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Can Chinese Cities Achieve Higher Technical Efficiency after Hosting Mega Events?

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Abstract

This study applies the stochastic frontier approach to estimate the technical efficiency of a group of Chinese cities which have hosted mega events such as the Olympic Games and Asian Games, etc. since 2000s. The purpose is to assess if their efficiency level can be strengthened in the process of event preparation. In the empirical analyses, it is observed that no significant improvement on technical efficiency can be achieved by the event hosting cities. The level of technical efficiency of the event hosting cities has even slightly declined in the event decade. Investment to gross domestic product (GDP) ratio is found to have positive linkages with technical efficiency, but it has not expanded satisfactorily to bring about significant efficiency improvement. Economic transition toward service sector with no comparative advantage, meanwhile, tends to discount efficiency. In general, hosting an event can only bring about short-lived contributions to economic benefits but not significant efficiency improvement. Policy makers should be cautious in the future before making their decisions to host mega events.

Keywords: *mega events, China, stochastic frontier analysis, technical efficiency*

JEL classification: *D24, O47*

1. Introduction[1]

In the aftermath of the London 2012 Olympic Games, the costs, benefits and appropriateness of hosting an international event have become popular topics once again. In practice, the organization of a mega event, such as the Olympic Games, incurs huge amount of capital investment for the construction and renovation of infrastructures and stadiums. While the infrastructure investment serves as direct fiscal stimulus to the economy, the mega event may be able to boost the prestige of the hosting city which can help to attract more visitors to strengthen the tourism industry. Given this belief, many countries have attempted to bid for the organization of mega international events. Japan, Korea and China, for example, are some of the countries in Asia which have successfully organized the Olympic Games.

In Wang (2002), the contributions of Tokyo 1964 and Seoul 1988 Olympic Games to the economy are discussed and stronger economic growth and job creations are observed as the positive impacts[2]. As remarked, the infrastructure investment made in the process has played a significant role. Nevertheless, there is still no guaranteed net economic gain to the hosting city. The Athens 2004 Olympic Games, meanwhile, cannot boost the growth rate of Greece significantly and is regarded as a failure in economic sense. In light of the Los Angeles 1984 Olympic Games and Atlanta Games 1996 Games, they can just bring about transitory impacts to employment with no long-run contributions at all (Baade and Matheson, 2002). The remark "economic benefits should be considered weak at best" (Coates and Humphreys, 2003: 347) is drawn to describe the impacts of sport events to the local economy. Pessimistic remarks can also be found in some studies in which the long-term contributions of Olympic Games to the economy are questioned (Sterken, 2006; Madden, 2006; Andersson, Armbrecht and Lundberg, 2008). In Madden (2006), with the Sydney 2000 Olympic Games as the example, the issue of consumption diversion from normal goods and services to Olympic Games related consumption is discussed. In Andersson, Armbrecht and Lundberg (2008), the extent of development in tourism industry is used as the criteria to assess the economic contributions of the Olympic Games. While studies conducted by independent researchers carry diversified positions toward event hosting, projections made by the authorities of the hosting cities are normally more optimistic. In Yu (2004)[3], for example, the impacts of the 2009 East Asian Games to Hong Kong are projected and it is believed that the Games can generate quantifiable economic benefits as well as higher city profile for Hong Kong.

In light of the Beijing 2008 Olympic Games, projections have been made by different online sources on the total investment, it ranges from USD2.2 billions (Wenweipo, 2008) to EURO8.95 billions (Wordpress, 2008), to a shocking amount of USD40 billions as the total infrastructure expenditures (The Blaze, 2012). An estimation of USD14.3 billions is also made on the total investment incurred in the Beijing Olympic Games in which USD8.6 billions is for environmental protection (Brunet and Zuo, 2009). There is no doubt that this huge sum of investment can bring about positive economic impacts to the hosting city. It is estimated that the Beijing Olympic Games can stimulate Beijing's gross domestic product in real term (RGDP) by 2.02 per cent per annum for the period of 2002 to 2007 (Zhang and Zhao, 2007).

Similar to the Olympic Games, hosting the World Exposition (Expo), Asian Games, East Asian Games or University Games, etc. have also involved significant amount of investments. The amount of money invested by various Chinese cities for the preparation of these events, according to various online sources, has amounted to USD625 millions for Macau 2005 East Asian Games (CNN, 2005), USD4.8 billions for Tianjin (People's Daily online, 2004) to co-host the Beijing 2008 Olympic Games, USD31 millions for Hong Kong 2009 East Asian Games (the Legislative Council of Hong Kong), USD4.2 billions for Shanghai 2010 Expo in which USD1.57 billions is the operating costs and USD2.65 billions is the construction costs (English.eastday.com), USD2.35 billions for Guangzhou 2010 Asian Games (Merinews, 2010) and USD3.1 billions for Shenzhen 2011 University Games (Chinawhisper, 2011) respectively. Given the investments on infrastructures and venue renovations, these mega events may consequently deliver positive economic impacts, such as higher growth rate, new job opportunities and faster development in the tourism industry to both the local economy and the neighbourhood.

