Evaluating Key Factors of Developing Green Logistics for Logistics Providers in China Using Multiple Criteria Decision Making

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ABSTRACT

The high-speed development of an economy not only improves quality of life but also results in a series of negative economic outputs, such as energy crises, resources depletion, environmental pollution, and ecosystem imbalance. Global environmental issues have been increasingly attracting people's attention. Due to the rapid growth of the social economy, the logistics services market has grown, but logistics activities have been recognized as the "hard-hit area" of pollution, so the development of green logistics has become the key to achieving energy savings. In this study, the evaluation criteria for green logistics development were constructed using the Delphi method. The well-known Decision Making Trial and Evaluation Laboratory (DEMATEL) and Analytic Network Process (ANP) in multiple criteria decision making (MCDM) were then used to evaluate the key factors of green logistics development and the causal relationships among them. The findings showed that finance and taxation policy and financial support were the key factors for green logistics development. The corporate image and competitiveness are the driving forces to develop green logistics from the viewpoints of logistics providers.

Keywords: Green logistics, DEMATEL, ANP, Delphi method, MCDM

Acknowledgements: This research is partially supported by the Ministry of Science and Technology of Taiwan under grant MOST 104-2410-H-033-023-MY2.

INTRODUCTION

In 1989, the British economist David Pearce was the first to put forward the concept of the green economy in the Green Economy Bluebook, which emphasized the need to consider the impact on the environment while exploring social economic growth (Zhu, 2012). After that, Jacobs (1992) thought that the green economy should take social and organization capital into consideration, which was in contrast to traditional economics, which defined labor, land, and man-made capital as the three basic factors of production. Jacobs emphasized that social organization is not independent of individuals and therefore should fit other organizations and individuals into the society and the environment. So far, the trend of world economic integration has been gradually strengthened and the social economy has increased for many years. However, the negative effects on the environment have become increasingly evident, so people have focused on taking measures to harmonize the development of the social economy and the environment.

In China, the growth in logistics and the economy have had significant positive interactions – high-speed economic growth can fuel the rapid growth of the logistics industry. At the same time, the healthy growth of the logistics industry will also promote the rapid take-off of regional economies (Liu and Li, 2007; Jiang and Zeng, 2011). Along with the increase in the social economy, logistics activities also tend to be more frequent. Some aspects of the logistics activities have a tendency to deepen the destruction of the ecological environment (Hazen, 2014), such as the noise and pollution emissions of logistics equipment involved in transportation and operations, the increase of waste in distribution processing, and urban traffic congestion (Banister and Button, 1993; Whitelegg, 1993). Many problems have led to logistics activities becoming the hardest hit sector in the destruction of the environment, so benefiting mankind has become the first premise of the development of the logistics industry, bringing with it the need to reduce environmental pollution and improve the quality of the environment (Li, et al., 2001). Therefore, the concept of green logistics arises at a historic moment.

The aim of green logistics is to reduce the pollution of the environment and reduce resource consumption. Advanced logistics technologies are used in transportation, storage, loading and unloading, distribution processing, packaging, and other logistics activities. With the intensified market competition all over the world, green logistics has increasingly become a new logistics model to adapt to the symbiotic development of the economy, society, and the environment (Yang and Guo, 2007). Generally speaking, if an enterprise wants to introduce a new production or business model a lot of new costs will be incurred at the same time, such as the costs to introduce advanced equipment, staff recruitment and training, the sunk cost of the original facilities, and the opportunity cost of the new model under uncertainty. The new model will not easily be accepted by the market, and green logistics will encounter many obstacles in the development process.

Green logistics takes the unification of benefits among individuals, corporations, society, and the environment as its guideline and the sustainable development of the society as the ultimate goal (Wang, 2004). For enterprises, the development of green logistics has vital practical significance, such as increasing the competitiveness and popularity of these logistics enterprises and avoiding green barriers in the international logistics market. For the government and society, developing green logistics will improve the image of the government and establish an eco-friendly society, which will ultimately achieve the harmonious development of the ecology, society, economy, and human life. In general, it

is the responsibility of the government, industry, and logistics enterprises to develop green logistics.

In multiple criteria decision making (MCDM), a combination of Decision Making Trial and Evaluation Laboratory (DEMATEL) and Analytic Network Process (ANP) called DEMATEL-based ANP (D-ANP) (Ou Yang et al., 2008) has been widely used to solve various real problems (Chiu et al., 2013; Hu et al., 2015; Ou Yang et al., 2013; Tzeng and Huang, 2011). To take interdependencies into consideration and determine the key factors of developing green logistics in China, a framework for data analysis on the basis of (Hu et al., 2015) was incorporated into the study. This study contributes to establish a framework consisting of the factors that can affect the development of green logistics by means of the survey from Chinese logistics providers. Furthermore, by using the D-ANP, we not only identify that finance and taxation policy and financial support were the key factors of developing green logistics, but give practical suggestions to help boost the positive development of green logistics in China.

