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Analyzing the Promoting Factors for Adopting Green Logistics Practices: A Case Study of Road Freight Industry in Nanjing, China

Yong Zhang[a], Russell G. Thompson[b]*, Xiangtai Bao[a], Yunjian Jiang[a]

[a]*Southeast University, China*
[b]*Institute of Transport Studies, Monash University, Clayton, Australia, 3800*

Abstract

Corporate Environment Management (CEM) is one of the most critical areas for encouraging truck fleets to adopt the green logistics activities under the serious situation of energy security and emission pressures. However, CEM has not been widely adopted in the road freight transportation industry in China yet. This paper describes green logistics practices in China and identifies factors which will have significant effect on the adoption of green logistics in truck fleets. A research framework was developed based on the theory of institutional economics, which was used to describe concept relationships between the driving factors and green logistics practices of truck fleets. A questionnaire survey was conducted in road freight transportation industry in Nanjing, China. A structural equation model was then developed to illustrate concept relationships using factor analysis. The main driving factors identified included an environmental management strategy, mandatory and normative and supply chain pressure. The current green logistics activities of truck fleets identified related to the logistics environment management, green storage and packaging, green transportation, fleet management, alternative fuel implementation and logistics innovation. These findings will aid the adoption of green logistics in the road freight transportation industry in China.

Keywords: Green logistics; corporate environment management; fleet management

* Corresponding author. Tel.: +61-3-9905-1850.
E-mail address: rgthom@unimelb.edu.au

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1. Introduction

Due to the growth of the Chinese economy in recent years, road transport has become a dominant part of the transportation system in China (He et al., 2005). The road freight sector accounted for 75.5% of the total freight volume in 2010. It is projected that in 2020, there will be 85.1 million vehicles and an extra 175.6 million motorcycles in China (Wang, Cai, Lu & Chen, 2007). Truck fleets[1] are one of the main elements of the road freight industry, which are taking on the transportation, loading/unloading, storage, distribution, purchasing and other logistics services. There are now more than 800,000 truck fleets in China. In 2010, the number of commercial trucks was 10,501,900. Considering the development path of the transport sector, there is little doubt that the road transport sector will become dominant in China's emissions inventories in the near future (Wang, Cai, Lu & Chen, 2007).

A major current issue for the Chinese government is to how reduce emissions and energy consumption within a development context. With the growing importance of environmental protection, more companies have begun to focus on Corporate Environment Management (CEM). Chinese companies are increasingly realizing the importance of environmental issues, and are trying to improve their environmental performance (Pan, 2007). The greening of fleets, especially trucks and automobiles, is increasing gaining the attention of companies in a variety of industrial sectors (Bae, Sarkis & Yoo, 2011). Green logistics has become popular in developed countries in recent years.

Most truck fleets in Nanjing, China have not yet taken positive actions to develop green logistics. Research has so far failed to understand the driving mechanism for truck fleets in China to implement CEM into logistics practice and adopt green logistics.

A review of the situation of Chinese road freight industry indicated that it is necessary to understand the current situation relating to green logistics practices as a prerequisite for identifying the driving factors for adopting green logistics initiatives in the future.

The main objectives of this study were to develop a mechanism for understanding the adoption of green logistics practices for truck fleets in China. A framework based on institutional economics was developed to identify the driving factors, green logistics practices and their relationships. An outline of the methods applied is presented. An analysis of green logistics practices in the road freight industry based on a survey of truck fleets is presented. A description of the driving factors for adopting green logistics for truck fleets is then provided. A structural equation model was developed to determine the relationships between the driving factors and adoption of green logistics practices. Finally, recommendations for promoting the development of green logistics in the Chinese road freight industry are presented.

2. Research Framework and Hypothesis

2.1. Literature review

Some companies have begun to implement proactive environmental protection measures, such as reporting environmental information that go beyond the basic commitments to achieve higher environmental goals (Liu & Anbumozhi, 2009). However, the environmental behavior of Chinese companies has not only been affected by government, it has also influenced by other stakeholders such as investors, surrounding residents, industry associations and employees (Clark, 2005). Therefore, other methods should be used, such as economic incentives to business-led voluntary initiatives and environmental information disclosure strategies, to enhance the interaction between companies and investors for higher environmental goals (Henriques & Sadorsky, 1996).