When most of the available studies attempt to explore the nexus of event hosting to GDP growth as well as to project the number of newly created jobs, the long-term economic impacts of an event has not been thoughtfully discussed. Better technical efficiency is defined as more outputs with the current inputs. If it can be achieved through hosting an event, then the hosting city can relax its urgency in upgrading its technology which is regarded as a more timely, risky and probably expensive growth enhancing process. This paper is then organized to estimate the technical efficiency level of the event hosting cities in China. The intention is to examine if a city can improve its technical efficiency after paying tremendous efforts to prepare to host a mega event. The Chinese cities, namely Beijing, Tianjin, Shanghai, Guangzhou, Hong Kong, Macau and Shenzhen which have hosted or co-hosted a mega or regional sporting or non-sporting event since 2000 are focused on[4]. In addition, Zhuhai, which is a Special Economic Zone (SEZ) of China adjacent to Macau is also covered even though it has not hosted any event. In the analyses, if significant improvement on technical efficiency is attained in the event decade, then the organization of an event may have contributed to efficiency improvement. It may become economically sound to invest to host a mega event. In addition, the linkages between technical efficiency and a number of economic factors are examined for the sake of the major driving forces of efficiency. Finally, the tendency of convergence in technical efficiency is also reviewed.

The remaining part of the paper is organized as follows. Section 2 reviews the economic conditions of the sampling cities and the investment they have made to host an event. Section 3 summarizes the available literatures in technical efficiency measurement. Section 4 describes the methodology and data employed in this study. Section 5 reports and discusses the results of the empirical estimations. The last section is the conclusion and implications.

2. The Economic Situation of the Event Hosting Chinese Cities

In the 2000s, a couple of mega events have been hosted by Beijing, Tianjin, Shanghai, Guangzhou, Shenzhen, Hong Kong and Macau. In the preparation process, huge amount of investment has been made which can be seen as strong fiscal stimulus to the hosting cities. To further illustrate, the ratios of event investment to GDP and Gross Fixed Capital Formation (GFCF) are measured and exhibited in Table 1. As the Beijing 2008 Olympic Games carries the largest scale, the ratios associated with this event are also the largest. For the other events, the cumulated investment has amounted to around 2 per cent of the GDP or less than 10 per cent of the GFCF in the event year. As the impacts of the event tends to arise not only at the event hosting year but also in the preparation and post-event phases[5], a long sampling period from 1990 to 2010 is formulated in order to capture all the influences. Two sub-periods, namely pre-event decade of 1990-2000 and event decade of 2001-2010 are also constructed for discussion and comparison purposes and given this settings, a series of events related figures are shown in Table 2.

As shown in Table 2, although more rapid economic growth is widely expected as the consequence of hosting an event, in the event decade only Beijing, Tianjin and Macau can manage to attain a RGDP growth rate slightly higher than that of the pre-event decade, with Tianjin as the one with the most promising growth progress. For Shanghai, Guangzhou, Shenzhen and Hong

Table 1 Event Investment Made by the Hosting Chinese Cities

	Total investment in event hosting USD billions	Event investment to GDP of the event year %	Event investment to GFCF of the event year %
Beijing	14 (40)	8.75 (25)	25.92 (74.05)
Tianjin	4.8	4.97	8.90
Shanghai	4.2	1.66	4.46
Guangzhou	2.4	1.51	4.87
Shenzhen	3.1	2.02	9.43
Hong Kong	0.37	1.79	8.98
Macau	0.6	5.29	20.58

Sources: Various online sources as quoted in the introduction part.

Table 2 Economic Profiles of the Event Hosting Chinese Cities

City	Period	Average RGDP growth %	Average GFCF to GDP ratio %	Average employment growth %	Tourists' arrival growth %
Beijing	1990-2000	10.39	48.54	0.48	11.54
	2001-2010	11.38	42.36	8.04	8.88
Tianjin	1990-2000	10.99	43.06	-1.20	19.18
	2001-2010	14.99	51.68	2.62	16.89
Shanghai	1990-2000	11.41	44.04	-1.26	7.71
	2001-2010	11.27	40.16	3.26	16.52
Guangzhou	1990-2000	16.17	41.48	3.86	9.65
	2001-2010	13.59	31.39	4.63	7.59
Shenzhen	1990-2000	24.27	39.32	16.21	16.56
	2001-2010	14.81	36.84	4.07	10.20
Zhuhai*	1990-2000	22.11	41.26	7.25	11.10
	2001-2010	13.11	21.45	3.04	13.97
Hong Kong	1990-2000	4.54	28.30	1.88	7.74
	2001-2010	-1.15	21.45	0.74	11.35
Macau	1990-2000	3.23	22.85	2.74	4.72
	2001-2010	12.08	20.74	4.60	11.13

