Analysis of the growth of regional productivity in
Pearl River Delta and Yangtze River Delta in Mainland
China

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Abstract: For the high economic development in China, elevation of
productivity serves as a key factor. The purpose of every ongoing reform and
execution of plan is to boost productivity and the Pearl River Delta (PRD) and
Yangtze River Delta (YRD) have benefited a lot. This study aims at 25 cities,
which are at least municipalities in PRD and YRD from 1996 to 2010, applying
metafrontier model to consider the differences among regions. We also exempt
the impact of environmental variables to reasonably evaluate technical
efficiency of regional economics. The result indicates that there exists
difference in productivity in PRD and YRD. PRD opens to the outside world
earlier; its concept and system are more advantageous than those of the YRD.
Moreover, PRD serves as the birthplace of China’s system innovation;
however, as policies turn the direction to YRD gradually, economic
development of PRD goes downhill and its productivity is in an unstable state.

Keywords: mainland China; regional economy; generalised metafrontier
Malmquist productivity index; gMMPI; catch-up.

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1 Introduction

The government in Mainland China choose non-balanced developing route to actively utilise fundamental basics in coastal areas, combing with special preferential policies to improve basic infrastructure and attract foreign direct investment (FDI) based on Tang Siu Ping’s policy, ‘let partial people rich and regions prosperous first’ during the preliminary period of enforcing reform and opening-up policy. By doing so, the government hopes that coastal areas, after gaining advanced development, can create radiation effect to stimulate all-round development in every corner of Mainland China. This skewed policy contributes to super-high economic growth rate in the economic region of coastal area. On the contrary, the development in midland and western region are relatively slow. To date, a more outstanding economic development in Mainland China is mainly centralised in the economic region of eastern coastal area, especially Pearl River Delta (PRD) and Yangtze River Delta (YRD); their economic performances have been dominated over others in regional development in the whole Mainland China, attracting great attention from every industry. Whether the prominent economic achievement of PRD and YRD also perform in the aspect of regional productivity is greatly concerned by every industry and is targeted as the key point of this study.

Mainland China takes progressive measures to promote the reforming and opening policy; its spirit is to reform centralised economic system that has been implemented for 30 years. The concrete method, starting from experimental unit and then expanding the
scope gradually, is to release power and give out benefits; namely empower more rights of economic independence to the local government and enterprises. As for the opening-up, it is to abandon the seclusion policy, open to the outside world, promote social exchange and integrate into international economic system (Keng, 2003).

Mainland China’s open door policy, during the preliminary period, aims at coastal areas as strategic point, commencing from founding four special economic zones, opening 14 coastal cities to expanding ‘opening areas’, stretching from coastal areas to the inland by stages (Kao, 2009). Cities or areas that have been planned as opening to the outside world have the privilege of special preferential policies and economic autonomy. For instance, local government possesses certain power to examine and approve foreign capital; it can also execute tax preferential policy flexibly. As a result, in the aspect of attracting FDI, promoting economic development and expanding foreign trade, the motivation and achievement outweigh those of undeveloped cities or areas.

PRD includes two sub-provincial cities1: Guangzhou and Shenzhen; seven prefecture-level cities2: Zhuhai, Foshan, Jiangmen, Dongguan, Zhongshan, Huizhou and Zhaoqing, nine cities in total; the total area is about 54,700 km² and the population is around 53 million. PRD is the earliest area that, under Mainland China’s decree, opened to the outside world, among which Shenzhen and Zhuhai, two special economic zones, are the earliest ‘experimental unit’ for opening-up policy. The central authorities empower special zones legislative rights, power of examining and approving foreign capital, enterprise income tax exempted and deducted and exemption of turning in income tax. Afterwards, PRD was established as an economic zone opening to the outside world and the government implements a series of preferential policies, expanding the areas gradually, inclusive of 28 countries and cities. Three reasons that make PRD’s original type of economic organisation transform hugely includes supporting each preferential policy, owning the niche of the geographical location (near Hong Kong and Macau) and accepting labour-intensive industries of Taiwan, Hong Kong and Macau to transfer in a big scale as a result of a surge of capital, technology and management experience. Having forming and opening to the outside world for more than 30 years, PRD has become export-oriented economic zone, especially labour-intensive industries: electronics, mechanics, foodstuff, the textile, tailoring, toy, footwear and materials for architectural design; they have begun to take shape; hence, industry chain remains quite intact.

The promotion of FDI encourages a rapid rate of industrialisation in PRD. A surge of FDI and foreign enterprises, on one hand, demands space for gather and enterprises often rely on cities to intensify the motivation of urbanisation; on the other hand, in order to attract more FDI, the local government has to create a good space for development and offer well-appointed infrastructure and social service for enterprises. Through inviting investments from overseas, urbanisation and industrialisation in PRD can combine closely. Also, for the purpose of attracting foreign investors to invest the local willingly, the local government is responsible for infrastructure in cities, institute a well-round system and create an environment for humanities. For foreign enterprises, they bring capital, skills and modern management model to prosper local economy and give feedback by tax revenue, facilitating the local government’s work of building well-appointed infrastructure. Besides, industrialisation and urbanisation will have virtuous cycle and positive impact on the local development.
YRD includes Shanghai city, southern part of Jiangsu Province and northern part of Zhejiang. It consists of one municipal city (Shanghai), three sub-provincial cities (Nanjing, Hangzhou and Ningbo), seven prefecture-level cities in Jiangsu (Suzhou, Wuxi, Changzhou, Zhenjiang, Nantong, Yangzhou and Taizhou) and five prefecture-level cities in Zhejiang (Jiaxing, Huzhou, Shaoxing, Zhoushan and Taizhou). There are 16 cities in total; the total area is about 109,900 km² and the population is about 101.78 million. YRD has been served as the core of manufacturing and commerce industry in Mainland China but it did not set up any special economic zone during the period of enforcing preliminary reform and opening-up policy. In the aspect of regional economics in Mainland China, YRD has not been under the spotlight until the continuous expansion of opening-up policy and the plan of bringing YRD into the ‘opening-up area’. In 1992, Tang Siu Ping brought up an idea in his ‘talks in the south’ which was developing Pudong’s economy in YRD should be listed as top priority; and further, he confirmed the decision in the political report of ‘the 14th party congress’. Henceforth, he regarded Shanghai as the core and prosperous economic zone in YRD which constitutes 15 prefecture-level cities mainly centering on Nanjing, Suzhou and Hangzhou. YRD has been flourished in a steady pace recently, making the ratio of GDP in Mainland China elevate by degrees and thus become main contributor in terms of total economic growth in Mainland China: the constructed model keeps changing, consumption and investments from both the government and enterprises increase steadily and feature of export-oriented economy become obvious. YRD covers two provinces, one city and chiefly comprises 16 prefecture-level cities; therefore, each area fully utilises its geographical advantage based on its spatial distribution of location, resources and the requests of production during economic development. Successfully, each area has developed each own unique style in terms of regional development model.

PRD and YRD have won the high esteem for their abilities of economic development since the launch of Mainland China’s reform programme; these two amount 1.71% and 11.59% of the land and population respectively in Mainland China but had created 27.01% GDP in 2010. In 1996, the two regions’ GDP grew from just US$186.6 billion in total, not even a quarter of GDP in Mainland China. However, according to statistics in 2010, GDP in PRD and YRD has reached US$1,636 billion among which GDP in PRD was US$568.9 billion; its ratio is to 9.39% in Mainland China, decreasing 0.04% compared with last year. As for GDP in YRD was US$1,067.2 billion; its ratio is to 17.62% in Mainland China, increasing 0.03% compared with last year. Motivation of economic growth in PRD and YRD is still amazingly strong, therefore, status of PRD and YRD will only elevate in the future.