LITERATURE REVIEW

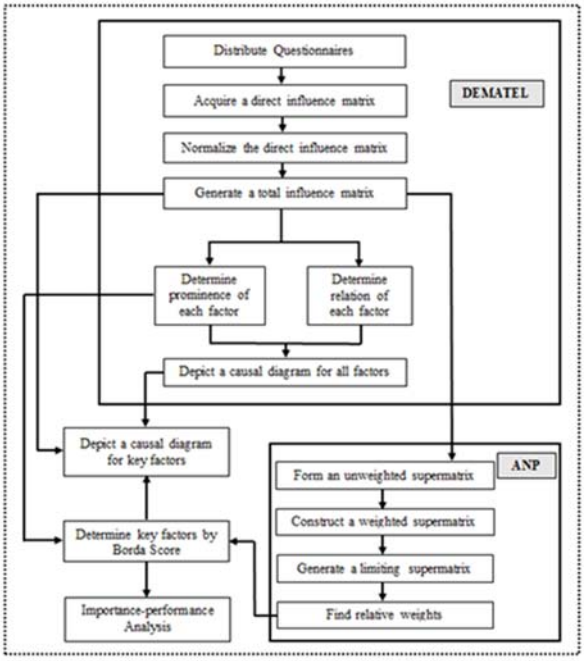
Scholars have expressed different views about the definition of green logistics (Wu and Duan, 1995; Rodrigue, Slack, and Comtois, 2001; Wang, 2002; Feng, 2003). After reviewing and comparing these views, we believe that green logistics should focus on the following points: (1) green logistics should emphasize the harmonious relationship between logistics and the environment; (2) green logistics has two direct objectives – reducing energy consumption and reducing waste emissions; (3) the way to implement green logistics is to focus on logistics technology and scientific management methods; (4) the concept of green logistics should go deep into the functions of transportation, storage, loading and unloading, handling, distribution processing, packaging, and delivery. In addition to the above characteristics, compared with traditional logistics activities, green logistics has more uncertainty (Xiao and Zhang, 2010).

Green logistics can not only have positive effects on environmental protection and reduce energy problem, it can also bring huge economic and social benefits to both the state and the enterprise. As a result, green logistics is one of the inevitable trends of the development of the logistics industry. Because logistics is a hierarchical system, the main behavior of green logistics should include not only the professional logistics enterprises but also the related production enterprises and consumers (Wang, 2002).

Murphy and Poist (2000) carried out empirical research based on hundreds of companies from the United States, Canada, and Europe. They found it was uncommon for government to take measures or enact laws about green logistics, but there was a widely held positive attitude from government towards this kind of practice, and they considered that the impact of government on green logistics produced much more good than harm. Therefore, the development of green logistics should put great emphasis on the role of the government. There are two characteristics of the development of green logistics at the government level: mandatory and supportive. Mandatory regulations will put pressure on enterprises (Zhang, Thompson, Bao, and Jiang, 2014). Supportive behaviors, which include fiscal and taxation policy, financial policy, environmental protection, and investment, will encourage enterprises to be actively involved in environmental management (Cao and Wen, 2011). In addition, the government departments should strengthen their propaganda and education in respect of green logistics (Xiao and Zhang, 2010).

Environmental responsibility for corporations is not only a government imposed duty, it is also related to its suppliers, subcontractors, joint venture partners, and distribution channels (Toyasaki, 2005). Liu and Shi (2007) said that green logistics was helpful in promoting the sustainable development of industry based on circulation economic theory. Wen (2015) pointed out that the logistics industry associations should actively promote the development of the green logistics industry by establishing and improving the supervision mechanism and by putting green logistics into the standardization and construction of information platforms. In the current economic situation, fierce market competition has resulted in a change from the traditional logistics businesses to the whole value chain of logistics enterprises. With the rapid development of the emerging logistics technologies and the wide use of alternative energy sources, it is clear that logistics industrial upgrading is imminent (Song, 2010).

Figure 1: The framework in the study



The government's mandatory policy is not the only reason for enterprises to embrace green logistics; it is also in their own interests. Murphy and Poist (2003) asserted that there were three reasons for enterprises to promote green logistics: improving customer relations, improving public relations, and reducing fuel consumption. With the intensification of market competition, any adverse environmental or social performance in the daily operations of a company will damage its corporate image and have a negative influence on the enterprise value (Duan, 2011). The enhancement of environmental protection consciousness has increased the demand for green logistics, and it is now slowly emerging, and the increased levels of international trade friction also make green logistics a weapon to break down the green barriers of the international market (Jiang, 2009). Enterprise

environmental planning ability will also become a new competitive advantage (Krikpatrick, 1990).

