most efficient DMUS. Based on the CCR model, it was observed that Sunkwang, Hanjin Transportation, LogisALL generate 88%, 81%, and 67% of inefficiencies, respectively.

We conducted another analysis to determine whether the inefficiency was ascribed to technical side or scale side by comparing the pure technical efficiency and the scale efficiency of the firms studied in our report. Defining the causes of inefficiency through the CCR (TE) model was not successful since the model presents a value of integrated inefficiency combined with technical and scale factors.

To circumvent this issue, we calculated the value of scale efficiency by dividing the CCR efficiency by the BCC efficiency, and compared the value with the BCC efficiency (PTE) to choose a smaller of the two as the cause of inefficiency of DMUs. From this process, we observed that inefficiency of six firms was ascribed to the pure technical efficiency. Among 14 firms, causes of inefficiencies of six stemmed from scale efficiency and the other six stemmed from pure technical efficiency. In more detail, causes of inefficiencies for Sunkwang, Intergis, Hansol CSN, Everways, Sinoko, and EUNSAN LOGIS attributes to scale factor and those of DONGBANG TRANSPORT LOGTISTICS, Hanjin Transportation, HYUNDAI LOGISTICS, CK LINE, Heung-A Logistics, and LostistcsALL to pure technical factor.

Hence, firms that are inefficient due to pure technical factors need to improve in efficiency with the technical side, i.e. the utilization of input components since the inefficiency arises from the relatively inefficient utilization of input factors. On the contrary, the super efficiency scores of Pantos Logistics and HYUNDAI Glovis marked 1.97 and 4.66, respectively, indicating that these firms could maintain their efficiency even if input elements are increased by as much as 2 and 4.7 times, respectively.

Table 7
Causes of efficiency and inefficiency by DMU

DMU	CCR (TE)	BCC (PTE)	SCALE (SE)	SUPER	Cause of inefficiency
Sunkwang	0.121	0.475	0.255	0.121	S
Intergis	0.485	0.786	0.617	0.485	S
Pantos Logistics	1.000	1.000	1.000	1.971	C
DONGBANGTRANSPORT LOGISTICS	0.238	0.305	0.779	0.238	P
Hanjin Transportation	0.191	0.207	0.927	0.191	P
HYUNDAI Glovis	1.000	1.000	1.000	4.664	C
HYUNDAI LOGISTICS	0.406	0.467	0.871	0.406	P
Hansol CSN	0.508	0.728	0.699	0.508	S
CK LINE	0.269	0.508	0.529	0.269	P
Heung-A Logistics	0.408	0.455	0.896	0.408	P
Everways	0.472	0.744	0.634	0.472	S
Sinoko	0.317	0.741	0.427	0.317	S
LogisALL	0.232	0.479	0.485	0.232	P
EUNSAN LOGIS	0.515	1.000	0.515	0.515	S
Average	0.440	0.635	0.688	0.771	

Note: P (operational inefficiency), S (scale inefficiency). C (Constant)

4.3 *A Dynamic Efficiency Analysis*

4.3.1 *A DEA Window Analysis*

A static analysis cannot measure changes in efficiency according to time points. Therefore, to measure the variation of efficiency over time, the DEA window method was employed for a dynamic analysis. With the evaluation results for efficiency for each window, trends in efficiency and stability were analyzed. Here the “line” was used to show how DMU scores in other periods changed within a given window (the period during which dynamic changes were observed), which allowed for an analysis of overall trends. On the other hand, the "column" was used to indicate the width of efficiency variations for a given window, which enabled an analysis of stability. The lower the value of the standard deviation or LDP, the more stable the efficiency was for each window.

Table 8
The stability and efficiency of DEA window analysis results

DMU	Average	SD	LDP	DMU	Average	SD	LDP
Sunkwang	0.104	0.013	0.037	Hansol CSN	0.444	0.029	0.096
Intergis	0.376	0.180	0.479	CK LINE	0.230	0.029	0.084
Pantos Logistics	0.929	0.085	0.216	Heung-A Logistics	0.313	0.094	0.299
DONGBANG TRANSPORT LOGISTICS	0.208	0.014	0.043	Everways	0.390	0.062	0.170
Hanjin Transportation	0.165	0.011	0.029	Sinoko	0.270	0.030	0.080
HYUNDAI Glovis	0.902	0.155	0.362	LogisALL	0.199	0.011	0.038
HYUNDAI LOGISTICS	0.361	0.037	0.104	EUNSAN LOGIS	0.442	0.058	0.184

Table 8 shows the results of the DEA window analysis. The standard deviation and LDP for Hanjin Transportation were 0.011 and 0.029,

respectively, indicating that the firm was the most stable provider, whereas those for Intergis were 0.180 and 0.479, respectively, highlighting it to be the most unstable one.

