Research on Export Efficiency Measurement and Influencing Factors of the Pearl River Delta Urban Agglomeration

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Abstract. This paper firstly analyses the export situation of the Pearl River Delta urban agglomeration in the past 10 years, and then uses the DEA model and panel data model to analyse export efficiency measurement and influencing factors of Pearl River Delta urban agglomeration. Finally, it proposes countermeasures to promote the improvement of the export efficiency of the Pearl River Delta urban agglomeration.

1. Introduction
As the largest economic region with the greatest development potential in China, the Pearl River Delta urban agglomeration has made tremendous contributions to China's foreign trade exports. It has great potential for docking Macau and Hong Kong. Current researches on export efficiency measurement of Pearl River Delta urban agglomeration are mainly concentrated on three aspects: First, elaborating on the factors of export trade development from geographical location, policy advantages, factor endowments and industrial structure by Lee Siting (2012), Peng Lihua, et al. (2017), etc.; Second, using DEA model to carry out the empirical analysis on the indexes of economic efficiency of urban agglomeration, such as comprehensive efficiency of urban agglomeration, scale return of urban agglomeration, DEA projection of urban agglomeration and regional comparison of economic efficiency of urban agglomeration by Lin Donghua (2016), etc.; Third, using VRS-DEA MODEL and a Malmquist index model with and without natural resource factors are constructed, and the static data and dynamic data are empirically analyzed by Yu LiPing, Yan Wei (2013), etc.

This paper determines the model indicators based on its development, using the DEA model and panel data model to analyze export efficiency measurement and influencing factors of Pearl River Delta urban agglomeration.

2. Analysis of the current export situation of the PRD Urban Agglomeration

2.1. Overall upward and steady growth of export trade
During 2009-2018, the foreign trade performance of Guangdong Province and the PRD, while declining in 2016, remained generally year-on-year growth trend. The total import and export value of the nine PRD cities was US$102.454 billion in 2018, which accounted for 94.65% of Guangdong Province’s total imports and exports entire year. Among them, nine cities in the PRD exported 607.079 billion U.S. dollars, accounting for 94.65% of Guangdong's total imports and exports. 94.04% of total exports, accounting for 13.17% of the country's total exports.
2.2. General trade is the main mode of trade and the pace of transformation is accelerating
After a long period of development, the processing trade in the Pearl River Delta has experienced a leap from quantity to quality, from a simple "three to one supplement" (processing, assembly, processing and compensation trade) type of small processing enterprises gradually to large enterprises and global production bases.

2.3 Description of specimens

2.3.1 Structure of export commodities
At present, high-tech products such as mechanical and electrical products are the mainstream export trend, and the structure of export products has shown diversification, rapid growth and constant optimization phenomenon.

2.3.2 Export commodity market structure
Guangdong's foreign trade exports are mainly concentrated in developed countries and regions such as the Hong Kong region, the United States, Europe and Asia. In recent years, the Pearl River Delta urban agglomeration's export trade with Russia has shown rapid growth, reaching 56.997 billion U.S. dollars, an increase of 21.7%, a higher growth rate than the seven traditional markets in Guangdong in the same period.

3. Export Efficiency Measurement of Pearl River Delta Urban Agglomeration Based on the DEA Model

3.1. Selection of variable data
A total of 1 output variable and 5 input variables are selected, which are parsed as follows.

3.1.1. Output variables
Total exports (EX)
In this paper, the total exports of the PRD and nine cities in each year are selected as output variables. This indicator intuitively reflects the size of the region's exports, with total exports increasing if a region is more efficient at exporting.

3.1.2 Input variables
(1) Foreign Direct Investment (FDI)
In this paper, the total amount of actual FDI in the Pearl River Delta (PRD) and nine cities in each year is selected as the reference indicator. This indicator reflects not only the support of foreign trade economic capital, but also a reflection of the economic scale effect of the city through industrial upgrading, introduction of high technology, technology spillover and so on.

(2) Level of economic development (GDP)
The region where the indicator is higher, is more developed and has the better infrastructure and the better the quality of life of its people. This means the greater export capacity.

(3) Number of practitioners (L)
In this paper, the actual number of employees in the Pearl River Delta (PRD) and 9 cities in each year is selected to reflect the labor force situation in each region. If the indicator is high, it indicates the region has more labor-intensive industries and is more dependent on foreign trade.

(4) Traffic network density (T)
In this paper, the sum of the total length of roads and railways in the Pearl River Delta and nine cities in each year is selected as the criterion for judging the density of the transportation network. The higher this indicator is, the better the transport facilities in the region and the lower the transport costs.

