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Influencing Factors of Agricultural Products Logistics Transportation Mode Selection- an Empirical Research Based on SEM

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Abstract

Reasonable transportation mode selection of agricultural products concerns the cost, efficiency and safety of the transportation process. The technical features and economic advantages of highway transportation are different and this transportation mode holds obvious advantages over other modes under the same transportation demand. This paper reviews the general principle and demands of transportation mode selection, establishes structural equation model and studies the impact of various factors under different transportation modes. By setting the formulation, low-carbon environmental philosophy" as impersonal restricted factors latent variables, setting "cost, efficiency, security preference" as subjective factors latent variables and the analysis and verification based on measurement model, the impact of different transportation modes on factors like cost, time and security is concluded, which provides suggestions for the transportation of agricultural products that have different requirement attributes.

Keywords*: agricultural products transportation; logistics transportation mode; transportation organization; SEM*

1. Introduction

Agricultural products have various types and are easy to be damaged. What' more, agricultural products have strong seasonal characteristic and the producing areas are dispersed. These lead to different technical standards in transportation process, multiple batches but small amount and large cost variation and pose high high demands in terms of timeliness, economy and security. The transportation of agricultural products is mainly achieved via highway or railway. Different transportation modes possess different technical and economical characteristics and comparative advantages in the aspects of time, cost and security. The inappropriate selection of transportation modes and improper joining will result in unreasonable transportation structure, thus increasing time and cost and enhancing security risk. Therefore, the reasonable selection of transportation modes play a very important role in effective circulation of agricultural products.

Railway transportation bears the characteristic of large transportation volume, low freight, high speed, security, accuracy and continuity, which is suitable for long-distance transportation of primary agricultural products; highway transportation is convenient in terms of loading and unloading and flexible. It can also be directly linked to warehouses and is highly adaptable to physiographic condition and agricultural products showing obvious nature difference, which is suitable for short-distance transportation of agricultural products. For the organizers of agricultural products transportation, they tend to be restricted by objective conditions and have different psychological demands for agricultural products transportation, thus showing different sensitivity towards economy, timeliness and security of transportation. The inquiry into the importance of influencing

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factors on transportation mode selection has important theoretical and practical significance in achieving the efficient circulation of agricultural products.

2. Literature Review

The existing literatures mainly focus on theoretical methods of transportation mode selection or research preference and angle of transportation influencing factors. WJM Steyn *et. al.,* (2015) proposed the influencing factors of agricultural products transportation rural road conditions through quantitative analysis of the evaluation of impact of low grade highway on the damage degree of tomato transportation [1]. Chen *et. al.,* (2015) discussed the selection of transportation modes under different carbon emission policies by establishing the model of retailers' ordering and transportation mode [2-3]. Kund (2015) studied the selection of different transportation modes applying fuzzy multiple criteria group decision method [4-5]. Fowler (2001) simulated the transportation mode of wheat and barley and explained the impact of cost on transportation mode selection [6]. Li *et. al.,* studied the risk factors of agricultural products transportation and pointed out that High air deposition and high agricultural production were the main factors influencing agricultural products transportation [7]. Xiang *et. al.,* (2013) and JanJevic *et. al.,* (2014) studied the role played by operational coordination and effective supervision of government administration sections in the refrigerated transportation of fresh agricultural products [8-10]. De Oliveir *et. al.,* (2015) conducted research on the optimal selection of transportation modes based on cost according to the characteristics of each transportation mode [11]. Koetse *et. al.,* (2009) studied the uncertain factors of various transportation modes of generalized cost posed by climate change and the impact of climate change on transportation mode selection [12]. In addition, some literatures also mentioned the impact of transportation demands like cost, time and security on transportation mode selection [13-15].

Previous research achievements provide reference for the analysis of influencing factors of agricultural products logistics transportation mode selection and rarely involve empirical analysis. Even in the models mentioned, the behavior principle and demand comparison of transportation means and systematic discussion of impact of cost, time and security on transportation mode selection are seldom considered. By the selection of objective and subjective factors influencing transportation mode selection, the structural equation model is established and empirically analysis of the impact of various factors on transportation mode under the optimal transportation effect together with comparative analysis, which is taken as the research perspective of this paper.