Table 9 shows the changes in efficiency by period for each DMU. Based on efficiency variations, Pantos Logistics and HYUNDAI Glovis had the highest efficiency scores (0.929 and 0.902, respectively), whereas Sunkwang had the worst score (0.104). The logistics provider with relatively large variations over periods was Intergis (0.296), whereas Hanjin Transportation and Sunkwang showed relatively small variations. According to changes over time for each provider, there was a decreasing trend in efficiency during 2007-2009 and 2008-2010, whereas there was an increasing trend afterward.

Table 9
The efficiency variation of each DMU's DEA window

	2007-2009	2008-2010	2009-2011	Average	Range
Sunkwang	0.118	0.098	0.096	0.104	0.022
Intergis	0.548	0.328	0.252	0.376	0.296
Pantos Logistics	0.954	0.938	0.896	0.929	0.057
DONGBANG TRANSPORT LOGISTICS	0.200	0.200	0.224	0.208	0.025
Hanjin Transportation	0.160	0.159	0.177	0.165	0.018
HYUNDAI Glovis	0.987	0.840	0.879	0.902	0.147
HYUNDAI LOGISTICS	0.386	0.349	0.347	0.361	0.039
Hansol CSN	0.427	0.430	0.476	0.444	0.048
CK LINE	0.208	0.216	0.265	0.230	0.057
Heung-A Logistics	0.378	0.266	0.296	0.313	0.112
Everways	0.349	0.356	0.464	0.390	0.116
Sinoko	0.308	0.250	0.252	0.270	0.058
LogisALL	0.199	0.190	0.208	0.199	0.018
EUNSAN LOGIS	0.432	0.429	0.464	0.442	0.035
Average	0.404	0.361	0.378	0.381	0.075
Range	0.869	0.840	0.800	0.836	

4.3.2 *A Malmquist Analysis of Productivity*

The Malmquist index was first introduced by Malmquist (1953) for the comparison of two economies by analyzing consumption of inputs. Fa¨re et al (1994) expanded the concept later to the DEA method to measure productvity change over time.

The input oriented Malmquist productivity index can be expressed as follows:

$$M_0 = \left[\frac{\theta_0^t(x_0^t, y_0^t)}{\theta_0^t(x_0^{t+1}, y_0^{t+1})} \frac{\theta_0^{t+1}(x_0^t, y_0^t)}{\theta_0^{t+1}(x_0^{t+1}, y_0^{t+1})} \right]^{1/2}$$

In this notation, productivity declines if $M_0 > 1$, productivity increases if $M_0 < 0$, and productivity remains unchanged if $M_0 = 1$

With the theoretical background of the Malmquist productivity index, we employed it to analyze the dynamic changes in components and productivity over time. Table 10 shows the results for changes in productivity from 2007 to 2011. In the table, an index higher than, lower than, or equal to 1 was taken to indicate improved, worsened, or unchanged productivity, respectively. A value subtracted 1 from the index denotes variations in productivity for two adjacent periods.

DMUs with a productivity index exceeding 1 included DONGBANG TRANSPORT LOGISTICS, Hanjin Transportation, HYUNDAI Glovis, Hansol CSN, CK LINE, Everways, Sinokor, and LogisALL. In terms of catch-up effects (variations in pure technological efficiency), DONGBANG TRANSPORT LOGISTICS, Hanjin Transportation, Hansol CSN, CK LINE, Everways, LogisALL, and EUNSAN LOGIS showed improved management efficiency from 2007 to 2011, and Intergis and Heung-A Logistics showed worsened management efficiency. In terms of frontier effects (technological advancement), Sunkwang, Intergis, HYUNDAI Glovis, Heung-A Logistics, and Sinokor showed technological progress from 2007 to 2011, whereas Everways and CK LINE showed technological retrogress.