(5) Local market effects (B)
In this paper, the GDP per capita of the Pearl River Delta (PRD) and nine cities in each year is
3.2. Selection of variable data

3.2.1. Total factor productivity analysis

(1) Changes in total factor productivity in PRD urban agglomeration and its decomposition, 2008-2017

From the overall average level of the PRD urban agglomeration, the overall export efficiency of the PRD urban agglomeration has been relatively high in recent years. In terms of pure technical efficiency value and scale efficiency value, the PRD has reached the optimal value. Therefore, the technical efficiency value has also reached the optimal level. The overall structure of export trade has stabilized. In terms of technological progress, the PRD's technological progress fell back more severely in 2010 and 2013-2015, but the overall structure was stable. However, the overall trend is increasing. Therefore, the main reason for TFP growth is attributed to technological progress, as shown in Table 1.

| Year | Purely technical efficiency | Scale efficiency | Technical efficiency | Technical advancement | Total factor productivity |
|------|-----------------------------|------------------|----------------------|-----------------------|--------------------------|
| 2009 | 1.000                       | 1.000            | 1.000                | 3.460                 | 3.460                    |
| 2010 | 1.000                       | 1.000            | 1.000                | 0.212                 | 0.212                    |
| 2011 | 1.000                       | 1.000            | 1.000                | 2.102                 | 2.102                    |
| 2012 | 1.000                       | 1.000            | 1.000                | 2.117                 | 2.117                    |
| 2013 | 1.000                       | 1.000            | 1.000                | 0.478                 | 0.478                    |
| 2014 | 1.000                       | 1.000            | 1.000                | 0.362                 | 0.362                    |
| 2015 | 1.000                       | 1.000            | 1.000                | 2.184                 | 2.184                    |
| 2016 | 1.000                       | 1.000            | 1.000                | 4.096                 | 4.096                    |
| 2017 | 1.000                       | 1.000            | 1.000                | 0.202                 | 0.202                    |
| Average | 1.000                     | 1.000            | 1.000                | 1.003                 | 1.003                    |

(2) Changes in Total Factor Productivity (TFP) in nine PRD cities and its decomposition, 2008-2017

Malmquist index analysis on a city-by-city basis was set in order to understand the situation within the PRD agglomerations better. After data collation, the results are integrated as shown in Table 2 below. From the overall average level, the overall export efficiency of each city is good. In terms of scale efficiency values, only Shenzhen and Dongguan have reached the best level, and some cities still need to improve. In terms of technological progress, all cities need to strengthen investment, so the main reason affecting TFP is technological progress.

| City         | Purely technical efficiency | Scale efficiency | Technical efficiency | Technical advancement | Total factor productivity |
|--------------|-----------------------------|------------------|----------------------|-----------------------|--------------------------|
| Guangzhou    | 1.001                       | 0.987            | 0.988                | 0.982                 | 0.970                    |
| Shenzhen     | 1.000                       | 1.000            | 1.000                | 0.989                 | 0.989                    |
| Zhuhai       | 1.000                       | 1.069            | 1.069                | 0.971                 | 1.038                    |
3.2.2. Cross-sectional data analysis of technical efficiency in nine PRD cities, 2017
To further analyze the gains in scale and improvements in input factors in the nine PRD cities, using the data in 2017 of PRD cities were subjected to multi-stage DEA model calculation, and after data collation, the results were integrated as shown in Table 3 below. From the results, it can be seen that the export of Pearl River Delta has the highest pure technical efficiency, with a mean value of 0.875.

| City     | Technical efficiency | Pure technical efficiency | Scale efficiency | Scale compensation |
|----------|----------------------|---------------------------|-----------------|--------------------|
| Guangzhou | 0.326                | 0.332                     | 0.982           | drs                |
| Shenzhen | 1.000                | 1.000                     | 1.000           | —                  |
| Zhuhai   | 0.510                | 1.000                     | 0.510           | irs                |
| Foshan   | 0.492                | 0.540                     | 0.911           | irs                |
| Dongguan | 1.000                | 1.000                     | 1.000           | —                  |
| Zhongshan| 0.606                | 1.000                     | 0.606           | irs                |
| Jiangmen | 0.128                | 1.000                     | 0.128           | irs                |
| Zhaoqing | 0.626                | 1.000                     | 0.626           | irs                |
| Huizhou  | 1.000                | 1.000                     | 1.000           | —                  |
| Average  | 0.632                | 0.875                     | 0.751           |                    |