There have been many studies related to external factors for adopting green logistics. Governmental regulations are considered to be the dominant forces. A fleet's environmental strategy is always influenced by

[1] In China, truck fleets have the same corporate characteristics, which are one type of various logistics providers. In common, they are stronger than other types of logistics providers about capability of line transport and distribution.

environmental regulations, such as emissions standards (Meegeren, 2001). Government legislation and enforcement actions are considered as having the most important impact on a truck fleets' environmental decision-making (Henriques & Sadorsky, 1996). In addition to external controls from laws and regulations, market participants and the community environment of a truck fleet are becoming important environmental issues (Chen & Soyez, 2003). Cooperation with suppliers, consumers and manufacturers can provide more effective ways to solve environmental challenges (Prakash & Potoski, 2006). When Chinese companies apply green logistics practices, market pressure also becomes a major factor (Zhu, Sarkis & Lai, 2007).

Some studies have shown that consumers often prefer to choose environmentally friendly raw products (Weber, 1990). When investigating the market demand for Taiwan enterprises, environmental management was identified as a powerful force (Wen & Chang, 1998). Public pressure has been found to play an important role in CEM (Gunningham, Kagan & Thornton, 2003). It was found that when developing an environmental plan, pressure from the public in CEM is generated by a number of decision-making policies in large companies in Canada (Henriques & Sadorsky, 1996).

Besides, CEM is also influenced by the company's own characteristics, such as ownership, size and financial position. One study showed that companies or enterprises, which are related to the field of natural resources, are more likely to do environmental planning, while companies or enterprises in the services sector are less likely to do this type of planning (Henriques & Sadorsky, 1996). Image or interest in company management can also be a factor (Downing & Kimball, 1982).

2.2. Framework for truck fleets' adopting green logistics

During the last decade, research has been conducted from a number of different perspectives such as the enterprise resource theory, organization learning theory and the theory of planned behavior. However, there have not been any previous studies involving the adoption of green logistics in truck fleets.

The theory of institutional economics recognizes the overall framework of business operations, and it emphasizes social pressure effects other than those from an organizations objectives (DiMaggio & Powell, 1983). The theory of institutional economics can explain how companies reach a consensus on increasing environmental issues and indicate how truck fleets' green logistics practices are developed and popularized. A framework of the drivers of the development of green logistics for truck fleets based on CEM theory and institutional economic theory is presented in Fig. 1.

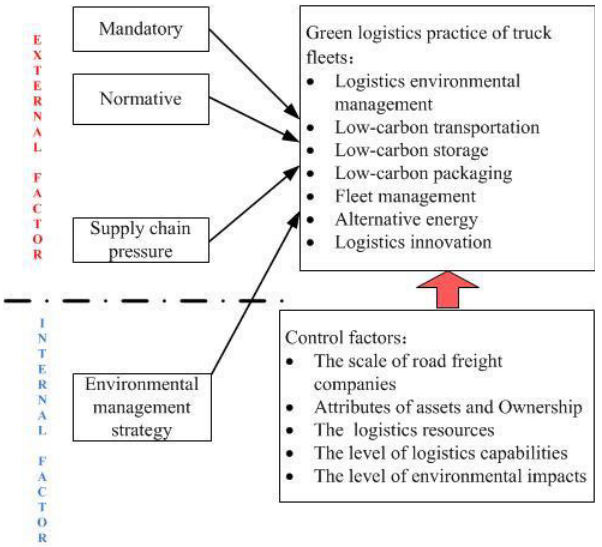

Fig. 1. Framework of drivers of green logistics for truck fleets

External institutional pressures are pressures from outside the organization and include factors such as national and local government initiatives for promoting the development of a low-carbon society, transportation and logistics industry associations, the public's normative expectations, supply chain members and peer competition imitation.

Mandatory pressure includes initiatives from all levels of government. These agencies are authorized to promulgate and implement regulations concerning green logistics. All kinds of planning and incentive measures for promoting the development of green logistics will directly affect the majority of truck fleets' environmental behavior.

Normative pressure mainly refers to green logistics standards defined by associations such as transport or logistics organizations. These standards relate to vehicles, technologies and equipment, and have a direct impact on the behavior of a majority of truck fleets. Supply chain pressure arises mainly from the supply chain partners, shareholders and customers.

Internal factors mainly refers to environmental management strategies and the learning ability of a truck fleet.