Table 10
Changes in productivity between 2007 and 2011

	Catch-up	Frontier	Malmquist
Sunkwang	0.882	1.058	0.933
Intergis	0.512	1.014	0.519
Pantos Logistics	1.000	0.757	0.757
DONGBANG TRANSPORT LOGISTICS	1.451	0.770	1.117
Hanjin Transportation	1.392	0.809	1.125
HYUNDAI Glovis	1.000	1.661	1.661
HYUNDAI LOGISTICS	0.984	0.798	0.785
Hansol CSN	1.459	0.747	1.089
CK LINE	1.747	0.676	1.182
Heung-A Logistics	0.606	1.080	0.655
Everways	1.866	0.554	1.033
Sinoko	0.943	1.088	1.026
LogisALL	1.317	0.851	1.121
EUNSAN LOGIS	1.048	0.820	0.859
Average	1.158	0.906	0.990
Maximum	1.866	1.661	1.661
Minimum	0.512	0.554	0.519
SD	0.396	0.269	0.278

Tables 11-13 display the results of periodic productivity analysis. In terms of catch-up effects, in general, the index increased from the previous period except the year of 2009-2010, which was a period of global financial crisis. In more detail, Pantos Logistics and HYUNDAI Glovis didn't show changes in periodic average technical efficiency, whereas, Everway, CK LINE, DONGBANG TRANSPORT LOGISTICS realized an increase in technological efficiency by as much as 17.8%, 17.1%, and 11.6%, respectively.

In terms of the frontier effects, contrary to the catch-up effect, an average of 28.9 % of frontier change was made during the period of global financial crisis in 2009-2010. Heung-A Logistics and LogisALL didn't show any changes, but HYUNDAI Glovis, Intergis, Sinoko made progresses by as much as 17.6%, 11.2%, 5.7%, respectively. On the other hand, Everways and CK LINE marked technological retrogresses by as much as 11.8% and 8.5%, respectively.

The periodic average of Malmquist productivity reveals that productivity increase was realized by 4.5 % in 2007-2008 and 10.5% in 2009-2010. HYUNDAI Glovis, LogistALL, and Hanjin Transportation yielded productivity increase by as much as 17.6%, 4.2%, and 4.1%, respectively, whereas Heung-A Logistics and HYUNDAI LOGISTICS generated productivity decrease by as much as 10.1% and 5.8%, respectively.

Table 11
Periodic catch-up effects of DMUs

	2007-2008	2008-2009	2009-2010	2010-2011	Average
Sunkwang	0.940	0.968	0.785	1.234	0.982
Intergis	0.906	0.535	0.742	1.423	0.902
Pantos Logistics	1.000	1.000	1.000	1.000	1.000
DONGBANG TRANSPORT LOGISTICS	1.005	1.276	0.849	1.334	1.116
Hanjin Transportation	0.957	1.290	0.872	1.293	1.103
HYUNDAI Glovis	1.000	1.000	1.000	1.000	1.000
HYUNDAI LOGISTICS	0.984	1.165	0.706	1.215	1.018
Hansol CSN	1.031	1.224	0.855	1.352	1.115
CK LINE	1.100	1.294	0.858	1.430	1.171
Heung-A Logistics	0.435	1.157	0.808	1.492	0.973
Everways	1.012	1.274	1.056	1.370	1.178
Sinoko	0.952	1.325	0.640	1.168	1.021
LogisALL	0.914	1.399	0.769	1.339	1.105
EUNSAN LOGIS	0.911	0.981	1.156	1.014	1.016
Average	0.939	1.135	0.864	1.262	1.050
Maximum	1.100	1.399	1.156	1.492	1.178
Minimum	0.435	0.535	0.640	1.000	0.902
SD	0.155	0.224	0.144	0.164	0.081

Table 12
Periodic frontier effect of DMUs

	2007-2008	2008-2009	2009-2010	2010-2011	Average
Sunkwang	1.155	0.861	1.359	0.779	1.039
Intergis	1.219	0.955	1.520	0.753	1.112
Pantos Logistics	1.090	0.777	1.172	0.747	0.947
DONGBANG TRANSPORT LOGISTICS	1.103	0.803	1.175	0.767	0.962
Hanjin Transportation	1.092	0.787	1.265	0.774	0.980
HYUNDAI Glovis	1.127	0.874	1.692	1.012	1.176
HYUNDAI LOGISTICS	1.091	0.792	1.187	0.768	0.960
Hansol CSN	1.110	0.807	1.172	0.767	0.964
CK LINE	1.122	0.692	1.110	0.737	0.915
Heung-A Logistics	1.190	0.799	1.240	0.773	1.001
Everways	1.012	0.692	1.110	0.712	0.882
Sinoko	1.077	0.805	1.553	0.792	1.057
LogisALL	1.078	0.771	1.372	0.782	1.001
EUNSAN LOGIS	1.168	0.823	1.119	0.755	0.966
Average	1.117	0.803	1.289	0.780	0.997
Maximum	1.219	0.955	1.692	1.012	1.176
Minimum	1.012	0.692	1.110	0.712	0.882
SD	0.053	0.067	0.185	0.070	0.078

