# The research on agricultural products logistics efficiency in China based on DEA-Malmquist model

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*Received 1 October 2014, www.cmnt.lv*

**Abstract**

Low efficiency has been the bottleneck that is hindering agricultural products logistics to play the role in improving economic and social development. But relevant research achievements are not many. This paper studies agricultural products logistics efficiency from 2008 to 2011 in China based on DEA and Malmquist index and finds that during later period of study, the total factor productivity of agricultural products logistics industry in the whole nation, east region, central region and west region was in a growing trend, mainly due to technological advance. During later period of study, technical efficiency of national agricultural products logistics was basically at a standstill. Among it, pure technical efficiency did not develop, but scale efficiency kept growing. From the perspective of regions, technical efficiency in east region showed downward trend and the development of pure technical efficiency and scale efficiency kept a standstill. In central region, technical efficiency and scale efficiency both fell, except that pure technical efficiency rebounded during the last period of study. The pure efficiency and scale efficiency in west region both developed, which accelerated the improvement of technical efficiency of this region from 2008 to 2011. Scale efficiency was the major influencing factor on the increase in logistics technical efficiency.

*Keywords:* Agricultural products logistics; efficiency; DEA; Malmquist index;

## 1 Introduction

China is a big country of agricultural products production and circulation. Agricultural products logistics industry is playing an important role in China's logistics industry system. According to statistical data, total social logistics of agricultural products in China in 2011 reached 2.63 trillion Yuan, and from 2005 to 2011, the average growth rate reached 8.64%. Agricultural products logistics is of great significance to meet social consumption demand for agricultural products, guide agricultural production and ensure the growth of farmers' income. However, logistics inefficiency has been the bottleneck problem to hinder the function of agricultural products logistics. It's very significant to research how to enhance operation efficiency of China's agricultural products logistics.

## 2 Literature Review

As a method of relative efficiency evaluation, DEA has been widely used in the field of logistics research because of several advantages, such as simultaneous processing many in-out indexes, with no need for man-made right weight, no necessary to confirm function relationship between in-out indexes in advance and so on.

According to existing related literatures, the studies in which DEA is used mainly focus on following aspects.

### 2.1 LOGISTICS EFFICIENCY MEASURE BASED ON ENTERPRISE LEVEL

Logistics efficiency measure aiming at enterprises is one of hotspots of DEA application in the field of logistics. Relevant research achievements at home and abroad are abundant. For example, using output oriented DEA model, Min and Joo studied the efficiency of six third-part logistics (TPL) companies in America, and found that non asset based logistics enterprises were higher in profitability than assets of enterprises. Then they put forward the best method to promote TPL market productivity[1]. Through adding some limiting conditions such as expert opinions, Hamdan and Rogers developed non-restricted model into restricted DEA model to evaluate the operation efficiency of TPL enterprises[2].

### 2.2 SELECTION OF LOGISTICS SERVICE PROVIDERS OR LOGISTICS ALLIANCE PARTNERS

Many scholars applied DEA to research how to select logistics service providers or alliance partners. Dai used AHP to ensure comprehensive quality of candidate enterprises and then took the evaluation results as output items of DEA to combine with input indexes to obtain DEA efficiency value of enterprises. At last, through (0-1) planning model, the partners to establish virtual logistics enterprises alliance could be selected[3]. Farzipoor used DEA to construct third-part reverse logistics optimization model to choose top TPL service providers[4]. Liu and

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Wang (2013) utilized DEA to calculate relative efficiency based on customer service level and strength, and used Delphi to calculate the weight of two kinds of efficiency to obtain weighted sum of synthetical efficiency, which served as the basis of selecting TPL service providers[5].