3. Principles and Objective Limits of Agricultural Products Transportation Mode Selection

3.1. Principle and Demand of Transportation Mode Selection

3.1.1. Economy of Transportation: The economy of transportation is reflected in transportation cost, which includes consumption cost of transportation activities and management cost of transportation enterprises. The consumption cost of transportation activities include manpower consumption, fuel of transportation means, maintenance and repair, cost of abrasion, insurance and so on, which are associated with transportation distance; the management cost of transportation enterprises includes operating cost, coordination cost, management cost and taxes., which are not associated with transportation distance.

3.1.2. Timeliness of Transportation: The timeliness of transportation is reflected in transportation efficiency. Giving no consideration to carrying capacity of transportation,

the load in unit area of the transportation of agricultural products are relatively low compared with steel and other heavy metal products. The loss of transportation means is mainly influenced by distance rather weight, so the main consideration is transportation distance in unit time. Transportation time usually includes the traveling time of vehicles, transferring time, waiting time, service time and delay time, which are prone to be influenced by factors like road condition, weather, driving level and transferring efficiency of transportation mode. Transportation distance is easily influenced by species characteristic of agricultural products, distance between producing area and selling area, transportation mode preference of shippers and change in market demand.

3.1.3. Security of Transportation: The security of transportation is reflected in the security of agricultural products transportation, which refers to the soundness degree and proportion of products specifically in the transportation process. The description of damage degree includes: squeezing, perishing and spoiling, heat death, disease infection, pollution of chemicals and total destruction. Compared with other goods, agricultural products are more easily to be damaged and have higher demand and difficulties in transportation, which requires the optimization of transportation organization mode. The reasonable selection of transportation mode can effectively reduce the damage degree of agricultural products in the transportation process to maintain the freshness, boost profits and save cost.

3.2. Objective Constraints of Transportation Mode Selection

3.2.1. Construction of Transportation Infrastructure: The convenient transportation condition between the producing are and selling area of agricultural products and the sound construction of transportation infrastructure along the transportation route are the keys in supporting the formation efficient and fast circulation system of agricultural products. The prerequisites like high grade highway density, development degree of transportation network, convenience degree of transportation service will determine whether agricultural products can be delivered safely and timely to the consumption market.

3.2.2. Support of Transportation Policies: Transportation policies, as the external force of transportation structure optimization, can support or restrain the development of some kind of transportation mode through the adjustment of monetary policies and fiscal policies and can lead the development of some kind of transportation mode by resource development policies and the sustainable development strategy. Policy support is an important means in realizing rapid, continuous and vigorous development of modern logistics transportation system of agricultural products and an important guarantee in promoting modern agricultural public service function.

3.2.3. Soundness of Transportation Technology Standard Establishment: Due to the biological, seasonal and regional characteristics of fresh agricultural products, the delivery without special treatment may lead to the spoiling and corruption in large amounts. The application of refrigeration and cold storage technique achieves the low temperature environment from harvest to delivery, thus guaranteeing the transportation quality of agricultural products, enhancing the security and saving the cost. Different kinds of agricultural products require differently in terms of technical indexes of low temperature storage like control time and control condition. The level of transportation technology also exerts impact on the security preference of transportation modes.

3.2.4. Impact of Low Carbon and Environmental Protection Philosophy: Transportation and production links should also consider social benefits and ecological

benefits in the pursuit of economic benefits. Transportation is energy consuming industry. Moreover, the ecological pollution and energy waste produced during the transportation activities of agricultural products can not be ignored. Every link of agricultural products transportation is accompanied by large amount of carbon emission. The selection of transportation mode should not take minimum expense or shortest time as the only optimization objective. If the selection is not reasonable, it will lead to longer transportation distance, thus increasing carbon emission.

4. Theoretical Hypothesis Model

We can see from the above analysis that the influencing factors of transportation mode selection can be divided into objective and subjective. The main body of circulation of agricultural products is different and perspective of the interests is also different, which results in the variation in interest demands and principles of transportation mode selection. At present, researches on transportation mode selection of agricultural products at home and abroad study the point of interest balance in terms of transportation mode selection starting with the balance among stakeholders of shippers, carrier and managers. Based on social welfare maximization principle, it can be investigated whether the whole transportation system can satisfy the transportation demand of agricultural products to a maximum state. Therefore, the addition of low carbon and environmental protection factors in the objective conditions and conducting research from the perspective of the interests of society bear certain significance in studying the factors influencing transportation mode selection.