The reform and opening-up policy had been the key factor for the swift development in PRD and YRD for the last 30 years. Nevertheless, speaking of gaining the central government’s permit on equal preferential policy, YRD is slower than PRD at least 13 years in terms of time. Moreover, the government once merely focused on Pudong in Shanghai early 1990. Judging from the conclusion, the economic development in YRD enjoyed greater achievement than that in PRD. The main reason can be summarised as follows: manufacturing and commerce industry in Shanghai is relatively active; infrastructure, intact; experts and professionals with technical skills are abundant. Hence, YRD can produce dramatic effect and increase economic growth greatly once benefited by the preferential policy. That FDI plays an important role in the economic development in both PRD and YRD is worth to be mentioned. In the early 20 years or more of the preliminary reform and opening-up policy, PRD attracted FDI so huge that it took the
lead in every corner of Mainland China. When it comes to the 21st century, the scale of FDI of two provinces and one city in YRD exceeds that of PRD and the gap begin to enlarge. Most foreign enterprises’ investment in PRD belongs to labour-intensive industry or low-level assembly industry in technological scope, plus, centering on processing trade featured by ‘three-plus-one’ and ‘huge import and export’, whereas, most foreign enterprises’ investment in YRD belongs to capital or skill-intensive industry or service trade. Due to this reason, FDI has different impact on industrial structure and economic development in both PRD and YRD. Namely, each has strong points.

2 Literature review

Literature review in earlier times used to emphasising on discussing the impact of FDI on uneven distribution of economic development in Mainland China when evaluating technical efficiency and productivity (Cheng et al., 2006). So far, research about the growth of economic productivity among the regions still lacked extensive one. Part of literature review targeted on evaluating technical efficiency of each province, such as Xu (2006). The researcher used the most common data envelope analysis (DEA) and stochastic frontier approach (SFA) when evaluating technical efficiency. DEA and SFA were being applied to Zhejiang, using panel data to confirm the experiment. The result showed that economic extraversion, financial development, industry focus, urbanisation, technological input and other aspects have the greatest impact on technical efficiency development in terms of regional economics. Feng and Li (2010) utilised the impact of DEA on 21 prefecture-level cities in Sichuan Province to assess economic efficiency from 2000 to 2008. The result showed that technical efficiency in Sichuan Province displayed unbalanced distribution; economic development in Sichuan Province chiefly hinges on extensive growth model featured by high input, low efficiency, and only through technical transformation, management reinforcement and elevating the quality of labours can technical efficiency become more efficient and thus boost input productivity and economic efficiency.

Yao (2007) went further with the application of SFA, using PRD as case study of technical efficiency. The result implied that technical efficiency of PRD is higher than that of YRD from 1981 to 1990. However, the gap decreased from 1991 to 2000. Therefore, he claimed that PRD should fully utilise closer economic partnership arrangement (CEPA) to strengthen economic relationship with Hong Kong, elevating regional technical efficiency and suggestion about productivity policy in PRD. Shu et al. (2008) used translog production function to explore the intensification of regional economic integration in Pan-Pearl River Delta from 2000 to 2005 and its influence on technical advancement and technical efficiency in every province of the region. The result indicated that the intensification of regional economic integration made frontier technical efficiency in every province of the region increase evidently but relatively, it was slow to increase frontier technical efficiency.

Parts of other literature reviews were focused on technical efficiency in big regions that across province and city. For example, Wu (2008) adopted SFA to estimate economic growth in Mainland China. The result suggested that economic growth in Mainland China was principally based on the increase of component input, especially the promotion of capital input was highly apparent for the belief that to attain sustainable
growth efficiently, Mainland China had to find a productivity-oriented substitute model. Wang and An (2009) adopted SFA model to explore the contribution of technology innovation to regional technical efficiency in Mainland China, choosing five indicators such as put technology into personnel and technology put into budgets. The result suggested that among five indicators, only the total amount of technology input on personnel had less to do with technical efficiency. He especially pointed out that we should lay special emphasis on technology innovation, policy and system to stimulate the elevation of regional technical efficiency. Fan et al. (2010) analysed the influence of R&D on technical efficiency in high-tech industry in Mainland China. He also echoed the point that technology input and innovation has positive impact on high-tech industry and regional economic development.

Wu (2000) applied for the growth of Malmquist productivity index (MPI) in total factor productivity (TFP) to explore whether economic growth in Mainland China is sustainable. According to the research, TFP had been on the upward trend from 1987 to 1995. Chen et al. (2011) said that the industry in Mainland China had been on the strong climb since 1978; besides, through the appraisal by SFA, the result indicated that the growth of TFP had been surpassed the quantity input since 1992. However, after 2001, productivity was on the downward trend. In this study, Jiang (2011) stated that opening to the outside world was the direct incentive for productivity but not astringent action. Lee and Huang (2016) use a recently developed generalised metafrontier Malmquist productivity index (gMMPI) to provide insights on productivity growth. Lee and Huang extend the gMMPI to broaden the index’s capacity by decomposing various sources of productivity change in the metafrontier context. The sample contains commercial banks from 12 Western European countries prior to the recent financial crisis. The empirical results show that an average bank’s productivity growth arises mainly from technical changes and scale effects.

Concluding from the above literature reviews, we know that all of those studies set certain province and city as the object of study; as for study on regions that across province and city is much less. These studies had common drawbacks: supposing that the object of study shared the same standard of productivity and examined it in a parallel way instead of considering whether the differences existed. About gMMPI had been applied to regional productivity in Mainland China, only Chen et al. (2009) did similar research. Hence, the study will apply metafrontier model brought up by O’Donnell et al. (2008) to put differences into consideration. Afterwards, put stochastic frontier model brought up by Battese and Coelli (1995) in study in order to consider the impact of environment on regions. The study would like to focus on comparing and analysing the productivity of PRD and YRD, choosing prefecture-level cities or above as the object of study, including municipalities, sub-provincial cities and prefecture-level cities. The study will use the newest productivity assessment tool to compare advantages of economic development between PRD and YRD; the object of study covers nine prefecture-level cities in PRD and 16 prefecture-level cities in YRD from 1996 to 2010, adopting gMMPI of PRD and YRD. Through deconstructing gMMPI, we can go on a little further, knowing what makes productivity in PRD and YRD change and thus urge policy making on regional development become more efficient.
3 Research methodology

Based on the metafrontier model, this investigation analyses the performance of productivity in different periods. Rao (2006) firstly deconstructed and analysed agricultural productivity in 97 countries from 1986 to 1990. MMPI then created a more comprehensive analysis. Afterwards, O’Donnell et al. (2008) together with Krishnasamy and Ahmed (2009) also analyse productivity index based on MMPI. Since metafrontier model is a foundation of MMPI, MMPI can analyse TFP of different samples. Compared with traditional MPI, analysis offered by metafrontier model can reflect the results more accurately in the real life.