Note: * Zhuhai has not hosted any mega events in 1990-2010.
Sources: *China Statistical Yearbook*, *Guangdong Statistical Yearbook*, *Yearbook of Statistics of Macau* and *Hong Kong Annual Digest of Statistics*, various issues.

Kong, their growth performance in the event decade have failed to prevail that of the pre-event decade. In light of the GFCF to GDP ratio, despite the fact that huge amount of money has been invested to prepare for the event, the average value of this ratio in the event decade is still less than that of the pre-event decade for most of the sampling cities, with Tianjin as the exception. In view of the number of employment, attributed to population growth and urbanization, an increase in the total number of employment is observed in the event decade by all, with diversified pace of growth. For the number of overseas' tourists hosted, expansion is found but the pace of growth recorded by some of the cities has fallen short of that of the pre-event decade. The double digit growth of incoming tourists faced by Hong Kong and Macau, meanwhile, is driven to a large extent by the "Individual Visit Scheme" (for the residents of selected cities in the Mainland to visit Hong Kong and Macau on an individual basis which was not allowed before) introduced by the Central Government of China in 2004.

In fact, none of the event hosting cities (except Macau)[6] has achieved outstanding improvement in economic performance in the event decade. As indicated in Table 2, Zhuhai, which has not hosted any mega event in the period of 2001-2010, has experienced a growth progress indifferent to that of Shenzhen and the other event hosting cities. So far the descriptive statistics shown in Table 1 and Table 2 have failed to deliver clear evidences of any kind to support the presence of stronger growth pace or significantly improved economic performance after hosting an event. More sophisticated analyses, such as the stochastic frontier analysis based technical efficiency estimation, are required to assess the extent of efficiency these cities have achieved in the sampling period for further assessment.

3. Literature Review

Improvement in technical efficiency, which is regarded as an important driving force to economic growth, is achieved if more outputs can be generated given the same set of input factors, or less input factors are required to achieve the same output target. There are two popular methods to estimate technical efficiency, namely the non-parametric data envelopment analysis (DEA), and the parametric stochastic frontier analysis (SFA). The DEA method is introduced in Charnes, Cooper and Rhodes (1978) and Banker, Charnes and Cooper (1984). The main advantage of DEA is that it does not require the specification of a production function but uses the frontier concept directly to measure the technical efficiency. However, the DEA cannot separate the stochastic errors from inefficiency and the estimated technical efficiency can be affected to a large extent by statistical errors. The SFA approach is firstly discussed in Aigner, Lovell and Schmidt (1977) and Meeusen and van den Broeck (1977). It requires the specification of a production function in which the best practice or technological frontier is defined. Then a comparison between the frontier and the actual output is conducted, and technical inefficiency presents if the actual output falls behind the frontier. If an improvement on production frontier is found, it is to say technological progress has been achieved. Adjustments in technical efficiency together with technological progress determine the growth in total factor productivity (TFP) which is an important driving force to economic growth apart from increases in inputs. In practice, assumptions on the distribution of the efficiency term must be given for the decomposition of the error term. It is also found that the estimation results of SFA are sensitive to the specification of the production function and the distribution pattern of the efficiency term.

The Battese and Coelli (1995) model[7] (BC model) is a popular model under the SFA approach. It is formulated to deal with unbalanced panel data, with the assumption that the sampling units have time-variant performance. The error term of the production function estimation is expressed as the difference between an independent and identically distributed random error and an independent and identically distributed non-negative truncations. The truncations is said to be explained by a vector of explanatory variables associated with technical inefficiency. Incorporating the BC model, a computer program FRONTIER 4.1 is designed by Coelli[8] to provide maximum likelihood estimates of technical efficiency.