METHODOLOGY

Analytic Network Process (ANP) is a popular method for obtaining the relative weights of individual criteria (Hu et al., 2012). Nevertheless, a serious problem with ANP is that if there are too many criteria involving pairwise comparisons then the time required for pairwise comparisons increases substantially (Xu and Wei, 1999). Furthermore, it is not easy to achieve consistency, especially for the matrix with a high order (Hu and Tsai, 2006). DEMATEL-based ANP (D-ANP), as proposed by Ou Yang et al. (2008), could be free from the consistency test. D-ANP takes the total influence matrix generated by DEMATEL as the unweighted supermatrix of ANP directly to avoid troublesome pairwise comparisons. On the basis of the framework presented by Hu et al. (2015), this study shows the framework for data analysis in Figure 1. In this framework we can see that the importance of criteria are determined by using DEMATEL and D-ANP to obtain the Borda score (Michel, 2006) of each criterion. The greater the Borda score, the more important the corresponding criterion becomes. The distinctive features regarding this framework can be referred to (Hu et al., 2015).

Determining the Total Influence Matrix

The performance values used to represent the degree of influence of one element on another were: 0 (no effect), 1 (little effect), and 2 (strong effect). Next, the direct influence matrix **Z** was constructed using the degree of effect between each pair of elements as obtained by the questionnaire. z_{ij} represents the extent to which criterion *i* affects criterion *j*. All diagonal elements are set to zero:

$$\mathbf{Z}=\begin{bmatrix} z_{11} & z_{12} & \cdots & z_{1n} \\ z_{21} & z_{22} & \cdots & z_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ z_{n1} & z_{n2} & \cdots & z_{nn} \end{bmatrix} \tag{1}$$

The direct influence matrix $\boldsymbol{Z}$ was subsequently normalized to yield a normalized direct influence matrix $\boldsymbol{X}$ after calculating

$$\lambda=\frac{1}{\max\limits_{1\le i\le n}\sum\limits_{j=1}^{n} z_{ij}} \qquad (i, j=1,2,...,n)$$

$$\boldsymbol{X}=\lambda\cdot\boldsymbol{Z} \tag{2}$$

The formula ($\boldsymbol{T}=\boldsymbol{X}(\boldsymbol{I}-\boldsymbol{X})^{-1}$) was used to represent the total influence matrix $\boldsymbol{T}$ after normalizing the direct influence matrix. In this step, $\boldsymbol{O}$ was the zero matrix and $\boldsymbol{I}$ the identity matrix:

$$\lim_{K\to\infty} X^{K}=0$$

$$T = \lim_{x \to \infty} \left(X + X^2 + X^3 + \ldots + X^K \right) = X \left(I - X \right)^{-1} \tag{3}$$

The total influence matrix $\boldsymbol{T}$ was viewed as an unweighted supermatrix and was used to normalize the total influence matrix to obtain the weighted matrix $\boldsymbol{W}$ for ANP. Finally, $\boldsymbol{W}$ was multiplied by itself several times until convergence to obtain the limiting supermatrix $\boldsymbol{W}^*$ and the global weight of all elements.

Identifying key factors

It can be seen that the rankings of the importance for factors resulting from the prominences generated by DEMATEL and the relative weights obtained by DANP were inconsistent. In the opinion of Hu et al. (2015), since both DEMATEL and DANP provide partial messages regarding the selection of key factors, decisions on key factors should not be based on prominences generated by DEMATEL or relative weights obtained by DANP as the sole consideration. This motivates us to use the abovementioned message to determine the final importance rankings of the factors. The overall rankings for the factors are shown by arranging the sum of rankings of each factor in ascending order.

Depicting the causal diagram for key factors

Following the total influence matrix, we can depict a causal diagram for the key factors. Moreover, importance-performance analysis (IPA), formulated by Martilla and James (1977), can be an appropriate tool to help users examine key factors that it is necessary to improve.

EMPIRICAL STUDY

Determining the Formal Decision Structure

In this section, the Delphi method was used to establish the criteria for green logistics development. The Delphi method was developed by Rand Corporation in the United States in the 1960s for long-term predictions (Pill, 1971; Shefer and Stroumsa, 1981; Rowe, Wright, and Bolger, 1991). It consists of a series of repeated interrogations of a group of experts and managers, whose judgments are of interest, through questionnaires in order to arrive at a group position regarding an issue. After the initial interrogation of each individual, each subsequent interrogation is accompanied by providing information in respect of the previous round of replies. Individuals are encouraged to reconsider and change their previous replies after consideration of the replies of the other members of the group (Chung, Lee, and Pearn, 2005).

According to the previous research, 27 criteria that have effects on green logistics development were selected. After stage-two of the Delphi discussions, 18 of the criteria satisfied the consensus deviation index (CDI) < 0.1. After further discussion the experts strongly agreed that the formal research framework should include the 11 criteria shown in Table 1.