The deconstruction of traditional MPI is to suppose the immobility of constant return to scale (CRS); however, increasing or decreasing returns to scale is likely to happen. Therefore, it implies that the result of analysing productivity will have the blind spot. For this reason, Chen and Yang (2008) expanded MMPI, introducing scale efficiency change (SEC) into gMMPI model and thus making gMMPI estimate the change of cross-period productivity better, plus improving the drawbacks of traditional MPI model. The derivation process of gMMPI can be broken into technical efficiency change (TEC), technical change (TC), SEC, pure technical catch-up (PTCU) and potential technological relative change (PTRC). The result indicated that the estimation of traditional MPI mode ignored SEC. Hence, the result was greatly different from gMMPI model. The introduction of scale efficiency made analysis of MPI become more comprehensive.

Chen et al. (2009) adopted gMMPI to analyse the growth of regional productivity in Mainland China, exploring the differences of productivity growth between eastern coastal areas and middle and western non-coastal areas. The result suggested that it was not easy to see the outstanding performance of western development policy in a short period of time because productivity growth was a notion; if examined in a long-term period, perhaps it was only because of the insufficient time to show the outcome of policy.

Neither of the MPI and MMPI formulae considered the SEC, which is a factor that may affect the result of the analysis. Chen and Yang (2008), therefore, introduced intertemporal SEC into the MMPI model to offer a more comprehensive analytical model. Based on Diewert (1976) quadratic identity lemma, and taking the weighted elasticity of the input distance using natural logarithm, the estimated change in input can be expressed as (1):

\[
\ln \text{MMPI}_{i,t+1} (y_{i,t+1}, x_{i,t+1}, x_{w,t}) = \left[ \ln D'_{i,t} (y_{i,t}, x_{i,t}, t) - \ln D'_{i,t} (y_{i,t}, x_{i,t}, t) \right] \\
-0.5 \left[ \frac{\partial \ln D'_{i,t} (y_{i,t}, x_{i,t}, t)}{\partial t} + \frac{\partial \ln D'_{i,t} (y_{i,t}, x_{i,t}, t)}{\partial t} \right] (1)
\]

Indices of TFP require several conditions including identity, reparability, proportionality, and monotonicity; as a result, equation (1) may not follow the principle of proportionality. By adopting Orea (2002) alternative of using a flexible quota of input distance as the weight for the input change, so the weight of the input variables fit the linear first-order condition and it can be expressed as (2):
In the above formula, the first term (TEC*) and the second term (TC*) on the right-hand side of the formula are the metafrontiers TEC and TC, respectively. However, equation (2) differs from equation (1) in that the factor of the third term on the right-hand side of equation (2) is the result of scale elasticity and change in factor input. Therefore, a firm’s increasing or decreasing returns to scale will also affect the increase or decrease of its input in time period \( t + 1 \). By multiplying with a natural exponent, gMMPI can be expressed as (3):

\[
g_{MMPI_{t,t+1}} = TEC^*_t \times TC^*_t \times SEC^*_t
\]

We factored into formula (2) the ratio of intertemporal changes in TGR to the level of technical improvement, and express it as (4):

\[
\ln g_{MMPI_{t,t+1}}(y_{t+1}, y_t, x_{t+1}, x_t) = \left[ \ln D^*_t(y_{t+1}, x_{t+1}, t) - \ln D^*_t(y_t, x_t, t) \right] - 0.5 \times \left[ \frac{\partial \ln D^*_t(y_{t+1}, x_{t+1}, t)}{\partial t} + \frac{\partial \ln D^*_t(y_t, x_t, t)}{\partial t} \right] + 0.5 \times \sum_{n=1}^{N} \left[ \left( -\sum_{k=1}^{N} x_{t+1, k}^* - 1 \right) x_{t+1, n}^* + \left( -\sum_{k=1}^{N} x_{t, k}^* - 1 \right) x_{t, n}^* \right] \times \left( \ln x_{t+1, n}^* - \ln x_{t, n}^* \right)
\]

By multiplying with a natural exponent, equation (4) can be simplified to the following equation:

\[
g_{MMPI_{t,t+1}} = TEC^*_t \times TC^*_t \times PTCU^*_t \times PTRC^*_t \times SEC^*_t
\]

From equation (5) we know that results from the productivity analysis conducted in this research can be obtained by multiplying the following components: technical efficiency change (TEC), technical change (TC), pure technological catch-up (PTCU), potential technological relative change (PTRC), and scale efficiency change (SEC*). Thus, this operation is more sophisticated and better than the traditional MPI method.

4 Model design, the construction of information and variable

4.1 Model specifications

From literature review, we can find out that most of them used translog production function to set variables (Schmidt, 1976; Tsai and Wann, 1955). Therefore, the study
adopts translog production function and set empirical model as follows based on Battese and Coelli (1995) model.

$$
\ln Y_{it} = \beta_0^g + \beta_1^g \left( \ln L^g_{it} \right) + \beta_2^g \left( \ln K^g_{it} \right) + \frac{1}{2} \beta_3^g \left( \ln L^g_{it} \right)^2 + \frac{1}{2} \beta_4^g \left( \ln K^g_{it} \right)^2 + \\
\beta_5^g \left( \ln L^g_{it} \right) \left( \ln K^g_{it} \right) + \frac{1}{2} \beta_6^g T + \frac{1}{2} \beta_7^g T^2 + \beta_8^g \left( \ln L^g_{it} \right) T + \beta_9^g \left( \ln K^g_{it} \right) T + Y^g_{it} - U^g_{it}
$$

(6)

- \(i = 1, 2, ..., N; N = 25\); with \(i\) representing the order of every city.
- \(t = 1, 2, ..., T; T = 25\); with \(t\) representing the order of every year.

In the sixth formula, \(g\) represents frontier production function in every group; \(i\) represents each city’s serial number; \(t\) represents serial number of time; \(Y_{it}\) represents each city’s gross output; \(L_{it}\) represents amount of the employed at the end of the year; \(K_{it}\) represents each city’s fixed assets in stock. The formula above is the mode of frontier production function in every group and metafrontier production function mode is listed as the following (7):

$$
\ln Y^g_{it} = \beta_0^g + \beta_1^g \left( \ln L^g_{it} \right) + \beta_2^g \left( \ln K^g_{it} \right) + \frac{1}{2} \beta_3^g \left( \ln L^g_{it} \right)^2 + \frac{1}{2} \beta_4^g \left( \ln K^g_{it} \right)^2 + \\
\beta_5^g \left( \ln L^g_{it} \right) \left( \ln K^g_{it} \right) + \frac{1}{2} \beta_6^g T + \frac{1}{2} \beta_7^g T^2 + \beta_8^g \left( \ln L^g_{it} \right) T + \beta_9^g \left( \ln K^g_{it} \right) T
$$

(7)

On the other hand, inefficient model is based on stochastic production frontiers brought up by Battese and Coelli (1995) to set the following formula:

$$
\mu_{it} = \delta_0 + \delta_1 \left( FDI_{it} \right) + \delta_2 \left( TRADE_{it} \right) + \delta_3 \left( R & D_{it} \right) + \delta_4 \left( PPOP_{it} \right) + W_{it}
$$

(8)

- \(i = 1, 2, ..., N; N = 25\); with \(i\) representing the order of every city.
- \(t = 1, 2, ..., T; T = 25\); with \(t\) representing the order of every city.

In the eighth formula, \(FDI_{it}\) represents FDI in every region; \(Trade_{it}\) represents the total amount of import and export; \(R & D_{it}\) represents the overall amount of science and education expenditure; \(PPOP_{it}\) represents numbers of professional technical personnel in every region.