Table 13
Periodic malmquist productivity index of DMUs

	2007-2008	2008-2009	2009-2010	2010-2011	Average
Sunkwang	1.087	0.833	1.068	0.961	0.987
Intergis	1.105	0.512	1.127	1.072	0.954
Pantos Logistics	1.090	0.777	1.172	0.747	0.947
DONGBANG TRANSPORT LOGISTICS	1.108	1.024	0.998	1.024	1.038
Hanjin Transportation	1.045	1.015	1.103	1.001	1.041
HYUNDAI Glovis	1.127	0.874	1.692	1.012	1.176
HYUNDAI LOGISTICS	1.074	0.922	0.838	0.933	0.942
Hansol CSN	1.144	0.988	1.002	1.037	1.043
CK LINE	1.233	0.896	0.953	1.055	1.034
Heung-A Logistics	0.518	0.925	1.002	1.153	0.899
Everways	1.024	0.882	1.172	0.976	1.014
Sinoko	1.026	1.067	0.994	0.925	1.003
LogisALL	0.986	1.078	1.055	1.047	1.042
EUNSAN LOGIS	1.064	0.808	1.293	0.766	0.983
Average	1.045	0.900	1.105	0.979	1.007
Maximum	1.233	1.078	1.692	1.153	1.176
Minimum	0.518	0.512	0.838	0.747	0.899
SD	0.163	0.146	0.202	0.111	0.066

5. Managerial Insights and Conclusion

5.1 *Managerial Insights*

Amid fierce competition and dynamic business environments today, it is highly advised that industry practitioners construct operational tactics and business strategy by considering other firms' performance and situations. Through the relative comparison in the same industry, a firm could identify strength and weakness of their own firm. In that regard, DEA study can provide a great benefit to industry managers as a bench marking tool computing efficiency scores of each DMUs under the study. Our study particularly attempts to evaluate operational efficiency of large Korean logistics providers over the period of 2007 through 2011. With our study that identifies static and dynamic features of individual firms in the logistics operations, managers can perceive business trends in the logistics industry, and the relative standing of their firm in terms of operational excellence.

5.2 *Conclusion*

With the worldwide logistics industry focusing on Asia, Korean logistics providers require management policies suitable for attracting global investment and gaining entry into global logistics markets. Based on the Logistics Policy Basic Act, the Korean government has implemented the Logistics Providers Certification and Inspection System.

The benefits of this certification will include an authority of priority to occupy logistics facilities, logistics facility expansion, obtaining capital loans and incentive necessary to exploit foreign markets, and tax incentives. The Korean government's logistics' policy intends to strengthen the competitiveness in the logistics industry through strengthening competitiveness by scale economy and creation of synergy effects. The reason for this government support is that the logistics industry is expected to become a new growing dynamic industry in the

future. For this, government is strengthening global competitiveness by developing global logistics firms through expansion and systemization.

According to the results of the descriptive statistics analysis for changes in productivity, the coefficient of variation showed a consistent decrease with a decrease in volatility for capital and the number of employees except for 2011. In terms of the CCR score and the BCC score, Pantos Logistics and HYUNDAI Glovis showed the highest level of efficiency, whereas Sunkwang and Hanjin Transportation, the lowest. The super efficiency scores for Pantos Logistics and HYUNDAI Glovis were 4.66 and 1.97, respectively. These providers were able to maintain their efficiency even when input elements increased by as much as 4.7 and 2 times, respectively.

According to the results of the DEA window analysis, the standard deviation and LDP for Hanjin Transportation were 0.011 and 0.029, respectively, indicating that they were the most stable logistics providers. Efficiency showed a decreasing trend during 2007-2009 and 2008-2010 but an increasing trend afterward. DMUs with a productivity index exceeding 1 included DONGBANG TRANSPORT LOGISTICS, Hanjin Transportation, HYUNDAI Glovis, Hansol CSN, CK LINE, Everways, Sinokor, and LogisALL. In terms of changes in pure technological efficiency, DONGBANG TRANSPORT LOGISTICS, Hanjin Transportation, Hansol CSN, CK LINE, Everways, LogisALL, and EUNSAN LOGIS showed improved management efficiency from 2007 to 2011. Further, for technological advancement, Sunkwang, Intergis, HYUNDAI Glovis, Heung-A Logistics, and Sinokor showed technological progress from 2007 to 2011. Korean logistics providers showed vulnerability in service quality and price competitiveness in comparison to global logistics providers. In this regard, Korean providers should develop and implement policies that can help enlarge the domestic logistics market through overseas expansion and increase the scale of the domestic market by attracting foreign firms.