### 2.3 EFFICIENCY ANALYSIS OF REGIONAL LOGISTICS INDUSTRY

In recent years, many domestic scholars have studied regional logistics operation efficiency from the perspective of industry rather than companies. Basically, studies are done following the idea to construct evaluation model and index system of regional logistics industry based on a certain DEA model, to make DEA effectiveness evaluation on logistics efficiency index through collecting and disposing data, and then to analyze the problem existing in ineffective DEA units from the perspectives of input redundancy and output insufficiency and come up with corresponding suggestions for improvement[6] [7].

No matter whether DEA is used, the literatures on agricultural products logistics efficiency are not many. Many foreign scholars try to find out the factors influencing the efficiency of agricultural products logistics and the strategies enhancing logistics efficiency from qualitative angle. Utilizing the analytical framework of neoinstitutional economics, Grosh[8] and Dorward et al. [9] analyzed the system adaptability of various trading forms and mutual relations of agricultural products logistics in developing countries and brought up some countermeasures to raise logistics efficiency from the perspective of institutional improvement. Quinn studied the impact of channel integration and normalization on channel function. He pointed out that assets specificity and uncertainty were main factors affecting agricultural products logistics efficiency[10]. At home, some scholars focus on the research on agricultural products circulation efficiency. Kou and Tan constructed evaluation index system of agricultural products logistics efficiency on the basis of standpoint index, mold index and specific index and pointed out the key factors influencing logistics efficiency were logistics pattern, structure, technology, network topology and system[11]. Ouyang and Huang measured agricultural products circulation efficiency of 28 provinces in our country. In their opinions, the circulation efficiency was not high, but the overall was on the rise and regional difference was obvious. The positive factors affecting circulation efficiency are rural logistics infrastructure, quality of labor and level of informatization[12]. Zhang et al. established comprehensive assessment system of agricultural products circulation efficiency based on seven indexes, degree of market integration, degree of market concentration, technical efficiency, degree of consumer satisfaction, circulation price, transaction expenses and time of circulation. Relying on it, they explored the influence factors of each index[13]. But just like that mentioned by Liu Dongying, agricultural products logistics is only one of components of agricultural products circulation[14]. The research on modern logistics should be done on the basis of “separation of three streams”, that is, agricultural products logistics should be studied independently. Hence, the research on agricultural products circulation efficiency cannot replace that on logistics efficiency.

So, based on existing research achievements, using DEA and Malmquist analytical method, taking 31 provinces in Mainland China as research objects, this paper makes dynamic measurement across the period from 2008 to 2011 of agricultural products logistics efficiency and analyzes total factor productivity to find out main factor influencing logistics efficiency.

## 3 Research Method

### 3.1 DEA MODEL

DEA is an effective method to calculate relative efficiency of DMU with same type of input and output. The essence is to estimate the leading surface of valid producing and compare each DMU to it to measure efficiency on the basis of in-out observed value. The DMU at the leading edge is considered as the most efficient one in in-out combination, whose efficiency index is set as 1. On the contrary, the DMU which is not at the leading edge is believed to be inefficient. At the same time, a relative index between (0, 1) is given as the benchmark in efficient point of efficiency frontier. Original DEA model was called CCR model, put forward by famous operational research experts Charnes, Cooper and Rhode. Depending on some groups of in-out data, it can calculate the efficiency using mathematical programming principle[15]. Afterwards, Banker, Charnes and Cooper brought up with more rigorous modified model (called BCC model), which changed the hypothesis on fixed returns to scale in CCR to changeable one. As a result, the technical efficiency in CCR model was divided into scale efficiency and pure technical efficiency, that is, technical efficiency =scale efficiency× pure technical efficiency[16].