4.2 Data source and variable constructions

In terms of setting variable, the study consults former relative literature review (see Table 1) among which output variable is the gross regional product \(Y\) of every city; it means that the in a region which is calculated by market price, all long-stationed organisation’s final result of productive activity in a certain period of time. Inferring from Table 2, we know that the average gross output in PRD is 1727.8 billion which is less than that of YRD, 1882.6 billion. Gross output of municipalities in YRD rockets high and is many times higher than those of sub-provincial and prefecture-level cities among which the gap in PRD is more obvious than that in YRD.
In the aspect of variable input, there are the employed $L$ and fixed assets in stock $K$. The employed $L$ implies that people earn money or receive remuneration by doing social labour work, including workers on duty, re-employment workers, privately-operated employer, privately-operated and individual employees, employers in township enterprises, workers in agricultural villages and other workers; it reflects the actual use of all laborious resources in a certain period of time. Inferring from Table 2, we know that employed people in PRD and YRD numbered 264.2 million and 318 million respectively; the arrangement of city category is the same as output variable, only the gap between two lessens. On the other hand, judging from 10 thousand per capita of the employed people’s contribution to gross regional product, we know the sum of money in PRD is 6.5 billion. The manpower utilisation in PRD is a little higher than that in YRD which amounts 5.9 billion; municipalities in YRD has even reached 9 hundred million.

Total investment in fixed assets $K$ means to use the monetary form to show the total expenditure of the workload of building the society, purchasing fixed assets and related things in a specific time. However, if only using yearly total investment in fixed assets as yearly input, it is hard to assess the benefit of investment; we have to put late effect into consideration. Hence, the study set fixed assets in stock as variable. Inferring from Table 2, we know that fixed assets in stock of PRD and YRD amounts 504.7 billion and 795.5 billion individually; and again, inferring from the ratio of total investment in fixed assets to gross regional product, we know that the ratio is 29.2% in PRD which is far lower than that in YRD, 42.3%. From this point, we know that total investment in fixed assets of YRD is higher than that of PRD among which level of prefecture-level cities is slightly higher than that of sub-provincial cities in PRD and vice versa in YRD. In YRD, level of prefecture-level cities are higher than that of municipalities, indicating that in order to elevate the comprehensive development of regional economics, capital construction in sub-provincial cities and prefecture-level cities also increases extensively.

The study consider the influence of environment variable on regional economic development to evaluate technical efficiency of YRD and PRD reasonably; the study also consult former literature reviews to divide environment variable into two parts: opening to the outside world and science input; for the former one we choose FDI and TRADE...
and the later one is generally called technology resources based on manpower, materials and finance that has been put into technology activities. Technology resources can be analysed by two parts: input of technology funds and input of technology personnel. Therefore, we choose science and education expenditure (R&D) and professional technical personnel (PPOP) for this section.

Judging from Table 2, in a general way, except the total amount of import and export, the total amount in PRD is much higher than that in YRD. As for the remaining three environment variables, the situation is the other way round. In terms of the arrangement of the city category, municipalities is the best, the same as the arrangement of input and output variables; the next are sub-provincial and prefecture-level cities among which the gap of total imports and exports is the widest. Hence, when evaluating productivity in a region, if not considering the differences within a region, the result is sure to miss specified.

Table 2  Descriptive statistics of variable

<table>
<thead>
<tr>
<th>Name of variable</th>
<th>PRD</th>
<th>YRD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sub-provincial cities</td>
<td>Prefecture-level cities</td>
</tr>
<tr>
<td>Output and input variable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regional gross output</td>
<td>4,228.0</td>
<td>1,013.5</td>
</tr>
<tr>
<td>Numbers of the employed</td>
<td>497.3</td>
<td>197.5</td>
</tr>
<tr>
<td>Fixed assets in stock</td>
<td>1,160.9</td>
<td>317.3</td>
</tr>
<tr>
<td>Environment variable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Actual usage of foreign capital</td>
<td>226.6</td>
<td>75.5</td>
</tr>
<tr>
<td>Total amount of import and export</td>
<td>7,174.9</td>
<td>1,524.5</td>
</tr>
<tr>
<td>Science and education expenditure</td>
<td>62.2</td>
<td>13.5</td>
</tr>
<tr>
<td>Professional technical personnel</td>
<td>48.4</td>
<td>8.3</td>
</tr>
</tbody>
</table>

Notes: The unit about people is 10 thousand people. The unit about money is 100 million RMB.
In terms of the relationship between environment variable and inefficient technique and concluding from literature review (Yuan et al., 2005; Xu, 2006; Yao, 2007; Wu, 2008), we know that the general thinks that FDI can be elevated through advanced technology and management experiences, producing positive spill over effect in the internal part of region but quite a few researchers believe that under certain circumstances does FDI must affect productivity. In the aspect of import and export trades, FDI is benefited for elevating the efficiency of resource allocation in a region. Hence, expecting the impact of FDI on technical inefficiency in a region is uncertain. The influence of import and export trades on technical inefficiency in a region is expected to produce negative effect; in other words, the increase of the total imports and exports are conducive to reducing inefficiency, and thus gaining higher technical efficiency. As for technology input, references about influence on regional technical efficiency are rare. The study sets total amount of science and education expenditure in every prefecture-level city or above as an indicator for research development. We suppose that elevation of research development will conduct to reduction of inefficiency; therefore, expectation has a remarkable negative effect. For experts and technical personnel, they have the same remarkable result.

The study set time from 1996 to 2010 as research period and the main resource of the study comes from YRD and PRD and Hong Kong and Macao SAR and Taiwan Statistical Yearbook and China City Statistical Yearbook, supplement with Regional Statistical Yearbook, Provincial Statistical Yearbook and City Provincial Yearbook, such as Guangdong Statistical Yearbook, Shanghai Statistical Yearbook, Jiangsu Statistical Yearbook and Zhejiang Statistical Yearbook among which PRD includes nine cities: Canton, Shengzhen, Zhuhai, Foshan, Jiangmen, Dongguan, Zhongshan, Huizhou and zhaqing; YRD includes 16 cities: Shanghai, Nanjing, Suzhou, Wuxi, Changzhou, Zhenjiang, Nantong, Yangzhou, Taizhou, Hangzhou, Ningbo, Jiaxing, Huzhou, Shaoxing, Zhoushan and Taizhou. Afterwards, classify them by municipals, sub-provincial cities and prefecture-level cities. On the other hand, considering the influence of inflation on information from 1996 to 2010, the study uses consumer price index (CPI) to deflate goods at 25 cities in PRD and YRD, in order to make criteria of variable consistent.