Table 1: The formal research framework

Goals		Criteria
Green Development	Logistics	Laws on green logistics (A1)
		Finance and taxation policy (A2)
		Financial support (A3)
		Demand for logistics industry transformation and upgrading (A4)
		Demand for technology upgrading (A5)
		Break the green barriers in international market (A6)
		Establish a corporate image (A7)
		Enhance the competitiveness of enterprises (A8)
		Business ethics and social responsibility (A9)
		Enhance the long-term value (A10)
		Meet the market demand for green logistics (A11)

Results Analysis

There were 79 senior managers from 53 Chinese logistics enterprises invited to join this study. Of the 79 questionnaires distributed to the respondents, 57 were returned to the researchers, and 37 of these were valid. Using the DEMATEL method, the initial direct influence matrix in Table 2 for criteria was calculated using Eq. (1). The normalized direct influence matrix in Table 3 was obtained through Eq. (2). The total influence matrix in Table 4 was calculated using Eq. (3) and Table 5 summarizes the prominence and relation of each criterion. Table 6 summarizes the cause/effect properties of the 11 criteria considered.

Table 2: The initial direct influence matrix for criteria

Criteria	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11
A1	0.0000	1.0811	0.9730	1.1622	1.2973	1.5676	0.8378	1.1622	1.4595	1.1892	1.0541
A2	1.1351	0.0000	0.9730	1.1892	1.4324	1.5946	1.0811	1.0541	1.5135	1.3784	1.2162
A3	1.1892	0.9730	0.0000	1.2703	1.4324	1.3514	1.1622	1.0541	1.5135	1.2973	1.1892
A4	1.0270	1.0000	1.1081	0.0000	1.3243	1.3784	1.0811	1.1081	1.2162	1.0811	1.1892
A5	0.6486	0.6486	0.6757	0.7027	0.0000	1.1081	0.7297	0.8649	1.0541	0.9730	0.9189
A6	0.4595	0.5676	0.6486	0.5405	1.0000	0.0000	0.7568	0.8649	1.0541	1.0541	0.8108
A7	0.9459	1.1081	1.1081	1.0270	1.3514	1.2432	0.0000	1.0811	1.2973	1.2703	1.0811
A8	0.9459	1.0270	1.0541	1.0541	1.3243	1.2162	1.1081	0.0000	1.3784	1.2162	0.8919
A9	0.4865	0.3243	0.5405	0.5676	0.7027	0.9459	0.5135	0.6486	0.0000	0.9730	0.9459
A10	0.8108	0.7027	0.7297	0.7568	1.2162	1.0541	0.9189	0.9730	1.2703	0.0000	1.0000
A11	0.7297	0.8378	0.7568	0.8649	1.0000	1.0270	1.0270	1.1351	1.1892	1.2432	0.0000

Table 3: The normalized direct influence matrix for criteria

Criteria	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11
A1	0.0000	0.0835	0.0752	0.0898	0.1002	0.1211	0.0647	0.0898	0.1127	0.0919	0.0814
A2	0.0877	0.0000	0.0752	0.0919	0.1106	0.1232	0.0835	0.0814	0.1169	0.1065	0.0939
A3	0.0919	0.0752	0.0000	0.0981	0.1106	0.1044	0.0898	0.0814	0.1169	0.1002	0.0919
A4	0.0793	0.0772	0.0856	0.0000	0.1023	0.1065	0.0835	0.0856	0.0939	0.0835	0.0919
A5	0.0501	0.0501	0.0522	0.0543	0.0000	0.0856	0.0564	0.0668	0.0814	0.0752	0.0710
A6	0.0355	0.0438	0.0501	0.0418	0.0772	0.0000	0.0585	0.0668	0.0814	0.0814	0.0626
A7	0.0731	0.0856	0.0856	0.0793	0.1044	0.0960	0.0000	0.0835	0.1002	0.0981	0.0835
A8	0.0731	0.0793	0.0814	0.0814	0.1023	0.0939	0.0856	0.0000	0.1065	0.0939	0.0689
A9	0.0376	0.0251	0.0418	0.0438	0.0543	0.0731	0.0397	0.0501	0.0000	0.0752	0.0731
A10	0.0626	0.0543	0.0564	0.0585	0.0939	0.0814	0.0710	0.0752	0.0981	0.0000	0.0772
A11	0.0564	0.0647	0.0585	0.0668	0.0772	0.0793	0.0793	0.0877	0.0919	0.0960	0.0000