It is assumed that there are n DMUs, and there are m types of input and p types of output in each DMU. The technical efficiency value of a certain specific DMU can be obtained from following output oriented CCR model.

$$\begin{aligned} &\min\ \theta \\ &s.t.\quad \sum_{j=1}^{n}\lambda_j x_j + s^- = \theta x_0 \\ &\qquad\ \sum_{j=1}^{n}\lambda_j y_j - s^+ = y_0 \\ &\qquad\ s^- \ge 0, s^+ \ge 0, \lambda_j \ge 0 \\ &\qquad\ \theta \text{ unrestrainted} \end{aligned} \tag{1}$$

It’s set that the optimal solution of the model are $\lambda^*$、$s^{*-}$、$s^{*+}$、$\theta^*$,the major conclusion of CCR model are: (1) if $\theta^*=1$, and $s^{*-}$, $s^{*+}$ are not both 0, the DEA effectiveness of $DMU_{j0}$ is weak. (2) if $\theta^*=1$,and $s^{*-}= s^{*+}=0$, the DEA of DMUj0 is overall effective. (3) if $\theta^* < 1$, the DEA of DMUj0 is overall invalid. (4) if $\sum\lambda_j^*=1$, DMU keeps constant in return to scale. If $\sum\lambda_j^* > 1$, DMU keeps decreasing in return to scale. The bigger the value is, the larger the decreasing trend of scale is. If $\sum\lambda_j^* < 1$, DMU keeps increasing in return to scale. The smaller the value is, the larger the increasing trend of scale is.

Corresponding BBC model is as follows.

$$
\begin{aligned}
\min\ & V_D = \theta \\
s.t.\ & \sum_{j=1}^{n} X_j \lambda_j + S^- = \sigma X_0 \\
& \sum_{j=1}^{n} Y_j \lambda_j - S^+ = Y_0 \\
& \sum_{j=1}^{n} \lambda_j = 1 \\
& \lambda_j \ge 0, S^- \ge 0, S^+ \ge 0
\end{aligned}
\tag{2}
$$

It's set that the optimal solutions of the model are $\lambda^*$、$s^{*-}$、$s^{*+}$、$\sigma^*$, the major conclusions of CCR model are: (1) if $\sigma^*=1$, and $s^{*-}$, $s^{*+}$ are not both 0, the DEA pure technical effectiveness of $DMU_{j0}$ is weak. (2) if $s^{*-}= s^{*+}=0$,the DEA pure technique of $DMU_{j0}$ is valid. (3) if $\sigma^* < 1$, the DEA pure technique of $DMU_{j0}$ is invalid.

MALMQUIST INDEX MODEL

Both CCR model and BBC model are usually used to make horizontal comparison of the conditions of all regions at the same point-in-time. In exploring deep information about historical data, especially in making judgment on future trend through the comparison of data, DEA method is incompetent. Therefore, Malmquist index model is introduced in this paper to cover the shortage. It was put forward by Swedish economist Malmquist when he studied consumption problems[17], and then combined with DEA by Charnes to measure production rate.

Taking technique Tt during the time of t for reference, Malmquist index can be expressed as follows[18].

$$
\begin{aligned}
M_0^t(x_{t+1}, y_{t+1}, x_t, y_t) &= d_0^t(x_{t+1}, y_{t+1}) / d_0^t(x_t, y_t); \\
M_0^{t+1}(x_{t+1}, y_{t+1}, x_t, y_t) &= d_0^{t+1}(x_{t+1}, y_{t+1}) / d_0^{t+1}(x_t, y_t);
\end{aligned}
\tag{3}
$$

In order to avoid the difference brought by haphazard selection of time, the geometric mean in above two formulas is taken as the Malmquist index to measure the change of production rate from the time of t to t+1. If the index is greater than 1, the total factor productivity from the time of t to t+1 is growing.

$$
M_0(x_{t+1}, y_{t+1}, x_t, y_t) = \left(\frac{d_0^t(x_{t+1}, y_{t+1})}{d_0^t(x_t, y_t)} * \frac{d_0^{t+1}(x_{t+1}, y_{t+1})}{d_0^{t+1}(x_t, y_t)}\right)^{1/2}
\tag{4}
$$