5 Analysis of empirical result

5.1 Analysis of productivity evaluation

Before evaluating analysis, we have to execute LR test. The point of this test is to check that whether there is any difference among every group. In the research report of Battese et al. (2004), it mentioned that if each group has the same standard of technical skills, adopting metafrontier model is meaningless. The formula of LR is $\lambda = -2\{\ln[L(H_0)] - \ln[L(H_1)]\}$ and $\ln[L(H_0)]$ is stochastic frontier likelihood function calculated by total sample in both PRD and YRD; $\ln[L(H_1)]$ is stochastic frontier likelihood function in both PRD and YRD. After calculation, $\lambda = 126.6542$ is greater than 1% significant level, meaning that technological gap exists. Therefore, that the study adopts metafrontier model to analyse is reasonable.
## Table 3: Estimated result of coefficient

<table>
<thead>
<tr>
<th>Variables</th>
<th>PRD</th>
<th>YRD</th>
<th>PRD &amp; YRD</th>
<th>PRD &amp; YRD-LP</th>
<th>PRD &amp; YRD-QP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coefficient</td>
<td>Standard error</td>
<td>Coefficient</td>
<td>Standard error</td>
<td>Coefficient</td>
</tr>
<tr>
<td>Constant</td>
<td>4.01447***</td>
<td>0.77257</td>
<td>7.45297***</td>
<td>0.73947</td>
<td>6.02202***</td>
</tr>
<tr>
<td>ln L</td>
<td>-0.98244***</td>
<td>0.35557</td>
<td>-0.86271***</td>
<td>0.30196</td>
<td>-0.92422***</td>
</tr>
<tr>
<td>ln K</td>
<td>1.36753***</td>
<td>0.31058</td>
<td>0.41671**</td>
<td>0.19758</td>
<td>0.76430***</td>
</tr>
<tr>
<td>(ln L)^2</td>
<td>0.74708***</td>
<td>0.15579</td>
<td>0.39690***</td>
<td>0.07879</td>
<td>0.45253***</td>
</tr>
<tr>
<td>(ln K)^2</td>
<td>0.25036***</td>
<td>0.07753</td>
<td>0.23075***</td>
<td>0.06528</td>
<td>0.13581***</td>
</tr>
<tr>
<td>(ln L) (ln K)</td>
<td>-0.47260***</td>
<td>0.10649</td>
<td>-0.23203***</td>
<td>0.06152</td>
<td>-0.22184***</td>
</tr>
<tr>
<td>T^T</td>
<td>-0.00424</td>
<td>0.00276</td>
<td>0.00746*</td>
<td>0.00430</td>
<td>0.00390</td>
</tr>
<tr>
<td>(ln L)T</td>
<td>0.04604***</td>
<td>0.01109</td>
<td>0.05922***</td>
<td>0.01441</td>
<td>0.04086***</td>
</tr>
<tr>
<td>(ln K)T</td>
<td>0.01144</td>
<td>0.01185</td>
<td>-0.03122***</td>
<td>0.01461</td>
<td>-0.00909</td>
</tr>
<tr>
<td>Constant</td>
<td>2.42073***</td>
<td>0.34501</td>
<td>2.49899***</td>
<td>0.12879</td>
<td>2.08843***</td>
</tr>
<tr>
<td>ln (FDI)</td>
<td>-0.19960**</td>
<td>0.09222</td>
<td>-0.08547**</td>
<td>0.03700</td>
<td>-0.04585*</td>
</tr>
<tr>
<td>ln (TRADE)</td>
<td>-0.13676**</td>
<td>0.06141</td>
<td>-0.19578***</td>
<td>0.03447</td>
<td>-0.14857***</td>
</tr>
<tr>
<td>ln(R&amp;D)</td>
<td>-0.03291</td>
<td>0.05798</td>
<td>-0.08101**</td>
<td>0.03019</td>
<td>-0.01728</td>
</tr>
<tr>
<td>ln(PPOP)</td>
<td>-0.08238*</td>
<td>0.05590</td>
<td>-0.11740***</td>
<td>0.05062</td>
<td>-0.11947***</td>
</tr>
</tbody>
</table>

LLF: 60.6028  78.5198  75.7955  -  -  -

Note: L: numbers of the employed; K: fixed-assets investment; T: time; *, **, and *** means reaching significant standard 10%, 5% and 1% respectively; LLF: log likelihood function.
From equations (6) to (8) of empirical model, we can calculate the result of coefficient of Stochastic Frontier and metafrontier model. See Table 3 for the detail. Considering the influence of environment variable, we know that the estimated result of PRD and YRD calculated by Stochastic frontier mode run up to 0.999, indicating that environment variable is the main reason for affecting technical inefficiency of regional economics. Furthermore, it will affect regional economics to be high technical efficiency or low one. From this point, we know that not taking the impact of environment variable into consideration can result in error in the result. Judging from stochastic frontier mode constituted by PRD and YRD, we conclude that FDI, TRADE, R&D and POP are all negative correlation; it indicates that the increase of FDI, TRADE, expenditure of R&D and experts can remarkably reduce the opportunity of technical inefficiency, and thus, boost regional technical efficiency.

González and Gascón (2004) did research on pharmaceutical industry in Spain and explained clearly that productivity growth came from remarkable contribution of the change of technical efficiency in the conclusion from 1994 to 2000. On an average, influence of technical change could be totally ignored. Table 4 in the study adopts the estimated result of yearly observation on productivity to observe gMMPI in the table. Here is the result: annually rise in PRD is around 8.55%, whereas, YRD is 16.46%; the former one is slightly lower than the later one. Nevertheless, the change of components is different. If seeing from the region, annual overall average in PRD is 1.0855 which suggests that there is 8.55% growth on an average during 14 years; the principal change is through TEC, changing 5.67%; secondly, through SEC, changing 2.31%; however, TECU is 0.53% backward. Take a look at annual overall average in YRD, we find the statistics show 1.1646%, meaning that it has grown to 16.46% during 14 years; the change is mainly through TEC, changing 19.36%; secondly, through TECU, changing 17.4%, the change is the smallest through SEC, changing 10.25%.

In order to obtain meaning of ‘chasing’ more specifically, the study divides inter-period variable value of technology gap ratio (TGR) into TECU and PTRC; if ratio of the former one is bigger than 1, it means that technology gap in every region will diminish with the passing of time; namely, TGR will increase which implies the phenomenon that production technology chasing after potential technology does exist. However, if ratio of the later one is bigger than 1, it indicates that speed of boosting potential technology is concurrent to current technology standard which means expansion of regional technical development, spatially or potentially.

PTCU values are more than 1 in six years during the sampling in PRD; the remaining PTCU in every year is all less than 1 and its average value is 1.0036. PTCU expands 0.36% annually, indicating that the problem of technology gap faced by PRD deducts with the passing of time. The phenomenon shows that production technology chasing after potential technology does exist. PTCU values are less than 1 only in one year during the sampling in YRD. The average value of PTCU is greater than 1 which is 1.1740; it suggests that PTCU increases about 17.4% yearly and the problem of technical gap faced by YRD will diminish even more with the passing of time. It indicates that production technology in YRD does chase after potential technology.

For PTRC, its ratio was greater than 1 in the remaining 12 years except the one during 1996 to 1997 and 1997 to 1998 in PRD which were 0.9949 and 0.9974. The average value was 1.0021 during the sampling period, implying that the potentiality of technical development in PRD went upward. All of PTRC in YRD was greater than 1 in 14 years. The average value was 1.1430 during the sampling period, indicating that the
Analysis of the growth of regional productivity

potentiality of technical development in both PRD and YRD went upward. The potentiality of technical development in PRD was 14.09% lower than that in YRD.