4. Research on Influencing Factors of Pearl River Delta Urban Agglomeration

4.1. Model construction
Based on the data collated in the previous section, the regression model was constructed as follows.

\[ \text{LNEX}_{it} = \alpha_i + \beta_1 \text{LNFDI}_{it} + \beta_2 \text{LN GDP} + \beta_3 \text{LN L} + \epsilon_{it} \]  

(1)

EX stands for total exports, FDI stands for foreign direct investment, GDP stands for regional economic development level, and L stands for Number of Practitioners. The variable subscripts \( i \) and \( t \) denote the data for year \( t \) for \( i \)-th individual, respectively, and the variable chosen is the main cause of the effect on \( Y \). It’s the intercept of the individual of the I cross-section to be estimated at \( t \), is the marginal value, the Coefficient corresponding to the explanatory variable to be estimated, is a random error term, in which LN represents the natural logarithm of data, in order to reduce the heteroscedasticity, and make the linear trend of data more significant.

4.2. Unit Root Test
Through the software operation, the result of Table 4 is as follows, as shown in the screenshot:

| VARIABLES | Levin, Lin & Chu t* | ADF-Fisher Chi-square | PP-Fisher Chi-square | Conclusion |
|-----------|---------------------|-----------------------|----------------------|------------|
| LNEX      | -13.4311***         | 32.7186**             | 31.9167**            | Stable     |
| LNFDI     | -1.6112*            | 26.263*               | 45.6562***           | Stable     |

Table 4 unit root test of panel data
### 4.3. Cointegration test

The software was used to do the cointegration test to obtain Table 5. Most of the statistics correspond to an accompanying probability of less than 0.01, rejecting at the 0.01 level of significance the absence of cointegration of the original Hypothesis that there is a cointegration relationship between variables.

**Table 5: Panel Cointegration test**

| Alternative hypothesis: common AR coefs. (within-dimension) | Statistic | Prob. | Weighted Statistic | Prob. |
|-------------------------------------------------------------|-----------|-------|--------------------|-------|
| Panel v-Statistic                                           | -0.2313   | 0.5915| -1.5117            | 0.9347|
| Panel rho-Statistic                                         | 0.1782    | 0.5707| 1.1540             | 0.8757|
| Panel PP-Statistic                                          | -5.7341   | 0.0000| -6.8204            | 0.0000|

| Alternative hypothesis: individual AR coefs. (between-dimension) | Statistic | Prob. |
|------------------------------------------------------------------|-----------|-------|
| Group rho-Statistic                                               | 2.2534    | 0.9879|
| Group PP-Statistic                                                | -7.9338   | 0.0000|
| Group ADF-Statistic                                               | -2.3170   | 0.0103|

### 4.4. Descriptive statistics

Specifically, it is necessary to understand the characteristics of the distribution of the data, which is obtained by means of descriptive statistical analysis of the data in Table 6. Table 6 is the basic information about each variable.

**Table 6 Descriptive statistics of the variables**

| VARIABLES | Mean   | Median | Maximum  | Minimum  | Std. Dev. | Skewness | Kurtosis |
|-----------|--------|--------|----------|----------|-----------|----------|----------|
| LNEX      | 5.7192 | 5.6701 | 8.3288   | 2.5129   | 1.2932    | -0.4227  | 3.1284   |
| LNFDI     | 3.1856 | 3.1816 | 6.2575   | 0.9839   | 1.0067    | 0.4286   | 3.2884   |
| LNGDP     | 8.2456 | 8.0440 | 10.0208  | 6.6368   | 0.8961    | 0.3528   | 2.0041   |
| LNL       | 5.7642 | 5.5079 | 6.8494   | 4.5863   | 0.6968    | 0.0110   | 1.7149   |

### 4.5. Relevance analysis

**Table 7 Relevance analysis**

| VARIABLES | LNEX  | LNFDI | LNGDP | LNL  |
|-----------|-------|-------|-------|------|
| LNEX      | 1.0000| (-----)|       |      |
| LNFDI     | 0.5634***| 1.0000| (-----)|      |
| LNGDP     | 0.8028***| 0.7276***| 1.0000|      |
| LNL       | 0.6530***| 0.6044***| 0.8784***| 1.0000|

Note: 0.3-0.5 weakly correlated, 0.5-0.8 moderately correlated, 0.8 and above strongly correlated, first row is the correlation coefficient. The second row is the p-value. ***, **, and * indicate significant at the 0.01, 0.05, and 0.1 levels of significance respectively.