Table 4: The total influence matrix for criteria

Criteria	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	d
A1	0.2304	0.3045	0.3074	0.3322	0.4201	0.4489	0.3165	0.3582	0.4551	0.4057	0.3612	3.9402
A2	0.3250	0.2414	0.3218	0.3490	0.4488	0.4710	0.3480	0.3679	0.4798	0.4377	0.3893	4.1798
A3	0.3280	0.3107	0.2512	0.3538	0.4475	0.4535	0.3524	0.3667	0.4783	0.4308	0.3864	4.1594
A4	0.3018	0.2973	0.3140	0.2475	0.4184	0.4323	0.3301	0.3517	0.4349	0.3950	0.3668	3.8897
A5	0.2137	0.2117	0.2208	0.2313	0.2367	0.3231	0.2377	0.2613	0.3296	0.3016	0.2721	2.8396
A6	0.1896	0.1948	0.2071	0.2080	0.2922	0.2272	0.2268	0.2475	0.3123	0.2912	0.2508	2.6475
A7	0.2964	0.3041	0.3137	0.3207	0.4200	0.4232	0.2527	0.3495	0.4402	0.4072	0.3596	3.8873
A8	0.2903	0.2926	0.3041	0.3159	0.4097	0.4127	0.3247	0.2651	0.4363	0.3952	0.3397	3.7862
A9	0.1697	0.1573	0.1777	0.1864	0.2418	0.2639	0.1870	0.2079	0.2044	0.2562	0.2335	2.2857
A10	0.2451	0.2357	0.2456	0.2573	0.3517	0.3496	0.2728	0.2929	0.3752	0.2602	0.3029	3.1891
A11	0.2494	0.2542	0.2572	0.2747	0.3508	0.3611	0.2906	0.3146	0.3838	0.3607	0.2424	3.3394
r	2.8393	2.8044	2.9208	3.0767	4.0376	4.1664	3.1393	3.3833	4.3299	3.9414	3.5046	

As shown in Table 7, a weighted supermatrix can be obtained by normalizing the total influence matrix. The limiting supermatrix derived by the weighted supermatrix was shown in Table 8.

Table 5: Prominence and relation of each criterion

Criteria	d	r	d+r	d-r
A1	3.940163	2.839338	6.779501	1.100826
A2	4.179831	2.80441	6.984241	1.375421
A3	4.159398	2.920792	7.08019	1.238606
A4	3.889677	3.076713	6.96639	0.812964
A5	2.839558	4.037578	6.877136	-1.19802
A6	2.647482	4.166446	6.813928	-1.51896
A7	3.887285	3.139252	7.026538	0.748033
A8	3.786197	3.383342	7.169538	0.402855
A9	2.285712	4.329913	6.615625	-2.0442
A10	3.18911	3.941439	7.130549	-0.75233
A11	3.339389	3.504581	6.843971	-0.16519

Table 6: Cause/Effect properties of criteria

Cause/Effect	Criteria
Cause	Laws on green logistics (A1), Finance and taxation policy (A2), Financial support (A3), Demand for logistics industry transformation and upgrading (A4), Establish a corporate image (A7), Enhance the competitiveness of enterprises (A8)
Effect	Demand for technology upgrading (A5), To break the green barriers in international market (A6), Business ethics and social responsibility (A9), Enhance the long-term value (A10), Meet the market demand for green logistics (A11)

Table 7: The weighted supermatrix for criteria

Criteria	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11
A1	0.0812	0.1086	0.1053	0.1080	0.1040	0.1077	0.1008	0.1059	0.1051	0.1029	0.1031
A2	0.1145	0.0861	0.1102	0.1134	0.1112	0.1130	0.1109	0.1087	0.1108	0.1110	0.1111
A3	0.1155	0.1108	0.0860	0.1150	0.1108	0.1089	0.1122	0.1084	0.1105	0.1093	0.1103
A4	0.1063	0.1060	0.1075	0.0804	0.1036	0.1038	0.1051	0.1039	0.1004	0.1002	0.1047
A5	0.0753	0.0755	0.0756	0.0752	0.0586	0.0775	0.0757	0.0772	0.0761	0.0765	0.0776
A6	0.0668	0.0695	0.0709	0.0676	0.0724	0.0545	0.0723	0.0732	0.0721	0.0739	0.0716
A7	0.1044	0.1084	0.1074	0.1043	0.1040	0.1016	0.0805	0.1033	0.1017	0.1033	0.1026
A8	0.1022	0.1043	0.1041	0.1027	0.1015	0.0990	0.1034	0.0783	0.1008	0.1003	0.0969
A9	0.0598	0.0561	0.0608	0.0606	0.0599	0.0633	0.0596	0.0615	0.0472	0.0650	0.0666
A10	0.0863	0.0841	0.0841	0.0836	0.0871	0.0839	0.0869	0.0866	0.0866	0.0660	0.0864
A11	0.0878	0.0906	0.0881	0.0893	0.0869	0.0867	0.0926	0.0930	0.0886	0.0915	0.0692