4.1. Objective Factors

Limit of objective conditions mainly refers to that the objective factors influencing transportation mode selection are not restricted by subjective conditions and transportation mode selection under the maximum principle of social welfare. The absence of sound transportation infrastructure conditions near the producing area of agricultural products means it is unable to conduct the transportation activities of agricultural products; moreover, the preference of time and cost may not be taken into consideration if of low carbon and environmental protection preference is selected. However, it can not be ignored from the long term perspective of economic and social sustainable development. To be more specifically, the objective factors influencing the transportation mode selection of agricultural products include construction of transportation infrastructure, construction of transportation supporting logistics system, transportation polices, transportation technology standard establishment and low carbon and environmental protection philosophy. Thereby, following hypotheses are proposed:

H1 significant impact of objective factors on transportation mode selection

H2 significant impact of objective factors on subjective factors

4.2. Subjective Factors

Subjective factors are more influenced by human factors and fall broadly into two categories. The first category is the subjective preference under the restriction of objective conditions, which is the subjective intention and selection behavior under certain restriction of objective conditions. For instance, the transportation mode which provides less damage, shorter time and higher security is more likely to be selected under the same transportation cost; the other category is the change in subjective perception and mentality of shippers, which refers to the difference in the perception of transportation, change in the understanding of cooperation with carriers. The first category includes the demand for economy, for timeliness and for security; the second category can be summarized as the cognition degree of transportation activities. The transportation of agricultural products

cannot break away from human factors and the majority of activities are conducted based on or mixed with human factors. Therefore, subjective factors also exert an important impact on the selection of transportation mode of agriculture products. Thereby, following hypothesis is proposed:

H3 significant impact of subjective factors on transportation mode selection

4.3. Theoretical Model

According to the above discussion, the theoretical model of the factors influencing transportation mode selection is established combined with the research hypothesis proposed, as is shown in Figure 1.

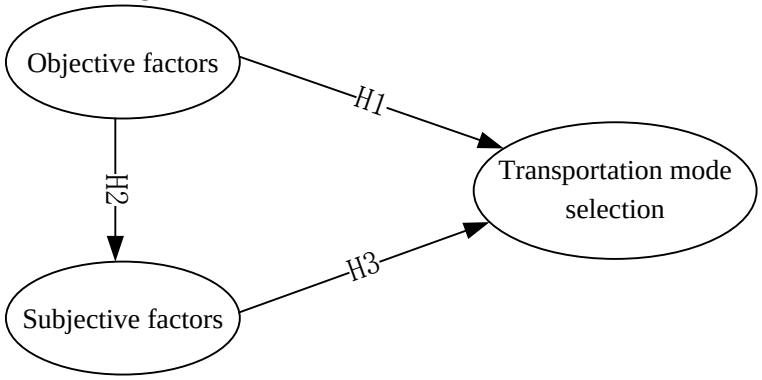

Figure 1. Theoretical Model

5. Empirical Analysis

5.1. Data Acquisition

Structural equation model is a kind of empirical analysis model method. The research thought of that model is to present the objective status of things in causal hypothesis way and then conduct verification making use of quantitative data. The Likert five-grade scale is adopted, which is {1, 2, 3, 4, 5}={strongly disagree, disagree, uncertain, agree, strongly agree}. Professionals such as the employed in transportation industry, experts and scholars, managers in transportation industry and producers of agricultural products are taken as research objects, and method of combining online questionnaires with field questionnaire is applied. Altogether 262 valid questionnaires are recalled and that number is greater than 200, which is suitable for structural equation model analysis [17].

5.2. Reliability and Validity Test

According to the data of investigation, SPSS21.0 and AMOS21.0 softwares are applied to carry out reliability and validity test. The reliability in the Cronbach's α coefficient test scale is adopted. The overall Cronbach's α coefficient in this scale is 0.758, greater than 0 .700, which proves that this scale has good reliability. The overall KMO value of this scale and the KMO value of most measurement indexes are greater than 0.700. Besides, the statistics Sig value of sphericity test is less than 0.001, proving high internal consistency of this questionnaire. The load on each factor of measurement indexes is greater than 0.500 and the reliability of variable combination is greater than 0.700. The test has proven that the scale is equipped with good discriminant validity and reliability, which is suitable for confirmatory factor analysis, as is shown in Table 1.