Environmental management strategies consider that awareness of issues and social norms will in turn affect the formation of behavior. However, the current size of truck fleets in China is small and it is common for senior managers solve fleet operating problems. Therefore, development of green logistics in truck fleets needs high-level support from managers for adoption. Awareness and attitudes of truck fleets towards CEM is often an important part of environmental strategic positioning.

2.3. Hypothesis

This study aimed to identify the relationships between both internal and external drivers (internal and external pressure) and green logistics practice which truck fleets carry out. The hypotheses are shown in Fig. 2.

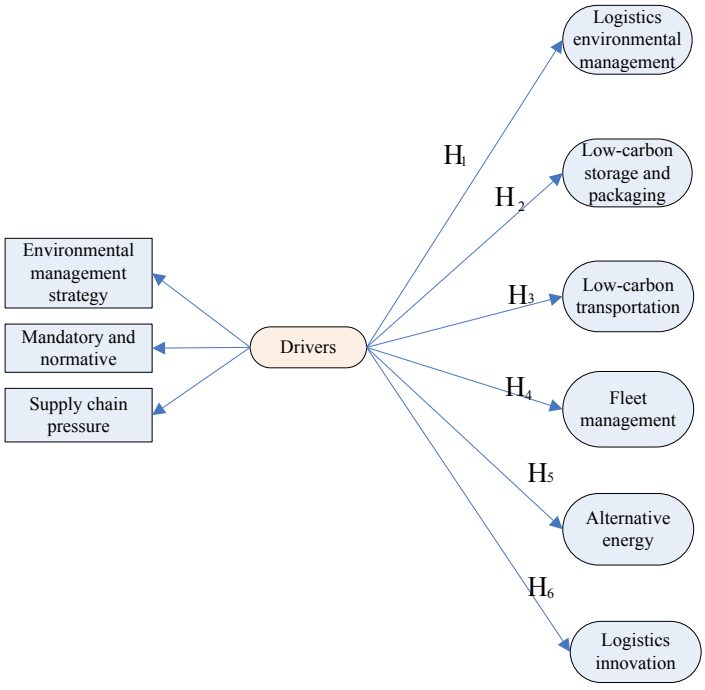

Fig. 2. Hypothetical model of the correlation between driving factors and green logistics practices

The hypothesis defined for this study are:

1. Internal and external pressure on truck fleets has a positive effect on carrying out logistics environmental management,
2. Internal and external pressure on truck fleets has a positive effect on carrying out low-carbon storage and packaging,
3. Internal and external pressure on truck fleets has a positive effect on carrying out low-carbon transportation,
4. Internal and external pressure on truck fleets has a positive effect on improving fleet management,
5. Internal and external pressure on truck fleets has a positive effect on using alternative energy in logistics processes, and
6. Internal and external pressure on truck fleets has a positive effect on promoting logistics innovation.

3. Methods

3.1. Questionnaire design and data collection

A questionnaire survey of truck fleets conducted in Nanjing from May to July in 2010 was used to collect the information used in this study. Interviews were conducted using a structured questionnaire.

The questionnaire was designed considering previous studies and the research framework presented in Fig. 1. A draft questionnaire was designed and pretested before the main survey. The pretest involved 10 respondents who had knowledge concerning green logistics. These 10 respondents were asked to comment on the length of the questionnaire, the format and the wording of the scales. Reliability analysis was used to check the items in the questionnaire, which resulted in some items being revised.

The final questionnaire consisted of three parts. The first part related to the demographics of the respondents including of type, history, turnover and profits of the company. The second part focused on the factors driving truck fleets to adopt green logistics. A total of 19 driving factors were considered. The final part of the questionnaire was concerned with green logistics activities, including 36 types of practices.

In the main survey, 142 questionnaires were delivered, of which 104 valid responses were received (a valid response rate of 73.3%). Table 1 presents the demographics of the responses.