Table 4  Estimated result of productivity in every year in PRD and YRD

<table>
<thead>
<tr>
<th>Regions</th>
<th>Year</th>
<th>TEC</th>
<th>TC</th>
<th>PTCU</th>
<th>PTRC</th>
<th>SEC</th>
<th>gMMPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRD</td>
<td>1997</td>
<td>1.1878</td>
<td>1.0005</td>
<td>1.0377</td>
<td>0.9949</td>
<td>0.5123</td>
<td>0.5740</td>
</tr>
<tr>
<td></td>
<td>1998</td>
<td>0.8169</td>
<td>0.9865</td>
<td>0.9797</td>
<td>0.9974</td>
<td>0.3956</td>
<td>0.3973</td>
</tr>
<tr>
<td></td>
<td>1999</td>
<td>1.5106</td>
<td>1.0147</td>
<td>1.0595</td>
<td>1.0079</td>
<td>1.5126</td>
<td>1.8222</td>
</tr>
<tr>
<td></td>
<td>2000</td>
<td>1.0892</td>
<td>0.9981</td>
<td>1.0016</td>
<td>1.0066</td>
<td>0.9473</td>
<td>0.9817</td>
</tr>
<tr>
<td></td>
<td>2001</td>
<td>1.0290</td>
<td>1.0001</td>
<td>1.0075</td>
<td>1.0000</td>
<td>1.1638</td>
<td>1.1735</td>
</tr>
<tr>
<td></td>
<td>2002</td>
<td>1.0006</td>
<td>1.0001</td>
<td>1.0011</td>
<td>1.0022</td>
<td>1.4989</td>
<td>1.6669</td>
</tr>
<tr>
<td></td>
<td>2003</td>
<td>0.9889</td>
<td>1.0021</td>
<td>1.0072</td>
<td>1.0011</td>
<td>1.1546</td>
<td>1.1861</td>
</tr>
<tr>
<td></td>
<td>2004</td>
<td>0.9805</td>
<td>1.0016</td>
<td>0.9964</td>
<td>1.0026</td>
<td>1.0560</td>
<td>1.1045</td>
</tr>
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<td>2005</td>
<td>1.0733</td>
<td>1.0013</td>
<td>0.9907</td>
<td>1.0027</td>
<td>0.9879</td>
<td>0.9880</td>
</tr>
<tr>
<td></td>
<td>2006</td>
<td>1.0635</td>
<td>0.9996</td>
<td>0.9955</td>
<td>1.0036</td>
<td>1.2172</td>
<td>1.3530</td>
</tr>
<tr>
<td></td>
<td>2007</td>
<td>1.0169</td>
<td>0.9997</td>
<td>0.9940</td>
<td>1.0022</td>
<td>1.5493</td>
<td>1.4762</td>
</tr>
<tr>
<td></td>
<td>2008</td>
<td>1.0350</td>
<td>0.9992</td>
<td>0.9957</td>
<td>1.0034</td>
<td>0.8087</td>
<td>0.8491</td>
</tr>
<tr>
<td></td>
<td>2009</td>
<td>0.9956</td>
<td>0.9996</td>
<td>0.9895</td>
<td>1.0004</td>
<td>0.5348</td>
<td>0.5313</td>
</tr>
<tr>
<td></td>
<td>2010</td>
<td>1.0054</td>
<td>0.9994</td>
<td>0.9947</td>
<td>1.0037</td>
<td>0.9843</td>
<td>1.0938</td>
</tr>
<tr>
<td></td>
<td>Total average</td>
<td>1.0567</td>
<td>1.0002</td>
<td>1.0036</td>
<td>1.0021</td>
<td>1.0231</td>
<td>1.0855</td>
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<tr>
<td>YRD</td>
<td>1997</td>
<td>1.1762</td>
<td>1.1314</td>
<td>1.0694</td>
<td>1.1450</td>
<td>0.5605</td>
<td>0.6029</td>
</tr>
<tr>
<td></td>
<td>1998</td>
<td>1.2708</td>
<td>1.1270</td>
<td>0.9659</td>
<td>1.1403</td>
<td>0.4378</td>
<td>0.3730</td>
</tr>
<tr>
<td></td>
<td>1999</td>
<td>1.2867</td>
<td>1.1772</td>
<td>1.5395</td>
<td>1.1427</td>
<td>1.3925</td>
<td>1.4991</td>
</tr>
<tr>
<td></td>
<td>2000</td>
<td>1.2058</td>
<td>1.1420</td>
<td>1.1266</td>
<td>1.1430</td>
<td>1.2694</td>
<td>1.4458</td>
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<tr>
<td></td>
<td>2001</td>
<td>1.1656</td>
<td>1.1410</td>
<td>1.1568</td>
<td>1.1435</td>
<td>1.1091</td>
<td>1.2347</td>
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<tr>
<td></td>
<td>2002</td>
<td>1.2136</td>
<td>1.1442</td>
<td>1.1459</td>
<td>1.1428</td>
<td>1.5233</td>
<td>1.6836</td>
</tr>
<tr>
<td></td>
<td>2003</td>
<td>1.0519</td>
<td>1.1332</td>
<td>1.2388</td>
<td>1.1450</td>
<td>1.0799</td>
<td>1.1872</td>
</tr>
<tr>
<td></td>
<td>2004</td>
<td>1.2200</td>
<td>1.1442</td>
<td>1.1786</td>
<td>1.1430</td>
<td>1.3273</td>
<td>1.4476</td>
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<td>2005</td>
<td>1.2121</td>
<td>1.1453</td>
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<td>1.1430</td>
<td>1.1828</td>
<td>1.2450</td>
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<tr>
<td></td>
<td>2006</td>
<td>1.2151</td>
<td>1.1454</td>
<td>1.1760</td>
<td>1.1429</td>
<td>1.1426</td>
<td>1.1951</td>
</tr>
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<td></td>
<td>2007</td>
<td>1.1876</td>
<td>1.1467</td>
<td>1.1649</td>
<td>1.1428</td>
<td>1.1964</td>
<td>1.1888</td>
</tr>
<tr>
<td></td>
<td>2008</td>
<td>1.1721</td>
<td>1.1463</td>
<td>1.1606</td>
<td>1.1428</td>
<td>0.9974</td>
<td>0.9649</td>
</tr>
<tr>
<td></td>
<td>2009</td>
<td>1.1679</td>
<td>1.1441</td>
<td>1.1815</td>
<td>1.1431</td>
<td>0.8992</td>
<td>0.8773</td>
</tr>
<tr>
<td></td>
<td>2010</td>
<td>1.1646</td>
<td>1.1459</td>
<td>1.1489</td>
<td>1.1428</td>
<td>1.3162</td>
<td>1.3588</td>
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<tr>
<td></td>
<td>Total average</td>
<td>1.1936</td>
<td>1.1439</td>
<td>1.1740</td>
<td>1.1430</td>
<td>1.1025</td>
<td>1.1646</td>
</tr>
</tbody>
</table>

Table 5 in the study adopts the estimated result of observation of hierarchical structure of cities on productivity to observe hierarchical among cities in PRD. We find that gMMPI in sub-provincial cities goes downhill; prefecture-level cities, uphill. The principal change of productivity growth between prefectural and sub-provincial cities is due to the change of SEC: reducing 26.37% in sub-provincial cities and increasing 11.37% in prefecture-level cities; the second is TEC, increasing 0.32% in sub-provincial cities and
the increase of prefecture-level cities is a little bit higher which is 7.19%. Observing hierarchical structure of cities in YRD, we know that gMMPI goes downhill; productivity of prefecture-level and sub-provincial cities are, however, on the rise. For productivity growth among three hierarchical structure of cities, the principal change of municipalities, sub-provincial cities and prefecture-level cities can be attributed to the change of SEC: municipal cities reduce 13.44%, sub-provincial cities and prefecture-level cities increase 5.89% and 7.31%; secondly, municipalities for the PTCU grow 3.48%, the TEC changes in the sub-provincial cities increase by 3.22% and prefecture-level cities increase by 4.91%.