Table 8: The limited supermatrix for criteria

Criteria	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11
A1	0.1027	0.1027	0.1027	0.1027	0.1027	0.1027	0.1027	0.1027	0.1027	0.1027	0.1027
A2	0.1087	0.1087	0.1087	0.1087	0.1087	0.1087	0.1087	0.1087	0.1087	0.1087	0.1087
A3	0.1086	0.1086	0.1086	0.1086	0.1086	0.1086	0.1086	0.1086	0.1086	0.1086	0.1086
A4	0.1020	0.1020	0.1020	0.1020	0.1020	0.1020	0.1020	0.1020	0.1020	0.1020	0.1020
A5	0.0748	0.0748	0.0748	0.0748	0.0748	0.0748	0.0748	0.0748	0.0748	0.0748	0.0748
A6	0.0697	0.0697	0.0697	0.0697	0.0697	0.0697	0.0697	0.0697	0.0697	0.0697	0.0697
A7	0.1020	0.1020	0.1020	0.1020	0.1020	0.1020	0.1020	0.1020	0.1020	0.1020	0.1020
A8	0.0995	0.0995	0.0995	0.0995	0.0995	0.0995	0.0995	0.0994	0.0995	0.0995	0.0995
A9	0.0603	0.0602	0.0603	0.0603	0.0603	0.0603	0.0603	0.0603	0.0603	0.0603	0.0603
A10	0.0839	0.0839	0.0839	0.0839	0.0839	0.0839	0.0839	0.0839	0.0839	0.0839	0.0839
A11	0.0879	0.0879	0.0879	0.0879	0.0879	0.0879	0.0879	0.0879	0.0879	0.0879	0.0879

The overall rankings for the criteria are shown in Table 9 by arranging the sum of the rankings of each criterion in ascending order. According to the overall ranking list, we take financial support (A3), finance and taxation policy (A2), enhance the competitiveness of enterprises (A8), and establish a corporate image (A7) as our key criteria.

Table 9: The overall ranking for criteria

Criteria	DEMATEL	D-ANP	Borda score	Ranking
Laws on green logistics (A1)	10	3	13	7
Finance and taxation policy (A2)	5	1	6	2
Financial support (A3)	3	2	5	1
Demand for logistics industry transformation and upgrading (A4)	6	4	10	5
Demand for technology upgrading (A5)	7	9	16	9
Break the green barriers in international market (A6)	9	10	19	10
Establish a corporate image (A7)	4	5	9	4
Enhance the competitiveness of enterprises (A8)	1	6	7	3
Business ethics and social responsibility (A9)	11	11	22	11
Enhance the long-term value (A10)	2	8	10	5
Meet the market demand for green logistics (A11)	8	7	15	8

Importance-performance analysis

As mentioned above, financial support is the most important factor driving logistics providers to develop green logistics. However, resources are limited, so it is necessary to decide how to deploy these limited resources to the best advantage. IPA is an effective means to resolve resource priority configuration effectively (Matzler, Bailom, Hinterhuber, Renzl, and Pichler, 2004). To assess the criterion performances, 37 managers from Chinese logistics providers were invited to be survey subjects. The relationship between rating and performance is shown in Table 10. The average values on the 11 criteria are shown in Table 11.

Table 10: Relationship between rating and performance

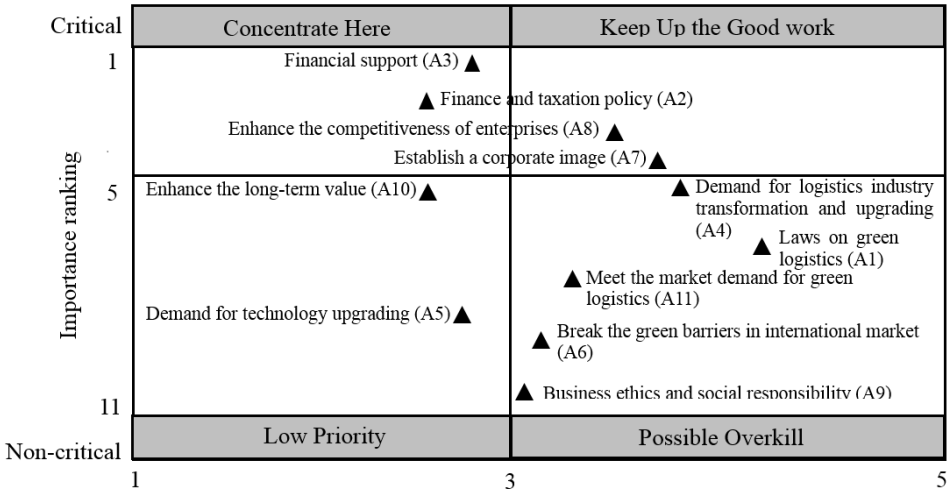
Rating	1	2	3	4	5
Performance	Very dissatisfied	Dissatisfied	Ordinary	Satisfied	Very satisfied