Table 1. Demographics of truck fleets

Items	Level	Percentage of respondents	Mean (std. deviation)
Type of truck fleet	1. Truck fleet for dangerous goods	30.6	3.53 (2.172)
	2. Truck fleet for consolidation	14.3	
	3. Transport agency	6.1	
	4. Truck fleet for multimodal transport	3.4	
	5. Truck fleet for storage	13.6	
	6. Truck fleet for general goods	29.9	
	7. Else	2.1	
Asset properties	1. State-owned or cooperative investment	15.5	2.23 (1.050)
	2. Private investment	67.0	
	3. Foreign investment	3.9	
	4. Partnership investment	6.8	
	5. Else	6.8	
Period of operation	1. 1-5 years	26.9	2.16 (0.986)
	2. 6-10 years	40.4	

	3. 11-20 years 4. 21-30 years 5. ≥ 30 years	26.0 2.9 3.8	
Annual turnover	1. ≤10 million 2. 11-50 million 3. 51-100 million 4. 101-1000 million 5. ≥ 1000 million	11.2 16.3 13.3 33.7 25.5	3.46 (1.333)
Number of employees	1. ≤ 20 2. 21-50 3. 51-100 4. 101-500 5. 501-1000 6. ≥ 1000	12.6 35.9 24.3 24.3 1.9 1.0	2.70 (1.092)
Annual profit	1. ≤ 5% 2. 6-10% 3. 11-15% 4. 16-20% 5. ≥ 20%	49.5 31.6 11.6 4.2 3.2	1.80 (1.017)
Number of Vehicles	1. <20 2. 20-100 3. ≥100	38.0 46.0 16.0	1.78 (0.705)

3.2. Data analysis

Statistical analysis was performed using SPSS17.0 and LISREL. In addition to general descriptive statistics, reliability analysis, factor analysis and variance analysis of structural modelling of the selected data from the survey was undertaken.

A two-step procedure was followed where the reliability of the data was investigated, then descriptive statistics were analyzed to determine the measurement model. Following this, structural equation modelling was used to find the best fit model and direction of the relationships among the theoretical constructs (Anderson & Gerbing, 1988).

4. Results and Discussion

4.1. Descriptive results

4.1.1. Driving factors for adopting green logistics in truck fleets

The fleets surveyed reported that the four most important driving factors for adopting green logistics were the, "Administrative department of local and industry policies and regulations", "The central government's legal and regulatory requirements", "Customer national sale environmental regulations" and "Public requirements" (Table 2).

From the survey, factors such as, "Needs to obtain the tax, honor, subsidies and other incentives" and "Needs to achieve its environmental mission" were found to have no significant effort on adopting green logistics for truck fleets.

Table 2. Driving Factors for Adopting Green Logistics

Observed Variable Number	Driving Factors	Mean (Standard Deviation)	Rank
1	The central government's legal and regulatory requirements	4.05 (0.659)	2
2	Administrative department of local and industry policies and regulations	4.07 (0.658)	1
3	Logistics industry associations' guidance and regulation	3.95 (0.674)	9
4	Recommendations and requirements of customers	3.8 (0.716)	16
5	Recommendations and requirements of the logistics partner	3.82 (0.693)	14
6	The public requirements	4.01 (0.631)	3
7	Customer national sale environmental regulations	4.01 (0.675)	3
8	Customer's environmental management requirements	3.87 (0.764)	12
9	Needs To establish the of company public image	3.98 (0.653)	7
10	Development requirements of company shareholders	3.85 (0.734)	13
11	Behavior requirements of the of employees	3.82 (0.773)	14
12	Needs to improve the competitiveness of enterprises	4.0 (0.668)	5
13	Needs to obtain the tax, honor, subsidies and other incentives	3.76 (0.77)	19
14	Needs to save costs	4.0 (0.697)	5
15	Needs to facilitate the disposal of hazardous waste	3.8 (0.817)	16
16	Needs to achieve its environmental mission	3.79 (0.821)	18
17	Needs for marketing	3.88 (0.759)	11
18	Part of enterprise culture	3.92 (0.72)	10
19	Needs to improve company environmental performance	3.98 (0.724)	8

Scale: 1. Very unimportant; 2. Unimportant; 3. Medium; 4. Important; 5. Very important

4.1.2. Green logistics practices adopted by truck fleets.

The prevalence of the 36 green logistics practices identified was determined, see Table 3. The three most popular green logistics practices activities found were, “Choosing the right mode of transport”, “Optimizing transport routes” and “Monitoring vehicle driving mileage”.

The three least popular green logistics practices activities stated were, “Use of alternative energy or new energy vehicles”, “Establishing alternative energy plans of companies” and “Reducing the number of used vehicles ”.