In the formula, $(x_{t+1},y_{t+1})$ and $(x_t,y_t)$ are respectively the inputs and outputs during the time of t+1 and time of t. And $d^t_0$ and $d^{t+1}_0$ are respectively the distance functions during the time of t and time of t+1 , taking the technique Tt during the time of t. Malmquist index can be divided into Efficiency change (Ech) and Technical change (Tch), the result is as follows.

$$
Ech = \frac{d_0^t(x_{t+1}, y_{t+1})}{d_0^t(x_t, y_t)}
\tag{5}
$$

$$
Tch = \left(\frac{d_0^t(x_{t+1}, y_{t+1})}{d_0^{t+1}(x_{t+1}, y_{t+1})} * \frac{d_0^t(x_t, y_t)}{d_0^{t+1}(x_t, y_t)}\right)^{1/2}
\tag{6}
$$

And Ech can be further divided into Pure efficiency change (Pech) and Scale efficiency change (Sech).

## 4 Setting Index and Selecting Data

### 4.1 INPUT AND OUTPUT INDEXES

Taking agricultural output as object, agricultural products logistics is a kind of physical economic activity in which agricultural products and relevant information are transferred from producers to consumers, which can meet customers' demands and realize the value of agricultural products. It consists of some logistics links, such as agricultural products collecting, distribution processing, packaging, storing, carrying, loading and unloading and transporting and distributing. At last, products will be delivered to consumers to realize their economic value and use value on the foundation of preserving or increasing their value. To embody the peculiarity of agricultural products logistics, the indexes should be selected depending on logistics input and output in the process of products sent from producers to customers.

The Cobb Douglas Production Function indicates that there are three main factors that can impact the output of a certain producing activity, capital input level, labor resources investment level and comprehensive technological level. Hence, in the paper, agricultural products logistics fixed investment and number of agricultural products logistics practitioners are chosen as the indexes to measure capital input level and labor resources investment level. Because there is not unified index to measure technical input level, and equipment and facility can play an important role in agricultural products logistics, the paper decides to replace it with logistics facility investment level. Taking the availability of data into consideration, the specific indexes are set as the length of domestic arteries and number of freight cars. The output index commonly used to measure logistics efficiency is rotation volume of freight transport. But there is no relevant data in existing statistical materials. Some scholars try to replace it with agricultural output, which is not accurate because some of products have been consumed by farmers themselves. In view of this, this paper sets total amount of agricultural products logistics as output index and add the index added value of agricultural products logistics to reflect the feature of "appreciation" of agricultural products. The input and output indexes are shown in table 1.

TABLE 1 Input and Output Indexes

| Input Index | Output Index |
|---|---|
| The length of domestic arteries X1(km) | Amount of agricultural products logistics Y1 (hundred million Yuan) |
| Agricultural products logistics fixed investment X2(hundred million Yuan) | Added value of agricultural products logistics Y2(hundred million Yuan) |
| Number of freight cars X3 (ten thousand) | |
| Number of agricultural products logistics practitioners X4(ten thousand person) | |

4.2 DATA SOURCES

In order to ensure the authenticity and veracity, the data used in the paper are all from China Statistical Yearbook and China Statistical Yearbook of The Tertiary Industry. And three indexes, agricultural products logistics fixed investment, total amount of agricultural products logistics and added value of agricultural products logistics, have been adjusted according to constant price in 2008. The length of domestic arteries is the total of three items, railway operation mileage, the length of inland waterway and the length of classified highway. Because there is no statistical data about number of agricultural products logistics practitioners in the Yearbooks, the number of transportation, storage and mail business practitioners is used in the paper.

## 5 Interpretation of Empirical results

Through MAXDEA software, the results of analyzing the data of 31 provinces in Mainland China from 2008 to 2011 are as shown in table 2.