Table 11: Performance assessment of eleven criteria

Criteria	Average values
Laws on green logistics (A1)	4.2432
Finance and taxation policy (A2)	2.7838
Financial support (A3)	2.9730
Demand for logistics industry transformation and upgrading (A4)	3.7297
Demand for technology upgrading (A5)	2.9459
Break the green barriers in international market (A6)	3.3784
Establish a corporate image (A7)	3.5946
Enhance the competitiveness of enterprises (A8)	3.4865
Business ethics and social responsibility (A9)	3.0811
Enhance the long-term value (A10)	2.7297
Meet the market demand for green logistics (A11)	3.3243

After consulting the experts, they all agreed to use 3 as a threshold value to distinguish criteria with acceptable (≥ 3) or unacceptable (< 3) performance values from the eleven criteria. Each criterion with its rank and performance value is depicted in Figure 2, and these are used by IPA to determine which key factors should be concentrated on.

Figure 2: Importance-Performance analysis



From Figure 2, it can be seen that, in addition to finance and taxation policy (A2) and financial support (A3), the other two key criteria, namely establish a corporate image (A7) and enhance the competitiveness of enterprises (A8), fall into the upper right grid. The Chinese logistics providers deemed that the key factors that fall into such a grid position should receive continuous focus to ensure good performance. Also, the Chinese logistics

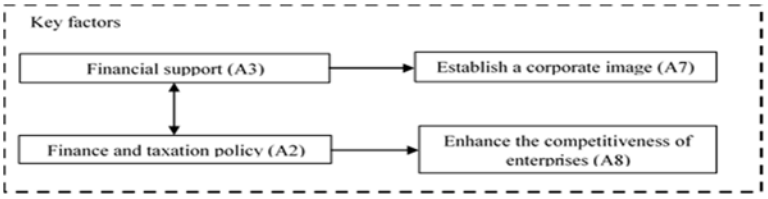
providers expect to obtain more finance and taxation policy and financial support that fall into the upper left grid. However, the resources committed to those criteria that fall into the lower right grid would be better employed elsewhere, and it is not necessary to focus additional effort on A5 and A10.

CONCLUSIONS AND IMPLICATIONS

Conclusions

According to the results of the empirical study, this study identifies four key factors that drive Chinese logistics providers to develop green logistics, namely: the finance and taxation policies (A2), the financial support (A3), the establishment of a corporate image (A7), and the enhancement of an enterprise's competitiveness (A8).

Figure 3: The causal diagram for evaluation criteria



According to the total influence matrix in Table 4, a causal diagram depicted in Figure 3 shows that Chinese logistics providers should energetically work on performance improvements of the finance and taxation policy (A2) and financial support (A3) to promote the development of green logistics in order to facilitate the other key factors. Also, the selection of A2 and A3 to be the starting point is appropriate because they are categorized into the class of “cause”.

Figure 3 shows that financial support of green logistics (A3) is the most important factor affecting the development of green logistics, and the reason for this is that enhancing the performance of A3 can directly drive the enhancement of the performance of the key factors A2 and A7, and it can also indirectly improve the performance enhancement of A8. In addition, the change in the performance of A2 will also have impacts on A3. Specifically, it is well known that the logistics industry is a heavy capital industry, so large amounts of capital need to be invested in infrastructure construction, the planning and construction of the social logistics network, the integrated information platform of the logistics industry, and the introduction and maintenance of enterprise logistics facilities and equipment. However, most logistics providers are small and medium-sized enterprises so these enterprises, or even the industry, cannot afford such a huge amount of money. This heavy capital pressure makes the operating environment much worse, so the financial support for green logistics (A3) from financial institutions, and even from the government, can help logistics providers to develop green logistics effectively. It can be seen why this has become the most important factor driving the development of green logistics.

A large number of environmental protection facilities in the current society, such as pollution-free waste treatment plants, the development of emerging alternative energy sources, and electric buses, rely on the government's financial support. Currently, the

construction of these facilities and the purchase of this equipment need support from the government's income sources. When the internal and external environment is fairly stable, the government's fiscal income is usually relatively fixed and the government spending commitments are multifarious, so the quota available for investment in environmental protection is limited. Therefore, it is especially important for the government to increase its income and reduce its expenditure on environmental protection, so the financial support of green logistics is seen as a new field requiring a share of the government's environmental protection investment. As a result, an increase in financial support for green logistics can effectively solve the difficulties of government financing so as to help the government to put more money into environmental protection.