PTCU value of PRD during the sampling period in sub-provincial cities is lower than 1 which is 0.9948. It suggests that the problem of technical gap faced by sub-provincial cities expands with the passing of time which means the decrease of TGR. Implies the existence of a production technology to catch up with the phenomenon of potential technology. PTCU value in PRD prefecture-level city is 1.0062, greater than 1, it means that TGR values rise, said the presence of production technology of potential technology catch-up phenomenon. PTCU value in YRD during the sampling period, whether in municipal cities, sub-provincial cities or prefecture-level cities, is greater than 1 which is 1.0348, 1.0250 and 1.0272 respectively. This implies that PTCU increases by 3% on an average of every layer of hierarchical structure of cities, meaning that the problem of technical gap faced by YRD reduces with the passing of time. The phenomenon expounds that production technology chasing after potential technology does exist.

Seeing from PTRC, its value of sub-provincial cities and prefecture-level cities in PRD is both greater than 1 and the average value between samples shows 1.0023, meaning that development of city technology in PRD goes upward. PTCU value in YRD, PTRC ratio in sub-provincial cities and prefecture-level cities in YRD, is greater than 1. It appears that the PTRC of municipalities is about 0.9999, the sample average being 1.0001. Therefore, the potentialities for technology development of sub-provincial cities and prefecture-level cities in YRD have increased by 0.22%.

<table>
<thead>
<tr>
<th>Regions</th>
<th>Hierarchical structure of cities</th>
<th>TEC</th>
<th>TC</th>
<th>PTCU</th>
<th>PTRC</th>
<th>SEC</th>
<th>gMMPI</th>
<th>Situation</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRD</td>
<td>Sub-provincial cities</td>
<td>1.0032</td>
<td>1.0003</td>
<td>0.9948</td>
<td>1.0027</td>
<td>0.7363</td>
<td>0.7428</td>
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<td>Prefecture-level cities</td>
<td>1.0719</td>
<td>1.0001</td>
<td>1.0062</td>
<td>1.0019</td>
<td>1.1137</td>
<td>1.1817</td>
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<td>Total average</td>
<td>1.0375</td>
<td>1.0002</td>
<td>1.0005</td>
<td>1.0023</td>
<td>0.9250</td>
<td>0.9623</td>
<td>Decline</td>
</tr>
<tr>
<td>YRD</td>
<td>Municipal cities</td>
<td>1.0238</td>
<td>1.0026</td>
<td>1.0348</td>
<td>0.9999</td>
<td>0.8656</td>
<td>0.9473</td>
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<tr>
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<td>Sub-provincial cities</td>
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<td>1.0013</td>
<td>1.0250</td>
<td>1.0001</td>
<td>1.0589</td>
<td>1.1652</td>
<td>Growth</td>
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<tr>
<td></td>
<td>Prefecture-level cities</td>
<td>1.0491</td>
<td>1.0006</td>
<td>1.0272</td>
<td>1.0002</td>
<td>1.0731</td>
<td>1.1656</td>
<td>Growth</td>
</tr>
<tr>
<td></td>
<td>Total average</td>
<td>1.0350</td>
<td>1.0015</td>
<td>1.0290</td>
<td>1.0001</td>
<td>0.9992</td>
<td>1.0927</td>
<td>Growth</td>
</tr>
</tbody>
</table>

### 5.2 Test analysis

Therefore, the present paper explores the relations between the development strategy and regional productivity. It firstly analyses the effectiveness of tenth five-year plan towards regional economic development, and secondly the 11th five-year plan which is based on
the promotion of coordinated social justice measures that gave rise somehow to regional economic development. This paper studies the period from 1996 to 2010, when Mainland China formed coordinated regional economic development strategy consisting of three periods. Therefore, we did a thorough exploration of the relationship between this development strategy and regional productivity, based on an analysis of the second period of the tenth five-year plan. We tried to assess for the effectiveness of the implementation of the regional economic development, and the third period of the 11th five-year plan in order to promote social justice, but also the implementation of a series of coordinated regional economic development strategy. The plan also includes measures to promote the rise of the central region and encourages the eastern region to be the pioneers of development. Therefore, this article divided the development plans into three important periods: the first period is from 1996 to 2000, the ninth five-year plan, the second period starting from 2001 ending in 2005, called the tenth five-year plan, and the third period from 2006 to 2010, known as the 11th five-year plan.

<table>
<thead>
<tr>
<th>Region</th>
<th>Time period</th>
<th>TEC</th>
<th>TC</th>
<th>PTCU</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1996–2010 [P] vs. [Y]</td>
<td>[P] &gt; [Y]</td>
<td>[P] &lt; [Y]***</td>
<td>[P] &lt; [Y]***</td>
</tr>
</tbody>
</table>

Note: *, **, and *** means reaching significant standard 10%, 5% and 1% respectively.

In Table 6, the PRD and YRD in PTCU present significant differences; In YRD the TEC, TC and PTRC, are also showing significant differences. From an area perspective, by observing the PRD and YRD in the 11 five-year plan, we notice that the TC and PTCU are significantly different in the YRD, and also significantly higher than that of the PRD’
TC and PTCU. In fact, in YRD, Shanghai and Suzhou, Wuxi, each city does their best to establish science park, to attract FDI and technology for the promotion of local development. They also established research institutions, and research centres for professional and technical training of their human resources. In addition, PTRC value in PRD is significantly higher than the YRD; this is due to the changes proposed in the signing of CEPA and the Pan-Pearl River Delta, and the continued absorption of advanced technology and management experience from Hong Kong and Macau, leading to the enhancement of the productivity. From this study, we notice that the gMMPI of YRD is significantly higher than that of the PRD. Analysing the gMMPI destructuralisation process, we found out that the TC value and PTCU value in YRD at 1% level were significantly higher in the PRD.

6 Conclusions and policy

This aim of investigation is to understand the technical efficiency of regional economics of 25 China cities for examining on analysis of the growth of regional productivity in PRD and YRD in Mainland China from 1996 to 2010. Besides, the prior research used to using SFA model to analyse data when doing research on regional economics but under a presupposition that different regions shared same production standard. In other words, SFA model did not consider differences among regions. Therefore, the study firstly uses metafrontier model to do research on regional economics in Mainland China, evaluating productivity growth of regional development. Furthermore, the study will explore different hierarchical structure of cities. These are all helpful for us to understand regional economic development and effectiveness of promoting policies.

