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The Study on Selection of Green Supply Chain Partners in USA Logistics Industry

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***Abstract*—Choosing the suitable green supply chain partners in logistics industry is important to reduce environment risk. The main purpose of this paper is to evaluation of performance measure for green supply chain partners in U.S.A logistics industry using Data development analysis. To conduct a valid and reliable evaluation process while applying the logistics companies case in U.S.A, we integrated the slacks-based measure of super efficiency (super-SBM) and Malmquist index to directly handle the slacks, explore best performer, analyzed the inter-temporal efficiency change, which is decomposed into 'catch-up' and 'frontier-shift' effects and find influential factors in selecting green supply chain partners (GSCPs) criteria from 2010 to 2013. The results show that most GSCPs have higher efficiency and contribute more effort to improving technical change during 2010-2013. By comparing the efficiency of GSCPs in logistics industry, this research provides an approach of decision-making information in logistics as well as contributes to reduce carbon dioxide (CO2) emissions in environmental protection.**

Keywords*—Green supply chain management, logistics, Data developent annalysis, Malmquist index, carbon dioxide emissions

I. INTRODUCTION

Nowadays, environmentally sustainable green supply chain management has emerged as an important organizational philosophy to achieve corporate profit and market share objectives by reducing environmental risks and impacts while improving ecological efficiency of these organizations and their partners [1]. Thus, it's important to do business with companies that are demonstrating their commitment to sustainable transportation and logistics providers. Logistics and transportation are one of the most important activities that are essential for sustaining our daily lives. However; the U.N. Framework Convention on Climate Change estimates that more than 20 percent of global emissions of greenhouse gases are produced by the transport of goods and people. As a result, there is a pressing need for action, particularly by the logistics industry. The purpose of this research is to evaluate the performance of green supply chain partners in U.S.A logistics industry by integrating the slacks-based measure of super efficiency (super-SBM) models and Malmquist productivity index in Data development analysis (DEA) to select the most eligible green supplier, in order to achieve environmentally sustainable supply chain and about determining strategies considered as most cost-effective for managing and responding to environmental issues in logistics.

II. PROPOSED METHODOLOY

This study used Supper - efficiency model (Super- SBM-Oriented) based on slack based measure and Malmquist model to evaluate the efficiency in logistics industry, especially in Green supply chain partners (GSCPs). According to Inbound Logistics, there are 75 green supply chain partners in USA logistics industry [2]. To get credible and equitable data, the plants belonging to third party logistics (3PLS) were first selected for evaluation. Next, the plants belonging to air/ expedited and trucking with complete financial statement were chosen. Finally, only 16 plants were considered in this study.

The conceptual framework is proposed in four stages. The evaluation process was followed in the framework as below:

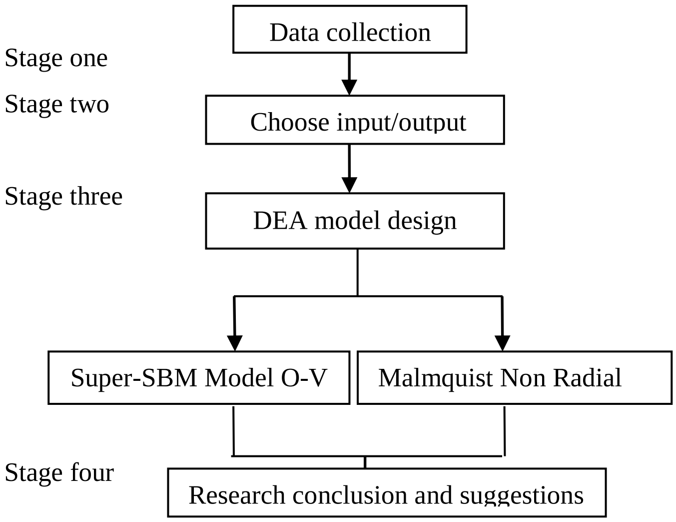

Fig. 1. Procedure of proposed method

Explanation of Figure 1:

- Stage one: Data collection. This study used companies that are related to logistics as DMUs, which includes 3PLS, air/ expedited and trucking that are U.S.A listed companies at stock exchange market as Table I
- Stage two: Choose input/ output variable. The data sources for this study consist of 16 plants annual reports for the period from 2010 to 2013. Information was collected from market observation posting system of U.S.A stock exchange cooperation.