Companies will never give up a chance to shape their brand images and green logistics can be a "golden signboard" for a logistics enterprise. However, as stated earlier, the progress from traditional logistics activities to green logistics activities will not be achieved overnight. It needs not only the establishment of a view on what constitutes a good environment, the deployment of resources, and the agreement of managers on the concept of green logistics, but it also needs monetary support. If the government provides financial support to develop green logistics activities, it will alleviate the pressure of capital shortages on green logistics enterprises and make green logistics enterprises go further towards dramatically improving the image of logistics industry enterprises.

The competitiveness of an enterprise is a kind of comprehensive ability of that enterprise that is reflected by its participation in a competitive environment and is evaluated by a comparison of an enterprise with all of its competitors. It is a kind of relative index and must be shown by mutual competition. At present, increasingly fierce competition, high homogeneity, low profit margins, high resource consumption, and environmental pollution have become common problems of the logistics markets on both sides of the Taiwan Strait and further reveals the convergence of the competitiveness of logistics enterprises. Accordingly, the question of how to improve the competitiveness of a logistics enterprise and put the enterprise in an impregnable position in the intensely competitive market has become a key issue to be solved to being about the healthy development of the logistics industry. For logistics enterprises, developing a green logistics business to meet the strong demand for green supply chain management in the market is the key to performing well in the competitive marketplace; succeeding in this task can quickly enhance an enterprise's competitiveness and eventually become its core competitive weapon. The company that carries out green logistics will receive financial support from the government, and this support can effectively solve the worries related to the access to technical innovation and the introduction of new talents to cultivate green logistics in order to enhance the enterprise's competitiveness.

Management Implications

According to the conclusions above, among the four key factors driving the development of green logistics there are two factors that are outside the control of the logistics providers: finance and taxation policy (A2) and financial support (A3). As shown in Figure 3, the financial support for green logistics is the most important factor affecting the development of green logistics. The improvement of A3's performance will improve other key factors, so the financial support for green logistics should be focused on firstly.

The results of IPA showed that the establishment of corporate image (A7) and the promotion of an enterprise's competitiveness (A8) are high performance areas, so the good

work on these should be continued. However, the performance levels in respect of finance and taxation policy and financial support are poorer, which means that the financial support and taxation policies that logistics providers receive are not good enough. Therefore, the financial institutions and the government must increase their financial support for the logistics providers who intend to develop green logistics by reducing credit standards and providing more convenient and extensive sources of funding. Also, the government should promote the scale of logistics financial applications together with logistics firms in order to provide sufficient financial support for enterprises to develop green logistics.

According to Figure 3, the two key factors for logistics providers to develop green logistics start from the promotion of the enterprise's image and enhancement of the enterprise's competitiveness. Both of these exhibited a good level of performance in the empirical study, suggesting that the development of green logistics providers could effectively improve their competitiveness and corporate image. The reason why logistics providers develop green logistics is not only to respond to the government's mandates and to get the government's financial support, but also they have a strong belief that green logistics can bring great benefits to their enterprises.

For the enterprises, green logistics is of social value. The implementation of green logistics by management will help the enterprises to set up a good enterprise image, which will win the public's trust and enable the enterprise to obtain environmental standards certification. The implementation will also help to break the green barriers of the market, which provides an advantage to an enterprise in the fiercely competitive market. Also, green logistics is of economic value. Embracing the concept of green logistics will not only force logistics companies to operate their businesses in a more environmentally friendly manner, but it will also make more effective use of their employees, goods, and resources, thus reducing operating costs and improving their competitive abilities. Therefore, logistics providers should adhere to the development of green logistics.

Logistics is a social system. Therefore, logistics providers should spread green logistics throughout their whole logistics system. Firstly, in transportation and distribution logistics providers should improve their vehicle scheduling and route planning to reduce the occurrence of excessive transportation, they should update their vehicle fuel systems to improve their fuel efficiency and to reduce exhaust emissions, they should enhance their utilization of clean energy, and they should reduce the number of deliveries in rush hours to reduce traffic congestion. Secondly, in warehousing and inventory management, logistics providers should adopt centralized inventory management and picking to improve operational efficiency. Furthermore, energy conservation and environmental protection concepts should be considered in the construction and maintenance of the warehouse. Thirdly, recycling packages, such as chopping blocks and containers, should be used. Polluting and non-biodegradable packages should be avoided as far as possible. Finally, in circulation processing, advanced operating methods that improve the operating efficiency and reduce residual materials should be implemented.

To sum up, logistics providers should actively adopt green logistics techniques in respect of transportation, storage, packaging, circulation processing, and other basic work. In addition, logistics providers should actively guide their customers to promote green supply chain management. Logistics industry associations should formulate a unified standard of logistics equipment, set indicators that limit environmental pollution in transportation, and promote the transformation and upgrading of the logistics industry. Governments should strengthen the legislation in respect of constraints and policy support.

The development of green logistics needs the joint efforts of the enterprises, industry, and government.

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