Table 1. Test Result of Reliability and Validity

Latent variable		Observation variable		Standardized load		CR value	
Code number	Name	Code number	Name	Railway	Highway	Railway	Highway
F1	Objective factors	**Q1**	Construction of transportation infrastructure	**0.73**	**0.81**	**0.706**	**0.791**
		Q2	Construction of transportation supporting logistics system	**0.60**	**0.69**		
		Q3	Transportation technology standard establishment	**0.64**	**0.65**		
		Q4	Low carbon and environmental protection philosophy	**0.47**	**0.63**		
F2	Subjective factors	**Q5**	Demand for economy	**0.69**	**0.88**	**0.776**	**0.842**
		Q6	Demand for timeliness	**0.75**	**0.77**		
		Q7	Demand for security	**0.76**	**0.79**		
		Q8	Change in subjective perception and mentality	**0.51**	**0.56**		
F3	Transportation mode selection	**Q9**	Associated with transportation distance	**0.79**	**0.68**	**0.731**	**0.732**
		Q10	Associated with the cost of agricultural products	**0.72**	**0.66**		
		Q11	Associated with the perishability of agricultural product	**0.55**	**0.73**		

5.3. Fitness Test

AMOS 21.0 is adopted to conduct structural equation model hypothesis test and the parameter measurement of fitness is carried out after the modification of model. As is shown in Table 2, in terms of overall fitness indexes, the significance probability is greater than 0.05 and other fitness value, like RMR value, chi-square freedom ratio and so on are all up to the acceptable standard of hypothesis models, which proves that the theoretical model fit in with the sample, thus accepting null hypothesis. On the whole, the fitness between the theoretical model and actual observation data is good.

Table 2. Fitness Test

Fitness indexes	P value	Chi-square freedom ratio（NC）	GFI	IFI	CFI	RMR	RMSEA
Railway	0.354	2.792	0.930	0.922	0.873	0.031	0.026
Highway	0.415	1.302	0.933	0.975	0.966	0.026	0.018
Fitness standard	p＞0.05	1＜NC＜3	＞0.90	＞0.90	＞0.90	＜0.05	＜0.08

5.4. Analysis of Hypothesis Test Result

Railway and highway transportation are selected to build the influencing factor structural equation model and analysis is conducted based on investigation data. AMOS21.0 software is used to carry out hypothesis test, thus obtaining the structural equation model diagram of standardization estimated value, as is shown in Figure 2, and Figure 3. Meanwhile, the results of hypothesis test are also obtained, as is shown in Table 3.

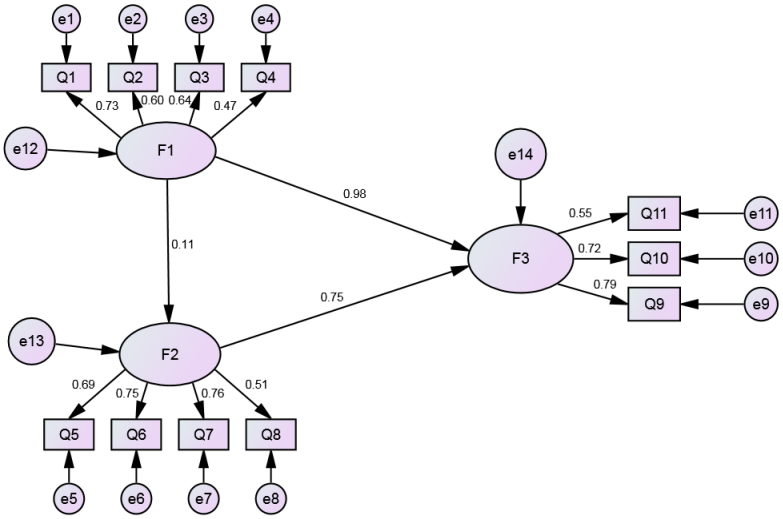

Figure 2. Model Diagram of Standardization Estimated Value of Railway Transportation

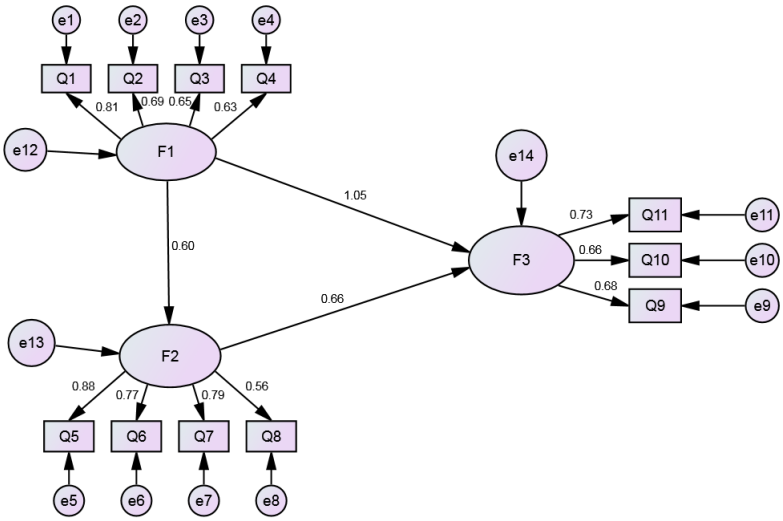

Figure 3. Model Diagram of Standardization Estimated Value of Highway Transportation