Table 3. Green logistics practices adopted by truck fleets

Observed variable number	Green logistics practice	Mean (std deviation)	Rank
1	Monitoring pollutants emitted from vehicles	2.96 (1.097)	31
2	Monitoring vehicle fuel consumption	3.77 (1.176)	6
3	Use of alternative energy or new energy vehicles	2.41 (1.094)	36
4	Efficient management of transport fleet	3.68 (1.23)	8
5	Reducing the number of used vehicles	2.88 (1.509)	34

6	Establishing vehicle repairing strategy	3.74 (1.123)	7
7	Monitoring the useful life of vehicle	3.66 (1.241)	9
8	Establishing alternative energy plans of companies	2.5 (1.207)	35
9	Classified using the vehicle	3.5 (1.386)	11
10	Monitoring vehicle driving mileage	3.95 (1.242)	3
11	Optimizing logistics performance	3.78 (1.236)	5
12	Optimizing transport routes	4.01 (1.145)	2
13	Optimizing transport load distribution	3.87 (1.27)	4
14	Choosing the right mode of transport	4.02 (1.171)	1
15	Making use of integrated transport	3.63 (1.316)	10
16	Using intensive mode of transport (containers or transportation with dumping trailers etc.)	3.22 (1.414)	17
17	Using recyclable packaging materials and logistics containers	2.87 (1.486)	33
18	Reducing use of transport packaging	2.99 (1.458)	29
19	Using improved or innovative handling systems	2.97 (1.376)	30
20	Full use of multi-modal transport hub and logistics center	3.08 (1.356)	24
21	Monitoring recycling of transportation waste	3.04 (1.4)	26
22	Recycling containers and other packaging materials of logistics	2.96 (1.421)	31
23	Reasonably choosing way of products warehousing	3.18 (1.46)	20
24	Optimizing storage space	3.13 (1.426)	22
25	Reasonable arrangements for the layout of warehouse space	3.21 (1.466)	18
26	Optimizing warehouse or Establishing overall company quality environmental management system der picking strategies	3.01 (1.362)	28
27	Establishing overall company quality environmental management system	3.19 (1.33)	19
28	Cooperation with partners or customers in environmental management	3.29 (1.244)	15
29	Environmental management certification, such as the ISO14000 series	3.06 (1.327)	25
30	Establishing related corporate environmental management information system	3.17 (1.242)	21
31	The audit of environmental performance practice	3.10 (1.195)	23
32	Selection of partners and their environmental performance assess	3.02 (1.213)	27
33	Carrying out employees' environmental management knowledge training	3.37 (1.133)	12
34	Carrying out company energy saving training and assessment	3.36 (1.182)	13
35	Establishing employees incentives to develop environmental performance	3.35 (1.237)	14
36	Establishing environmental management strategies	3.27 (1.264)	16

Scale: 1. Disagreed;2. Agreed to plan; Planning to do; Starting to do;5. Been applied.

5. Model Results

5.1. Analysis of driving factors for truck fleets' adopting green logistics

The overall reliability of the survey of driving factors α was estimated to be 0.953. Factor analysis using principal component analysis, using orthogonal rotation with Kaiser standardized method, convergence after 6 iterations, which KMO test coefficient =0.877, and Bartlett's sphericity test (df = 171, sig = 0.000). Using factor analysis, the 19 green logistics development drivers were extracted to 3 principal component factors, environmental management strategic factors, mandatory and normative factors and supply chain pressure factor. Table 4 shows the results of the factor analysis.

Table 4. Results of driving factor analysis of green logistics practices in truck fleets

Observed variable number	Factor	Factor loading	The total explained variance	Reliability coefficient α
	Environmental management strategy factors		27.2%	0.929
16	Needs to achieve its environmental mission	.861		
17	Needs for marketing	.845		
18	Part of enterprise culture	.815		
15	Needs to facilitate the disposal of hazardous waste	.812		
13	Needs to obtain the tax, honor, subsidies and other incentives	.774		
19	Needs to improve company environmental performance	.685		
14	Needs to save costs	.647		
	Mandatory and Normative factor		24.3%	0.920
1	The central government's legal and regulatory requirements	.822		
3	Logistics industry associations' guidance and regulation	.819		
2	Administrative department of local and industry policies and regulations	.806		
7	Customer national sale environmental regulations	.736		
6	The public requirements	.661		
8	Customer's environmental management requirements	.635		
	Supply chain pressure factor		21.5%	0.923
10	Development requirements of company shareholders	.816		
11	Behavior requirements of the of employees	.772		
5	Recommendations and requirements of the logistics partner	.759		
4	Recommendations and requirements of customers	.700		
12	Needs to improve the competitiveness of enterprises	.678		
9	Needs To establish the of company public image	.543		