- Stage three: model design. Firstly, we use the Super–SBM-O-V model which proposed by Tone (2002) [3] is an appropriate version of DEA for ranking these efficient Green supply chain partner companies in this study. Then, we implement the Output-oriented Malmquist productivity index [4] to a sample of Green supply chain partners. This model was chosen to compute in order to evaluate the productivity change of a DMU between two time periods.
- Stage four: Research conclusion and suggestions. The results show that they can guarantee the viability of the company. Based on the super efficiency scores and MPI index, we find that most GSCPs have higher efficiency and contribute more effort to improving technical change.

TABLE I. GREEN SUPPLY CHAIN PARTNERS LIST

DMU_S	Full English name of companies	Stock name
DMU_1	Ryder	R
DMU_2	Werner Enterprises, Inc.	WERN
DMU_3	Hub Group Inc	HUBG
DMU_4	C.H. Robinson Worldwide	CHRW
DMU_5	FedEx Corporation	FDX
DMU_6	United Parcel Service, Inc.	UPS
DMU_7	Con-way Freight	CNW
DMU_8	J.B. Hunt Transport Services, Inc	JBHT
DMU_9	Celadon Group, Inc.	CGI
DMU_{10}	Old Dominion Freight Line	ODFL
DMU_{11}	Saia Inc	SAIA
DMU_{12}	CSX Corporation	CSX
DMU_{13}	Norfolk Southern Corp.	NSC
DMU_{14}	Knight Transportation	KNX
DMU_{15}	Union Pacific Coporation	UNP
DMU_{16}	Swift Transportation Co	SWFT

III. RESEARCH RESULTS

A. Performance rankings- Super SBM

The Super-SBM oriented (Super-SBM-O-V) model is applied to assess the relative performances and used as a ranking measure of the 16 GSCPS in U.S.A. It can be found out from Table II, Super SBM is highly in the measurement of efficiency and the rank is clear [5]. The results show that the sixth (United Parcel Service, Inc.) DMU6 has best value and the score always larger than 1 from 2010 to 2013, it is also ranked in the first place in 2013. DMU4 (C.H. Robinson Worldwide, Inc.) is ranked in the second place, and DMU10 (Old Dominion Freight Line) is ranked as the third best DMUs in 2013. That means these company reach the efficiency of output. In other words, DMU7 over invested in input. Thus, if it wants to reach the efficiency level, it should lower its inputs.

B. Components of the Malmquist productivity index: (1) efficiency change

First, we observe the efficiency effect of DMUs. The change in efficiency is called "catch-up" effect [4]. The annual efficiency change index for each DMUs is shown in Table III and figure 2.

Table III shows the results of efficiency change scores of GSCPs as well as their components of the companies which belong to Green supply chain partners. The results of output technical efficiency change present that there are 3 companies (DMU_9, DMU_{11}, DMU_{14}) having no evidence of changes in the input technical efficiency level during the period of 2010-2013.

TABLE II. EFFICIENCY RANK AND SCORE

	2010		2011		2012		2013	
DMU	Score	Rank	Score	Rank	Score	Rank	Score	Rank
DMU_1	0.390304	15	1.046552	8	1.046552	8	1.084461	7
DMU_2	0.764153	13	0.909759	14	0.909759	14	1.012374	9
DMU_3	1.32628	4	1.130601	6	1.130601	6	1	11
DMU_4	1.610008	1	1.701967	1	1.701967	1	1.331328	2
DMU_5	1.115172	7	1.15746	5	1.15746	5	1.140892	5
DMU_6	1.419855	3	1.383747	2	1.383747	2	1.366234	1
DMU_7	2.15E-02	16	0.472521	16	0.472521	16	0.449934	16
DMU_8	0.788557	12	1.019557	9	1.019557	9	1.05502	8
DMU_9	0.999893	10	1	11	1	11	1	11
DMU_{10}	0.674219	14	1.126958	7	1.126958	7	1.290887	3
DMU_{11}	0.999711	11	1	11	1	11	1	11
DMU_{12}	1.000338	8	1.003082	10	1.003082	10	0.576199	15
DMU_{13}	1.130438	6	1.315366	3	1.315366	3	1.132695	6
DMU_{14}	1	9	1	11	1	11	1	11
DMU_{15}	1.184168	5	1.171036	4	1.171036	4	1.269728	4
DMU_{16}	1.524519	2	0.628216	15	0.628216	15	1.003267	10