If Estimate≥0.2, C.R > 1.96 are satisfied simultaneously and $p < 0.05$, achieving significant level, it verifies the path coefficient is valid and that the hypothesis is valid; on the contrary, it verifies the path coefficient is invalid and that the hypothesis is invalid.

Table 3. Result of Hypothesis Test

Transportation mode	Research hypothesis	Standardized path coefficient	C.R.	P	Results
Railway	H1	0.980	2.901	***	Accept
	H2	0.113	1.905	0.001	Refuse
	H3	0.748	2.283	***	Accept
Highway	H1	1.047	3.294	0.001	Accept
	H2	0.595	1.749	***	Accept
	H3	0.659	2.322	0.003	Accept

Notes: *** means that P<0.001. If p>0.001, then the value of p will be shown.

The analysis results show that: hypothesis H1 and H3 accept the railway transportation, H1, H2 and H3 accept the highway transportation and H2 refuse the railway transportation. Based on the results, we find that both objective and subjective factors pose notable positive impact on the selection of transportation mode under these two transportation modes. Besides, the objective factors of highway transportation have some impact on subjective factors.

6. Conclusion and Discussion

The research results show that the selection of transportation mode is restrained by objective factors and influenced by subjective factors. Moreover, the impact of influencing factors on different transportation modes is various in the case of highway and railway transportation. The common point between the influencing factors of these two transportation modes is that objective factors play the dominant role while subjective factors play the secondary role. For railway transportation, the influence degree of objective factors on transportation mode selection is that: construction of transportation infrastructure > transportation technology standard establishment > construction of transportation supporting logistics system > low carbon and environmental protection philosophy; the preference level of subjective factors on transportation mode selection is that: demand for security > demand for timeliness > demand for economy > change in subjective perception and mentality. For highway transportation, the influence degree of objective factors on transportation mode selection is that: construction of transportation infrastructure > construction of transportation supporting logistics system > transportation technology standard establishment > low carbon and environmental protection philosophy; the preference level of subjective factors on transportation mode selection is that: demand for economy > demand for security > demand for timeliness > change in subjective perception and mentality.

The impact of construction of transportation infrastructure and transportation supporting logistics system is the greatest, which are the prerequisites for the selection of transportation mode. Therefore, the constriction of railway and highway transportation network system should be promoted and the combined transportation network of railway and highway should be established. Under the characteristics of small profit space, scattered distribution of producers, failure of formation of scale system in agricultural production, the construction and operation of modern agricultural product logistics system need the support and guidance from the government. The impact of transportation technology standard establishment on transportation mode selection is great, which means that relevant transportation service technical standard and transportation technical requirements should be studied and formulated. Different kinds of agricultural products lead to different technical indexes, like control time and control condition of low temperature storage. The technical indexes needed in the cold-chain transportation should

be studied and developed, which mainly includes normative standard of transportation process, transportation service technical standard and requirement for temperature control transportation technical standard of perishable products, thus establishing a standardization system for the security of agricultural product modern logistics. In addition, information and and network technology are applied to build an intelligent security monitoring system, like the development of monitoring network information platform of agricultural products transportation quality, achieving the real-time dynamic monitoring of transportation temperature during the transportation process and guaranteeing the security of cold-chain transportation. The energy type consumed by different transportation modes, the unit energy consumption and the development level of transportation technology are different, so we should take minimum carbon emission as the target considering the impact of low carbon and environmental protection. Based on the nature, transportation technology demand, transportation volume and distance demand of agricultural products, appropriate transportation mode of agricultural products should be selected combine with local road condition, climatic environment and economic development level.

Difference in agricultural products, purpose and difficulty of transportation bears different purpose attributes in terms of the selection of economy, timeliness and security. Different transportation schemes will produce different transportation effect and therefore transportation activities should be reasonably planned. Reasonable route and mode should be selected and comparison and optimization should also be conducted based on existing transportation conditions. The research reveals that other factors are retrained by economic factors. Although economic factors are the most important, timeliness and security can never be ignored and social benefits should also be given consideration when developing economic benefits.

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