5.1 MALMQUIST INDEX ANALYSIS

Table 2 indicates that from 2008 to 2009, 2009 to 2010 and 2010 to 2011, the mean values of national Malmquist index were respectively 0.964, 1.031 and 1.083, which stated that the total factor productivity (TFP) of national agricultural products logistics industry showed an upward trend. It could be found through decomposing Malmquist index that the mean values of Ech were respectively 1.067, 0.998 and 1.015 at three periods of time, showing the status of rising-declining-rising. The mean values of Tch were 0.905, 1.033 and 1.067. The change direction and scope of mean values of above two indexes showed that the former was 6.7%, -0.2% and 1.5% and the latter was -9.5%, 3.3% and 6.7%, which explained technical progress had greater impact on TFP than on technical efficiency during the study period. It was during the periods of 2009 to 2010 and 2010 to 2011 that the technical progress of agricultural products logistics made TFP rise. There were three reasons why logistics technique could upgrade. The first reason was that urgent need of agricultural products logistics stimulated the enthusiasm of domestic logistics enterprises with the development of agricultural production, especially agricultural products processing industry and the improvement of agricultural products consumption level. In order to meet market's demand and contend for markets, logistics enterprises all put forth their efforts to advance technical equipment. The second was that in recent years, the governments at all levels in China increasingly attached their importance to agricultural products logistics and the technical content in the construction of logistics infrastructure was more and more improved. The third was that the introduction of overseas-funded enterprises improved the technical level of logistics industry to some extent.

From the angle of regional classification, the status in east region was similar to national variation trend. The mean values of Malmquist index were respectively 0.990, 1.053 and 1.059. Except in the year of 2008 to 2009, the TFP in east region in later two periods of time was increasing. In central region, the mean values were 0.827, 0.985 and 1.073. The TFP only increased during the time of 2010 to 2011. But the mean values in west region were respectively 1.032, 1.042 and 1.113, which showed the TFP in this region went upward during three periods of time. On the whole, the growth situation in west region was the best. Because comparing with other two regions, this region had lower starting point of agricultural products logistics and was in the condition of growing quickly, the TFP was in sustainable growth and its scope was larger than that in east and central regions.

5.2 ECH ANALYSIS

According to the results in table 2, the mean values of national Ech were respectively 1.067, 0.998 and 1.015. At the time of 2009 to 2010, the mean value was slightly less than 1 and it was slightly more than 1 at the time of 2010 to 2011. The nearly equal values meant that the development of technical efficiency level of agricultural products logistics in China kept nearly standstill from 2009 to 2011. after decomposing the Ech, it could be found that the mean values of Pech were respectively 1.032, 0.995 and 1.005, which indicated that the pure technical efficiency kept unchanged from 2009 to 2011. That is to say, without considering scale effect, the utilization efficiency of resources put into logistics technology, logistics equipment and personnel was not improved. The mean values of Sech were respectively 1.036, 1.003 and 1.012, which demonstrated that the matching degree of input scale and output scale of logistics resources were improved continually.

Among three regions, the mean values of Ech in east region were respectively 1.047, 0.998 and 0.992, of Pech were 1.051, 1.002 and 0.98 and of Sech were 1.001, 0.996 and 1.01. The data showed that the development of pure technical efficiency and scale efficiency of regional agricultural products logistics was in stagnant situation. In central region, the mean value of Ech were respectively 0.975, 0.966 and 1, of Pech were 0.974, 0.979 and 1.028 and of Sech were 1.003, 0.986 and 0.975, which explained that the pure efficiency and scale efficiency in this region were in decline, except that pure efficiency level rebounded during the last study period. Above-mentioned phenolmenon indicated that the development scale of agricultural products logistics of two regions had been basically saturated. In west region, the mean values of Ech were respectively 1.146, 1.020 and 1.047, of Pech were 1.052, 1 and 1.012 and of Sech were 1.091, 1.02 and 1.037. The data showed that the pure efficiency and scale efficiency of this region both developed, which indicated that the leve

## 5.3 TCH ANALYSIS

Table 2 showed that the mean values of national Tch were 0.949, 1.033 and 1.067 at the three periods of the study, which was in stark contrast to the standstill of technical efficiency change.