TABLE III. ANNUAL EFFICIENCY CHANGE FROM 2010 TO 2013

Catch-up	10=>11	11=>12	12=>13	Average
DMU_1	2.681378	1.00908	1.026899	1.572452
DMU_2	1.190547	1.099574	1.012022	1.100714
DMU_3	0.85246	0.992735	0.890958	0.912051
DMU_4	1.057117	1.002585	0.780212	0.946638
DMU_5	1.037921	1.127276	0.874396	1.013198
DMU_6	0.974569	0.777484	1.269922	1.007325
DMU_7	21.98297	0.989519	0.962285	7.978257
DMU_8	1.292941	1.035065	0.999727	1.109244
DMU_9	1	1	1	1
DMU_{10}	1.6715	0.994086	1.152276	1.272621
DMU_{11}	1	1	1	1
DMU_{12}	1.002743	0.639761	0.897881	0.846795
DMU_{13}	1.16359	0.874917	0.984236	1.007581
DMU_{14}	1	1	1	1
DMU_{15}	0.98891	1.114017	0.973304	1.02541
DMU_{16}	0.412075	0.998849	1.59885	1.003258
Average	2.456795	0.978434	1.026436	1.487222
Max	21.98297	1.127276	1.59885	7.978257
Min	0.412075	0.639761	0.780212	0.846795
SD	5.228949	0.123321	0.188527	1.738908

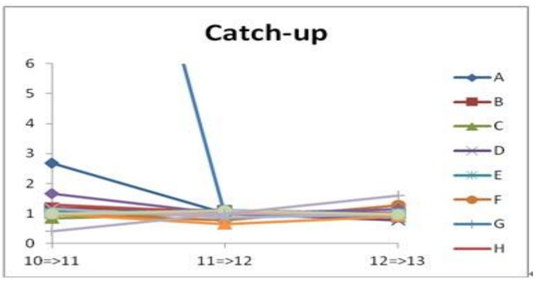

Fig. 2. Annual efficiency change from 2010 to 2013

In 2013, DMU_7 (Con-way Freight) had the largest improvement in efficiency change with score is 7.978257. According average index shows that as a whole, the performance of these companies had been improved from 2010 to 2013. The efficiency change score of these companies was always larger than 1 except for DMU_{12}, its efficiency change scores lower than other companies.

C. Components of the Malmquist productivity index: (2) technical change

Technical-efficiency or the so-called ‘‘innovation’’ or “frontier-shift” effect measures can be compared across time by means of the Malmquist index. In turn, the Malmquist index can be decomposed into two parts: change in technical efficiency and change in best- practice [4].

The results show that during the period of 2010 to 2013. There are 8 logistics companies that having the output technical improvement. There are 8 companies still improve their level of input technical change during the period of 2010 to 2013 as the previous year. Table IV and figure3 shows that DMU9 (Celadon Group, Inc.) has an efficiency score of one in all the years. There are have 8 companies with technical change scores have efficiency score larger than 1, which indicates that they were reach efficiency change level. DMU6 (United Parcel Service, Inc.) has the highest average in the technical efficiency in the period 2010 to 2013. DMU16 (Swift Transportation Co) has scores smaller than 1 from 2011 to 2013. The interpretation of this is that Swift Transportation Co. has low per capital incomes because it seems that it was not investment in new technologies.

TABLE IV. TECHNICAL (FRONTIER) CHANGE OVER THE PERIOD 2010 TO 2013

Frontier	10=>11	11=>12	12=>13	Average
DMU_1	0.938197	1.336349	1.211213	1.16192
DMU_2	0.913608	1.04317	0.992737	0.983171
DMU_3	1.029052	1.0419	1.027608	1.032853
DMU_4	1.015689	1.040676	1.033418	1.029928
DMU_5	1.184574	0.860028	1.240945	1.095182
DMU_6	1.068291	1.00985	2.048535	1.375558
DMU_7	0.834259	1.131308	0.970415	0.978661
DMU_8	0.866662	1.026548	0.98498	0.959397
DMU_9	1	1	1	1
DMU_{10}	0.838103	1.076613	1.033319	0.982678
DMU_{11}	1.17893	1.12247	1.044798	1.115399
DMU_{12}	1.291143	1.56839	1.083977	1.314503
DMU_{13}	1.114362	0.986038	1.038669	1.046356
DMU_{14}	1.00802	1.019136	1.006997	1.011384
DMU_{15}	1.070172	1.080795	1.021964	1.057644
DMU_{16}	1.04493	0.79002	0.963337	0.932762
Average	1.024749	1.070831	1.106432	1.067337
Max	1.291143	1.56839	2.048535	1.375558
Min	0.834259	0.79002	0.963337	0.932762
SD	0.129004	0.177179	0.262985	0.124039