5.2. Factor analysis of green logistics practices in truck fleets

In the survey, the whole liability coefficient α of the development of green logistics practice of 104 Nanjing truck fleets was estimated to be 0.962. Principal component analyses were used in the factor analysis. Using orthogonal rotation with Kaiser standardized method, with convergence after 8 iterations, the KMO test coefficient = 0.884, and Bartlett's sphericity test (df = 630, sig = 0.000). Using factor analysis, the 36 green logistics development drivers were extracted to 6 principal component factors. They are environmental management of logistics factor, low-carbon storage and packing factor, low-carbon transportation factor, fleet management factor, the new alternative energy factor and logistics innovation factor. Table 5 shows the results of factor analysis.

Table 5. Factor analysis results of green logistics practice development in truck fleets

Observed variable number	Green logistics practices	Factor loading	The total explained variance	Reliability coefficient α
	Environmental management strategy factors		20.4%	0.957
31	The audit of environmental performance practice	.853		
32	Selection of partners and their environmental performance assess	.839		
36	Establishing environmental management strategies	.828		
33	Carrying out employees' environmental management knowledge training	.808		
30	Establishing related corporate environmental management information system	.798		
35	Establishing employees incentives to develop environmental performance	.778		
34	Carrying out company energy saving training and assessment	.778		
28	Cooperation with partners or customers in environmental management	.684		
29	Environmental management certification, such as the ISO14000 series	.678		
27	Establishing overall company quality environmental management system	.572		
	low-carbon storage and packing factor		18.2%	0.936
25	Reasonable arrangements for the layout of warehouse space	.863		
24	Optimizing storage space	.857		
23	Reasonably choosing way of products warehousing	.819		
26	Optimizing warehouse order picking strategies	.802		
22	Recycling containers and other packaging materials of logistics	.764		
18	Reducing use of transport packaging	.661		
21	Monitoring recycling of transportation waste	.643		
20	Full use of multi-modal transport hub and logistics center	.622		
17	Using recyclable packaging materials and logistics containers	.576		
	low-carbon transportation factor		14.0%	0.911
12	Optimizing transport routes	.819		
14	Choosing the right mode of transport	.772		
11	Optimizing logistics performance	.768		
13	Optimizing transport load distribution	.756		
10	Monitoring vehicle driving mileage	.709		
9	Classified using the vehicle	.620		
15	Making use of integrated transport	.589		

5	Reducing the number of used vehicles	.429		
	fleet management factor		9.7%	0.871
4	Efficient management of transport fleet	.782		
6	Establishing vehicle repairing strategy	.760		
7	Monitoring the useful life of vehicle	.759		
2	Monitoring vehicle fuel consumption	.726		
	the new alternative energy factor		6.8%	0.815
3	Use of alternative energy or new energy vehicles	.859		
8	Establishing alternative energy plans of companies	.854		
1	Monitoring pollutants emitted from vehicles	.449		
	logistics innovation factor		6.0%	0.594
16	Using intensive mode of transport (containers, or transportation with dumping trailers etc.)	.713		
19	Using improved or innovative handling systems	.578		

5.3. Structural equation modeling results

Based on the requirements and corresponding constraints of the structural equation model, and in order to reduce the complexity of the model, through analysis, the green logistics practice factors of observation variables were reselected under the premise of not affecting the accuracy of the model.

Based on the requirements and corresponding constraints of the structural equation model, and in order to reduce the complexity of the model, through analysis, the green logistics practice factors of observation variables were reselected under the premise of not affecting the accuracy of the model.

SPSS 17.0 and LISREL were used to perform statistical analysis of the six dimensions of the 21 indices related to the analysis, from the correlation matrix, and the LISREL software was used to verify the whole model. After comparing these to the recommendation indices in Table 6, it was found that the goodness of fit indices, and the hypothesis proposed in this study are correct.

Table 6. Applicable comparison of the structural equation modeling

Model /Index	χ^2	χ^2/df	*GFI*	*RMSEA*	*CFI*	*NNFI*	*AGFI*	*RMR*
Recommended value	—	<3	>0.8(Dawes *et al.*,1998)	<0.1(Hair *et al.*,2006)	>0.9(Hair et al.,2006)	>0.9	>0.85	—
Model index value	300	1.82	0.95	0.065	0.94	0.92	0.91	0.027

The results of the structural variance model are presented in Fig. 3. These results show that the drivers of green logistics development have an active impact on 6 categories of fleets' green practices. The stronger the internal and external drivers of green logistics developments in truck fleets are, the more occurrence of the six types of green logistics practice there will be.