It can be seen that since the correlation coefficients between the explanatory variables and the
explained variables are all significant at the 0.01 level of significance, the initial judgement that the regression is meaningful is followed by model selection and regression.

4.6. Model selection
The type of specific model needs to be identified before the panel model analysis can be performed. Therefore, the mixed model, the random effect model and the fixed effect model need to be determined by the F test and the Housman test. And from these, one model is selected for analysis, thus finalizing the results of the model.

Table 8 Model F-test

| Effects Test           | Statistic | d.f.  | Prob. |
|-----------------------|-----------|-------|-------|
| Cross-section F       | 45.3819   | (8,78)| 0.0000|
| Cross-section Chi-square | 155.9215 | 8     | 0.0000|

The F-test value of the model is 155.9215, which corresponds to a prob. value of 0.0000 and is significant at 0.05 Level rejects the original assumption of the mixed model that the fixed effects model is superior to the mixed model.

Table 9 Hausmann test

| Test Summary        | Chi-Sq. Statistic | Chi-Sq. d.f. | Prob. |
|---------------------|-------------------|--------------|-------|
| Cross-section random| 10.5754           | 3            | 0.0143|

The Hausmann's test value for the model is 10.5754, which corresponds to a prob. value of 0.0143 and is significant at 0.05 level rejects the original assumption of the random effects model that the Fixed effects model is superior to the random effects model.

By integration, the following table 10 is obtained. fixed effects model results: adjusting R-squared to 0.9310, the variable explains the 93.10% of overall, with an F value of 110.1971, corresponding to a prob. value of 0.0000 in the rejecting of the original hypothesis that the entire model is insignificant at the 0.01 level of significance, i.e. LNFDI, LNGDP, and LNL are all significant at the 0.01 level of significance, and there is a significant negative effect at LNFDI, there is a significant positive effect of LNGDP, LNL, holding all other variables constant, each 1% increase in FDI causes a 0.3094% decrease in EX, and each increase in GDP Each 1% increase in L causes a 0.9324% increase in EX, and each 1% increase in L causes a 2.0496% increase in EX.

Table 10 Fixed effects model results

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|----------|-------------|------------|-------------|-------|
| LNFDI    | -0.3094***  | 0.0760     | -4.0737     | 0.0001|
| LNGDP    | 0.9329***   | 0.1643     | 5.6772      | 0.0000|
| LNL      | 2.0496***   | 0.4712     | 4.3493      | 0.0000|
| C        | -12.8021*** | 2.2027     | -5.8119     | 0.0000|

Note: ***, **, * indicate significant at the 0.01, 0.05, and 0.1 significance levels respectively.

5. Suggestions for countermeasures to improve export efficiency in PRD urban agglomerations
After the current situation analysis and empirical analysis, it has been proved that the PRD urban agglomeration has made better development in trade exports during this decade, but there are still some problems and shortcomings, and development has been hindered.

Therefore, to seize the opportunity to enhance the superiority of foreign trade itself and improve the efficiency and competitiveness of exports better, the following 4 countermeasures are proposed.

5.1. Urban agglomeration aspects

5.1.1. Play to the Bay Area's strengths in the broader context
The construction of the Guangdong-Hong Kong-Macao Greater Bay Area is in full swing, with quality resources and large amounts of capital flowing, talents in various fields and high-tech enterprises are also targeting this region with huge potential. Therefore, as urban agglomerations, regional coordination mechanisms can be used to complement strengths, trade policies and provisions need to be established that are interlinked across cities.

5.1.2. Strengthening science and technology development and encouraging innovation
From the empirical results, it is clear that the advancement of technology plays a key role in the overall export efficiency. Therefore, a mechanism for the introduction of science and technology and an improved mechanism for the protection of science and technology can be established to lay the foundation for scientific and technological innovation. Secondly, an innovation incentive system can be established to stimulate the motivation of talents to develop science and technology independently.

5.2. Input factors

5.2.1 Rational use of foreign capital while taking into account domestic demand
From the statistics, it can be seen that the amount of foreign investment is huge and increasing every year, accompanied by the transfer of industries, technology and talent. Therefore, a mechanism for the use of foreign capital can be established and improved, and a large amount of capital can be invested in the weak links and emerging economic growth areas of the city.

5.2.2. Attracting talent and increasing employment opportunities
According to the results of the panel data analysis, the increase in the number of employed persons is a major driver of export growth. To this end, a talent attraction mechanism can be established to bring in a large number of foreign workers while tapping local talent. At the same time, infrastructure such as settlement, housing, travel and community should be improved to lay a good living foundation for the newly employed population.

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