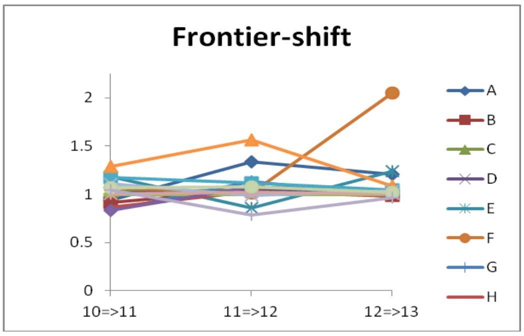

Fig. 3. Technical (Frontier) Change over the Period 2010 to 2013

D. Productivity changes: (3)the Malmquist productivity index and its decomposition.

The Malmquist index indicates the change of productivity between period t and t+1. In this case, if MI > 1, this indicates an improvement in efficiency by which is meant that the productivity of a specific logistic companies increases over the previous year that’s mean these companies are moving along the best production frontier; while MI = 1 and MI < 1 indicate a reduction in efficiency which means that the productivity of a specific logistics companies decreases over the previous year.

Table V and figure 4 shows the results of Malmquist index during 2010 to 2011 that there are an improvement on the productivity level in 14 logistics companies with a MPI values larger than 1. On the contrary, the productivity levels of 2 companies in the same period are decrease with a MPI less than 1, which indicates that productivity loss. The worse productivity in this period comes from the deterioration of input technical efficiency in most cases.

From 2012 to 2013, ten of the companies had productivity growth and other six of the companies had productivity loss. The reduction of the productivity level in this period is mostly from the regression of the input technical efficiency. DMU7 had the highest productivity growth, followed by DMU1. The main source of improvement comes from the development of technical efficiency and technical change.

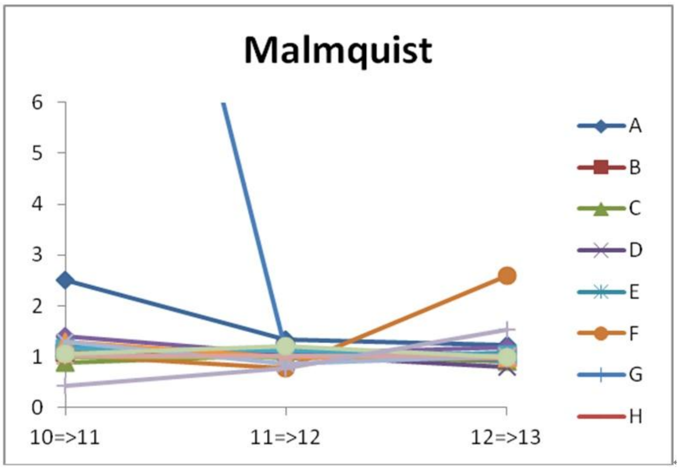

Fig. 4. Annual productivity change (MPI) from 2010 to 2013

TABLE V. ANNUAL PRODUCTIVITY CHANGE (MPI) FROM 2010 TO 2013

Malmquist	10=>11	11=>12	12=>13	Average
DMU_1	2.515661	1.348482	1.243794	1.702646
DMU_2	1.087692	1.147042	1.004672	1.079802
DMU_3	0.877226	1.034331	0.915556	0.942371
DMU_4	1.073702	1.043366	0.806286	0.974451
DMU_5	1.229495	0.969489	1.085077	1.094687
DMU_6	1.041123	0.785142	2.601479	1.475915
DMU_7	18.33948	1.119451	0.933815	6.797581
DMU_8	1.120543	1.062544	0.984711	1.055933
DMU_9	1	1	1	1
DMU_{10}	1.400889	1.070246	1.190669	1.220602
DMU_{11}	1.17893	1.12247	1.044798	1.115399
DMU_{12}	1.294685	1.003394	0.973282	1.090454
DMU_{13}	1.296661	0.862701	1.022296	1.060553
DMU_{14}	1.00802	1.019136	1.006997	1.011384
DMU_{15}	1.058304	1.204024	0.994682	1.08567
DMU_{16}	0.43059	0.78911	1.540231	0.919977
Average	2.247062	1.036308	1.146771	1.476714
Max	18.33948	1.348482	2.601479	6.797581
Min	0.43059	0.785142	0.806286	0.919977
SD	4.311724	0.145044	0.421705	1.43309

IV. CONCLUSION

The purpose of this study research is evaluate the performance of green supply chain partners to select the most

eligible green supplier in order to achieve environmentally sustainable supply chain and about determining strategies considered as most cost-effective for managing and responding to environmental issues in supply chain.

The evaluation of green supply chain partners which was published by Inbound Logistics used the technical called Data Envelopment Analysis and Malmquist productivity index to estimate the efficiency scores of the green supply chain partners in U.S.A.

The empirical evidence of this paper provides some implications and suggestions for green supply chain companies to improve more their profit, technical, scale efficiencies and CO2 emission.

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