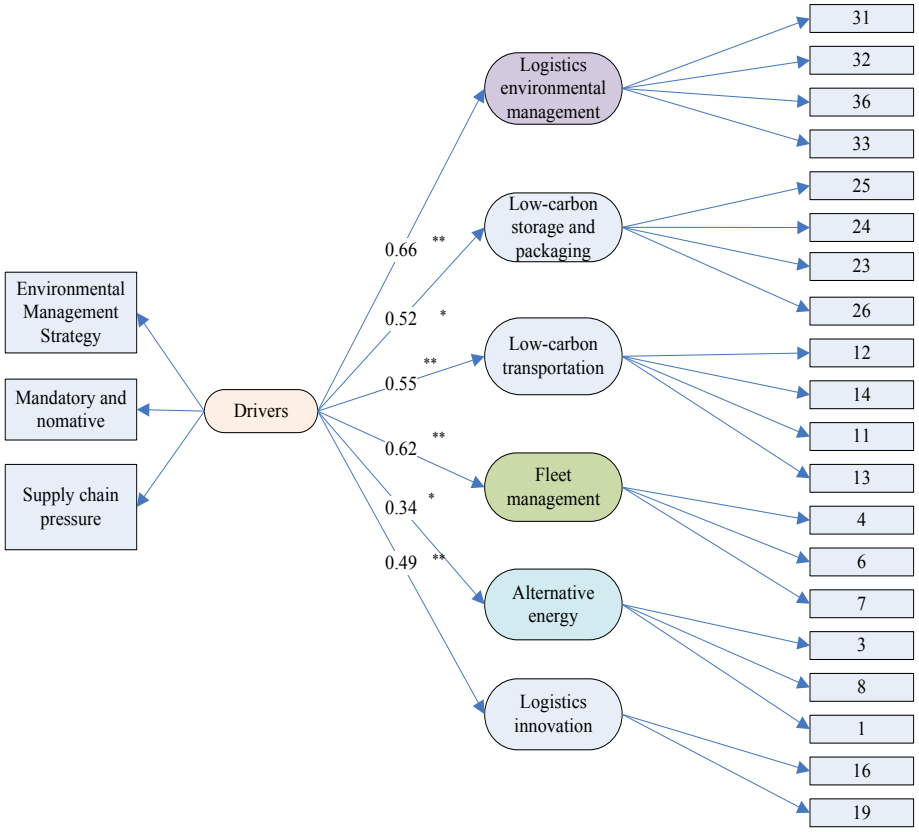

Fig. 3. Results of structure equation model (*p < 0.05; **p < 0.01)

6. Conclusions and Future Work

In this study, a systematic framework of internal and external drivers based on the institutional economics theory was proposed. Then based on CEM and institutional economics, the study hypotheses were defined. Survey data was used to build a structural equation model to test the validity of hypothesis. This enabled a number of conclusions relating to the adoption of green logistics to be made.

It was determined that the drivers for adopting green logistics for truck fleets are composed of both external and internal factors. External factors include the mandatory pressure, normative pressures and supply chain pressures. Internal factors mainly refer to the environmental management strategy.

Six types of green logistics practices were analyzed, logistics environmental management, low-carbon warehousing and packaging, low-carbon transportation, fleet management, alternative energy and logistics innovation.

According to the structural equation model, different drivers have different effects on the adoption green logistics practice. The most influential green logistics practice affected by the driving factor identified was the logistics environmental management, followed by the fleet management, low-carbon transport, low-carbon storage and packaging, logistics innovation and new energy alternatives.

This study validates that there is an effect mechanism between the internal and external drivers and the development of green logistics in truck fleets in Nanjing, China. It shows the creation or improvement of the internal and external environment for development can greatly improve the majority of Nanjing truck fleets to adopt green logistics practices.

Compared with previous studies, this study has identified the driving mechanisms for truck fleets to adopt

green logistics practices through investigation, theoretical analysis and quantitative modelling. The results are important for promoting the implementation of green logistics practices in truck fleets. Considering the differences between the internal and external drivers and green logistics behavior, the quantitative relationships developed will be further studied. Additional surveys will also be conducted in other cities in China.

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