Switching to three regions, the mean values of Tch in east region were respectively 0.949, 1.056 and 1.068. Those in central region were 0.847, 1.019 and 1.073, and in west region were 0.903, 1.021 and 1.062. The technological level of agricultural products logistics of three regions was developing, keeping pace with the change of whole country.

TABLE 2 Malmquist Index of Agricultural Products Logistics and Its Decomposition from 2008 to 2011

| | **Ech 2008～2009** | **Ech 2009～2010** | **Ech 2010～2011** | **Pech 2008～2009** | **Pech 2009～2010** | **Pech 2010～2011** | **Sech 2008～2009** | **Sech 2009～2010** | **Sech 2010～2011** | **Tch 2008～2009** | **Tch 2009～2010** | **Tch 2010～2011** | **M 2008～2009** | **M 2009～2010** | **M 2010～2011** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Peking | 1.236 | 1.000 | 1.000 | 1.170 | 1.000 | 1.000 | 1.057 | 1.000 | 1.000 | 0.885 | 1.111 | 0.999 | 1.094 | 1.111 | 0.999 |
| Tianjin | 1.014 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.014 | 1.000 | 1.000 | 1.199 | 1.064 | 1.009 | 1.216 | 1.064 | 1.009 |
| Hebei | 1.056 | 1.000 | 1.000 | 1.040 | 1.000 | 1.000 | 1.015 | 1.000 | 1.000 | 0.931 | 1.022 | 1.113 | 0.983 | 1.022 | 1.113 |
| Liaoning | 1.185 | 0.966 | 1.026 | 1.071 | 1.043 | 1.000 | 1.107 | 0.926 | 1.026 | 0.925 | 1.076 | 1.124 | 1.097 | 1.040 | 1.153 |
| Shanghai | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.847 | 1.238 | 1.001 | 0.847 | 1.238 | 1.001 |
| Jiangsu | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.923 | 1.020 | 1.036 | 0.923 | 1.020 | 1.036 |
| Zhejiang | 0.928 | 1.064 | 0.927 | 0.915 | 1.059 | 0.922 | 1.014 | 1.005 | 1.006 | 1.069 | 1.010 | 1.055 | 0.992 | 1.074 | 0.978 |
| Fujian | 1.015 | 0.973 | 0.949 | 1.005 | 0.957 | 0.936 | 1.011 | 1.017 | 1.014 | 0.954 | 1.067 | 1.131 | 0.968 | 1.039 | 1.073 |
| Shandong | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.850 | 0.932 | 1.011 | 0.850 | 0.932 | 1.011 |
| Hainan | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.926 | 1.054 | 1.222 | 0.926 | 1.054 | 1.222 |
| Guangdong | 1.079 | 0.970 | 1.006 | 1.360 | 0.964 | 0.918 | 0.793 | 1.006 | 1.096 | 0.926 | 1.021 | 1.044 | 1.000 | 0.991 | 1.051 |
| Shanxi | 0.783 | 1.067 | 0.919 | 0.735 | 1.054 | 0.937 | 1.066 | 1.013 | 0.981 | 0.819 | 1.048 | 1.082 | 0.642 | 1.118 | 0.994 |
| Jilin | 1.024 | 0.847 | 1.066 | 1.034 | 0.891 | 1.071 | 0.991 | 0.951 | 0.995 | 0.814 | 1.025 | 1.077 | 0.834 | 0.868 | 1.148 |
| Heilongjiang | 0.948 | 0.894 | 1.065 | 0.974 | 0.956 | 1.213 | 0.973 | 0.935 | 0.878 | 0.814 | 1.025 | 1.133 | 0.771 | 0.916 | 1.207 |
| Anhui | 1.027 | 1.032 | 0.970 | 1.011 | 1.014 | 1.000 | 1.016 | 1.018 | 0.970 | 0.963 | 1.084 | 1.074 | 0.989 | 1.119 | 1.042 |