For this, firstly, diversification in government policy is required to develop global logistics firms, secondly, business expansion from existing B2B internal logistics (logistics between logistics firms to B2C (firms and consumers) is also required. Thirdly, logistics firms need to strengthen joint activities with shippers to secure the transaction volume. Fourthly, regional customized consultation and regional specialization is required to provide varied logistics services to the world by constructing diverse logistics supply network along with established FTA enactment with many countries.

In this regard, future research should examine the determinants of efficiency based on financial data for a better understanding of certified logistics providers.

References

BANKER, R.D., CHARNES,A. and COOPER, W.W. (1984), "Some models for estimating technical and scale inefficiencies in Data Envelopment Analysis", *Management Science*, Vol. 30, pp.1078-1092.

CHARNES, A., COOPER, W.W. and RHODES, E. (1978), "Measuring the efficiency of decision making units", European Journal Operational Research, Vol 2, No. 2, pp. 429-444.

FA¨RE, R.S., GROSSKOPF, S. and LOVELL, C.A.K. (1994), Production Frontiers. Cambridge University Press.

JEON,H.J. and KIM,Y.M. (2012), "Financial result analysis of certified integrated logistics system" *International Commerce*, Vol. 27, No.3, pp.145-164.

LEE, S.W. (2013), "A grand discussion for the new leap of Korea maritime logistics-A strategy of securing global logistics market to realize creative economy", *Maritime Logistics Conference, Korea Maritime Institute*, pp.101-167.

LIEB, K., J. and, LIEB, R.,C. (2010), "Environmental sustainability in the third-party logistics (3PL) industry", *International Journal of Physical Distribution & Logistics Management,* Vol. 40, No. 7, pp.524 – 533.

MALMQUIST, S. (1953), "Index numbers and indifference surfaces", *Trabajos de Estatistica,* 4, pp. 209–242.

MIN, H., and JOO, S. J. (2006), "Benchmarking the operational efficiency of major third-party logistics providers using data envelopment analysis", *Supply Chain Management: An International Journal*, Vol 11. No. 3, pp. 259-265.

MIN, H., and Joo, S. J. (2009), "Benchmarking third-party logistics providers using data envelopment analysis: An Update", *Benchmarking: An International Journal*, Vol.16, No.5, pp.572-587.

MIN,H., DEMOND, S. and JOO, S.J., (2013) "Evaluating the comparative managerial efficiency of leading third party logistics providers in North America", *Benchmarking: An International Journa*l, Vol. 20 No. 1, pp.62-78.

PARK, H.G. (2010), "The efficiency analysis of information system of global logistics company", *International Commerce*, Vol.25, No.3, pp.95-109.

PARK, H.G. and KANG, D.H. (2013), "The plan of Gwangyang hinterland on logistics provider service to FTA", *The International Association of Area Studies*, IAAS.

POLI, P. M. and SCHEREGA, C. A. (2000), "The relationship between the functional orientation of senior managers & service quality in LTL motor carriers," *Journal of Transportation Management*, Vol.12, No.2, pp.17-31.

PRAVIN, K., and SINGH, R.K. (2012), "A Fuzzy AHP and TOPSIS methodology to evaluate 3PL in a supply chain", *Journal of Modelling in Management*, Vol. 7 No. 3, pp.287 – 303.

SANG, B. S. and H, S.Y.(2007), "A research for improving the certification scheme of the integrated logistics company", *The Korea Transport Institute*, 2007-07.

SCHEREGA, C. A. (2004), "The relationship between operational efficiency & customer service: A global study of third-eight large international airlines", *Transportation Journal*, Vol.43, No.3, pp.48-58.

SEO,S.B, KIM,T.S., and KIM,Y.J. (2004), "A way to vitalization of integrated logistics companies for reinforcement plan of competitiveness on Korean logistics industry", *The Korea Transport Institute,* 2004-11, pp36-37.

ZHOU, G., MIN, H., XU, C. and CAO, Z. (2008), "Evaluating the comparative efficiency of Chinese third-party logistics providers using data envelopment analysis", *International Journal of Physical Distribution & Logistics Management*, Vol.38, No.4, pp.262-279.