6.1 Conclusions

Since PRD opened to the outside world earlier than YRD, regulations and mechanisms in PRD were better. Most of Taiwanese businessmen investing in PRD work in a traditional industry. They also undertake big-scale industry adjustment and take action in energy conservation and carbon reduction, strictly controlling traditional industry, high-polluted or high energy-consuming industry. Simultaneously, labour cost in Mainland China has been gone up and labour shortage occurred. These are due to execution of policy on labours’ welfare and propagation of dealing with waste water discharge. Under this circumstance, take Taiwanese businessmen in YRD for example, especially those working in a traditional industry, they are under great stress. For this reason, Taiwanese businessmen are intended to move to PRD, mainly because that YRD is also under great pressure of facing industry adjustment and problem of energy conservation and carbon reduction. Nevertheless, the local official’s working efficiency, consciousness of serving people and qualities of workers are all better than those of PRD. For Taiwanese businessmen, so far, YRD has been the top priority for them to do business in Mainland China. The following is findings from the study:

PRD and YRD have been the two fastest regions in terms of economic growth in Mainland China from 1996 to 2010. The greater contribution to Mainland China’s economic growth they made, more attention paying to regional economic development will they got. Up to now, among three big fully-developed cities in Mainland China, PRD and YRD have been the important regions in the aspect of economic development. The
development of PRD was more mature than that of YRD and industrial structure in PRD
adjusted and upgraded much quicker also. Nevertheless, economic development in YRD
is better; exclusiveness of policies in PRD deprived advantages of regional economic
development in this region. Moreover, PRD was limited to space and indirectly affected
its economic development. Attracting FDI also served as an important element of curbing
one region’s economic development and encouraging the other.

Inferring from LR test, the study finds that there is difference between the structure of
PRD and YRD. Hence, we can use metafrontier model to analyse the impact of
environment variable on technical inefficiencies in regional economics. The result
confirmed that elevation of FDI, TRADE, R&D and PPOP is beneficial for significantly
reducing the influence on technical inefficiency. Metafrontier model showed that
according to productivity growth in PRD in every year, TEC is the main change and next,
SEC. In YRD in every year, TEC is the main change and next, PTCU. If based on
hierarchical structure of every city, the situation will be different: gMMPI in
sub-provincial cities in PRD will go downhill and prefecture-level cities climb upward.
SEC is the main change and next, TEC; gMMPI in municipal cities in YRD goes
downhill; sub-provincial cities and prefecture-level cities upward. For productivity
growth among three hierarchical structure of cities, the principal change of sub-provincial
cities and prefecture-level cities can be attributed mainly to the change of SEC; secondly
to TEC. As for the main change of municipalities is SEC and PTCU, the next.

From the above mentioned, we know that because PRD opens to the outside world
earlier, its concept and system are more advantageous than those of the YRD. Moreover,
PRD serves as the birthplace of Mainland China’s system innovation and development in
Shenzhen was regarded as miracle. However, as policies turn the direction to YRD
gradually, economic development of PRD goes downhill and its development becomes
more inefficient, meaning that there is much room for improvement in PRD than that in
YRD and it is the reason that PRD has been dedicated to industry purgation in recent
years.

6.2 Meaning of policy

After observing the trend of regional economic from now on, the government plays an
important role in promoting. Regional development in the past used to make decision
between justice and efficiency. Tang Siu Ping’s policy, ‘let partial people rich and
regions prosperous first’ represented a standpoint that he listed efficiency as top priority
and it deeply affected regional economics in Mainland China for 30 years. After the
reform, Mainland China lacked experience to cope with difficulties no matter in the
aspect of establishing sound system or economic development. Under this circumstances,
Mainland China created economic zones, opened coastal areas in advance and set many
developing areas, empowering PRD and YRD many rights of testing when under the
reform and other preferential policies were established also, such as special economic
zone in Shenghen and in Zuhai in PRD, economic technology developing regions in
Pudong in Shanghai in YRD along with Kunshan, Nantong, Hangzhou and Ningbo in
Suzhou.

Reforming for 30 years, preferential policies in PRD and YRD has been implemented
since policy of special economic zone has been implemented in 1979; Shenghen and
Zuhai are beneficiaries. In 1984, opening coastal area benefited Guangzhou in YRD so as
Shanghai, Nantong and Ningbo. Policy of economic-technical development area of the same year could be applied to above-mentioned policy also. Policy of opening coastal area in 1985 could be applied to PRD and YRD as well. In 1990, policies in Mainland China gradually turned the direction to YRD and policy of Pudong in Shanghai could be applied in YRD in most cases. Policy of free trade zone this year made Guangzhou, Shenghen and Zuhai gain the preferential policy once more; Shanghai in YRD was also the beneficiary of this policy.

Mainland China builds market economy system in socialism on one hand, and on the other hand, the relationship between the central and the local and the local with the local become complicated day by day. Unlike planned economy system, the local government merely passively follows the instruction given by the central government; hence, the relationship between the central and the local and the local with the local are easier to handle with. However, every region is craved for developing economy nowadays, the relationship between the central and the local and the local with the local is no longer like municipal aid purely; instead, it is more like exchanging benefits. Therefore, the preferential policy will be pushed to next space with the passing of time. The advantage of economic development in PRD will be replaced by YRD gradually and the questions that will YRD become next PRD and whether next PRD will appear or not. These are all key problems that remain to be solved in regional economic development in both PRD and YRD. If readers are interested in the subsequent development, you can do research on Pan-Pearl River Delta or Pan-Yangtze River Delta which is actively promoted by the government right now. Compared with segment of 'coastal areas,' ‘inland’ and ‘the east, the middle and the west’, research on Pan-Pearl River Delta or Pan-Yangtze River Delta will be closer to reality.

Figure 1  TEC trend (see online version for colours)

Figure 2  TC trend (see online version for colours)
Figure 3  PTCU trend (see online version for colours)

Figure 4  PTRC trend (see online version for colours)

Figure 5  SEC trend (see online version for colours)

Figure 6  gMMPI trend (see online version for colours)
References


**Notes**

1 Sub-provincial city: there are 15 sub-provincial cities, including ten sub-provincial city (Shenyang, Changchun, Harbin, Nanjing, Hangchow, Tsinan, Wuhan, Guanghzou, Chengdu and Xian) and five cities specially designated in the state plan (Chongqing, Dairen, Ningbo, Qingdao and Shenzhen).

2 Prefecture-level cities: in Mainland China, status of prefecture-level city is more like a city in a region, being to prefectural administrative region; prefecture-level city is the second level of local administrative unit. For the reason that its administrative status is similar to regional administrative unit, it is called prefecture-level city. In general, prefecture-level cities are big cities apart from municipalities and sub-provincial cities.

3 In the 4th meeting of ‘The forum for the coordination of urban economy of the Yangtze River Delta’ in Nanjing in 2003, Taizhou in Zhejiang was being included and, thus, the number of cities in YRD expanded from 15 to 16.

4 Hayami (1969) firstly brought up metafrontier production theory. After several adjustments, Battese et al. (2004) defined metafrontier model as stochastic frontier likelihood function that based on different technical groups, enveloping certain part of stochastic frontier likelihood and, thus, take shape into enveloping-featured metafrontier.

5 According to calculation on convention of capital stock by Chen et al. (2009) (see the following equation), I represents total asset investment; $\delta$ represents rate of depreciation and the rate is set as 15% annually; $w$ represents growth rate of asset investment and the rate is set as 20% annually.
\[ K_i = I_i + (1 - \delta) I_{i-1} + (1 - \delta)^2 I_{i-2} + \ldots = \sum_{j=0}^{\infty} I_{-j} (1 - \delta)^j = I \sum_{j=0}^{\infty} \left[ \frac{1 - \delta}{1 + w} \right]^j = \frac{I}{1 + w} \]

6 \[ \lambda = -2 \left[ 67.656 - (36.187 + 77.1044) \right] = 91.2708 > \chi_{0.01, 20} = 31.4104 \]

7 TGR should be between 0 and 1; the higher the value, the closer frontier production in groups approaches metafrontier and vice versa.