| Jiangxi | 1.021 | 0.920 | 1.020 | 0.997 | 0.903 | 0.983 | 1.025 | 1.019 | 1.037 | 0.801 | 0.975 | 1.062 | 0.818 | 0.897 | 1.083 |
| Henan | 1.000 | 1.000 | 0.957 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.957 | 0.872 | 0.945 | 1.051 | 0.872 | 0.945 | 1.006 |
| Hubei | 1.012 | 0.947 | 1.016 | 1.045 | 1.013 | 1.022 | 0.969 | 0.936 | 0.995 | 0.826 | 1.036 | 1.052 | 0.836 | 0.981 | 1.069 |
| Hunan | 0.982 | 1.018 | 0.983 | 1.000 | 1.000 | 1.000 | 0.982 | 1.018 | 0.983 | 0.869 | 1.019 | 1.054 | 0.853 | 1.038 | 1.035 |
| Inner Mongolia | 1.192 | 0.939 | 0.988 | 1.142 | 0.940 | 0.988 | 1.044 | 0.999 | 1.000 | 0.870 | 1.068 | 1.092 | 1.037 | 1.003 | 1.079 |
| Guangxi | 0.951 | 0.927 | 1.025 | 1.000 | 1.000 | 1.000 | 0.951 | 0.927 | 1.025 | 0.860 | 1.028 | 1.051 | 0.818 | 0.953 | 1.078 |
| Chongqin | 1.075 | 0.909 | 1.337 | 1.033 | 0.923 | 1.273 | 1.041 | 0.985 | 1.050 | 0.952 | 1.044 | 1.041 | 1.024 | 0.949 | 1.392 |
| Sichuan | 0.907 | 1.009 | 1.110 | 0.922 | 0.978 | 1.109 | 0.984 | 1.032 | 1.001 | 0.945 | 1.108 | 1.109 | 0.857 | 1.118 | 1.231 |
| Guizhou | 1.597 | 0.966 | 1.036 | 1.536 | 0.961 | 1.032 | 1.040 | 1.005 | 1.004 | 0.892 | 1.057 | 1.089 | 1.425 | 1.021 | 1.128 |
| Yunnan | 1.037 | 1.035 | 1.134 | 1.002 | 1.030 | 1.123 | 1.036 | 1.005 | 1.010 | 0.980 | 1.091 | 1.112 | 1.016 | 1.130 | 1.261 |
| Tibet | 1.205 | 1.054 | 1.143 | 1.000 | 1.000 | 1.000 | 1.205 | 1.054 | 1.143 | 0.991 | 1.075 | 1.097 | 1.193 | 1.134 | 1.253 |
| Shanxi | 0.939 | 0.953 | 0.999 | 0.949 | 0.940 | 1.002 | 0.990 | 1.013 | 0.997 | 0.922 | 0.958 | 1.024 | 0.866 | 0.912 | 1.023 |
| Gansu | 1.032 | 0.985 | 0.858 | 1.000 | 1.000 | 0.734 | 1.032 | 0.985 | 1.170 | 0.755 | 0.808 | 0.965 | 0.779 | 0.796 | 0.828 |
| Ningxia | 1.674 | 1.128 | 1.116 | 1.000 | 1.000 | 1.000 | 1.674 | 1.128 | 1.116 | 0.831 | 0.888 | 0.981 | 1.391 | 1.002 | 1.095 |
| Qinghai | 1.074 | 1.089 | 0.943 | 1.043 | 1.008 | 1.000 | 1.030 | 1.080 | 0.943 | 0.892 | 1.034 | 1.083 | 0.957 | 1.126 | 1.021 |
| Xinjiang | 1.073 | 1.243 | 0.870 | 1.004 | 1.215 | 0.879 | 1.070 | 1.023 | 0.989 | 0.944 | 1.092 | 1.104 | 1.013 | 1.357 | 0.960 |
| Mean Value in East | 1.047 | 0.998 | 0.992 | 1.051 | 1.002 | 0.980 | 1.001 | 0.996 | 1.013 | 0.949 | 1.056 | 1.068 | 0.990 | 1.053 | 1.059 |
| Mean Value in Central | 0.975 | 0.966 | 1.000 | 0.974 | 0.979 | 1.028 | 1.003 | 0.986 | 0.975 | 0.847 | 1.019 | 1.073 | 0.827 | 0.985 | 1.073 |
| Mean Value in West | 1.146 | 1.020 | 1.047 | 1.052 | 1.000 | 1.012 | 1.091 | 1.020 | 1.037 | 0.903 | 1.021 | 1.062 | 1.032 | 1.042 | 1.113 |
| Mean Value in Whole Country | 1.067 | 0.998 | 1.015 | 1.032 | 0.995 | 1.005 | 1.036 | 1.003 | 1.012 | 0.905 | 1.033 | 1.067 | 0.964 | 1.031 | 1.083 |

TABLE 2 Malmquist Index of Agricultural Products Logistics and Its Decomposition from 2008 to 2011

With reference to the regional division method released by national Bureau of Statistics on June 13, 2011, 31 provinces in mainland China are classified into east region(Peking,,Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong ,Guangdong and Hainan), central region (Shanxi, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei, Hunan) and west region (Inner Mongolia, Guangxi, Chongqin, Sichuan, Guizhou, Yunnan, Tibet, Shanxi, Gansu, Ningxia, Qinghai, Xinjiang).

## 6 Conclusions

Following conclusions can be drawn through the analysis of the empirical results.

### 6.1 CONCLUSION 1

Overall, the TFP of the whole country and three regions improved increasingly from 2008 to 2011, owing to the enhancement of technical level of national agricultural products logistics. So, in order to keep the growth of TFP, new logistics technology and equipment should be introduced and practitioners' quality should be improved. In aspects of cold-chain logistics, green logistics, logistics automation and intelligentization and logistics informatization, more efforts should be devoted to upgrade and update existing technology.

### 6.2 CONCLUSION 2

During 009 to 2010 and 2010 to 2011, the development of technical efficiency level of national agricultural products logistics stopped. The pure technology efficiency level didn't develop, but scale efficiency kept enhancing. From the perspective of regions, technical efficiency in east region showed downward trend and the development of pure technical efficiency and scale efficiency kept standstill. In central region, technical efficiency and scale efficiency both fell, except that pure technical efficiency rebounded during the last period of study. The pure efficiency and scale efficiency in west region both developed, which accelerated the improvement of technical efficiency of this region from 2008 to 2011. Scale efficiency was the major influencing factor on the increase in logistics technical efficiency. Therefore, to promote the increase in technical efficiency, east and central regions should switch from "extensive" pattern depending only on quantity input to "intensive" pattern relying on quality promotion. Existing resources should be used more effectively and logistics scale should be maintained or suitably reduced. The starting time of agricultural products logistics in west region is late and vast development space is the advantage of this region. Recently, agricultural products logistics industry has developed quickly, and the growth of pure efficiency and scale efficiency in this region is faster than that in central region. But at present, the increase in scale efficiency is mainly due to the scale extension. When developed to a certain size, scale efficiency keeps standstill, agricultural products logistics industry in west region will be faced with the same trouble as that in east and central regions. Thus, west region should adhere to the "two-way simultaneously", which is to expand scale, intensify self-management and improve the use of existing resources, such as invest capital, technology, land, personnel and so on.

## Acknowledgments

This study was supported by Science and Technology Research Project of Jiangxi Education Department (GJJ12263)

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