Kim and Han (2001), Coelli, Rahman and Thirtle (2003), Ao and Fulginiti (2003), Movshuk (2004), Koh, Rahman and Tan (2004) and Revilla-Molina, Bastiaans, van Keulen, Mew, Zhu and Villano (2008) are studies which have applied the BC model to estimate the technical efficiency on the industry or firm's level (including the technical efficiency of manufacturing sector, agricultural sector, iron and steel industry, etc.) across a series of countries (including Korea, Bangladesh, China, Singapore, etc.). When these studies have diversified scope of discussion, coverage and spatial focus, direct comparison on their research findings becomes impossible. Notwithstanding the diversified interest, the Translog production function is found to be the appropriate specification over the alternative Cobb-Douglas specification and has been adopted in these studies. In the mean time, the FRONTIER 4.1 computer program and maximum likelihood estimation are the tools utilized in these studies. In the technical inefficiency analyses of these studies, a series of inefficiency related factors (including investment to GDP ratio, the length of highway or railway system, the size of fiscal expenditure, etc.) have been considered, with an intention to explain the estimated technical inefficiency as well as testing their hypotheses. In the inefficiency estimations that concern about the industries or firms in China, the ratio of the sum of imports and exports to GDP (openness ratio) is commonly used as the explanatory variable, and is found to have a direct linkage with technical efficiency (Ao and Fulginiti, 2003). Although the Translog production function is widely employed in the literature, this specification is applied with uncertainty. In Movshuk (2004), a comparison is made between Translog and Cobb-Douglas production function on their goodness of fit. The problem of multicollinearity is found to be serious under the Translog specification. It can lead to over-rejection (on the explanatory variables) and a large estimated coefficient (Movshuk, 2004). Therefore, cautions have to be paid in the application of the BC model with the Translog specification.

When the majority of the BC model's applications are made on the industry or firm's level, there are still a number of papers focusing on the nation as a whole. Pires and Garcia (2004) is a comparative study to apply the BC model to estimate and rank the technical efficiency level for a sample of 75 countries. In light of the studies on China, Wu (1995; 2000) and Yu (2008) are the available literatures which have advocated the BC model to estimate parametrically the efficiency level of Chinese provinces. Wu (1995; 2000) have employed the BC model and a "two-step" approach, comprising of two separated regressions in production function estimation and error term decomposition, to measure the technical efficiency. This "two-step" approach, however, is criticized by researchers for the accumulated estimation errors that it may contain. As the SFA approach has certain advantages over the DEA approach (Yu, 2008: 2), it is thus employed to measure and examine the technical efficiency of 28 provinces in China. To identify the sources of inefficiency, human capital, openness to international trade, household registration system (*hukou system*), size of the government are inferred as the related factors and are found to have crucial linkage with efficiency.

Notwithstanding its popularity, the BC model is suffered from some drawbacks when it is implemented to conduct panel data analyses. As indicated in Greene (2005), heterogeneity on the firm or provincial level has not been carefully tackled by the BC model and very often, the estimated result is the sum of inefficiency and individual heterogeneity. Then "true fixed-effect" model is developed to segregate the cross sector or province heterogeneity from the estimated inefficiency. Nevertheless, the implementation of this fixed-effect model under panel data analysis can lead to "incidental parameter" problem, given an increasing number of fixed-effect parameters or dummies which contain no attractive meanings from economists' point of view. The incidental parameter problem refers to biased or inconsistent statistical results which may distort the role of some explanatory variables. In Wang and Ho (2010), two transformation methods, namely the first-difference and the within-transformation methods have been introduced to overcome the incidental parameter problem. With the support of the Monte Carlo studies, it is proved that the transformation can successfully remove the individual heterogeneity from inefficiency and the estimated index is a pure time-varying inefficiency index. In addition, without the insertion of dummy variables, the incidental parameter problem is no longer an issue in the estimation.

4. Methodology and Data

4.1. Methodology

The SFA approach and the associated BC model is suffered from the disadvantage of a mis-specified common functional form for the production frontier. Taking into account the *ex-post* pattern of our sample (in which almost all the sampling cities have already hosted an event) and their similar administrative position in the country (in which all the sampling cities are municipalities, SEZs or SARs of China instead of a mixture of provinces and cities), the risk for making specification mistake is lessened. Hence, the BC model is firstly employed in this study to estimate and examine the technical efficiency level of the event hosting cities of China. In practice, the BC model carries the following specification:

$$Y_{it} = f(X_{it};\beta)\exp(V_{it} - U_{it}) \tag{1}$$

where Y_{it} is the real GDP of city i at time t in logarithm; X_{it} is a vector of factor inputs and β is a vector of unknown parameters. The V_{it} are assumed to be independent and identically distributed random errors $N(0,\sigma_V^2)$, U_{it} are assumed to be non-negative random variables which are independent and identically distributed and are truncated at zero with $N(\mu_{it},{\sigma_U}^2)$ distribution.

$$\mu_{it} = z_{it}\delta \text{ and } U_{it} = z_{it}\delta + W_{it} \tag{2}$$

where z_{it} is a vector of variables which can affect the efficiency of a city and δ is a vector of parameters to be estimated, W_{it} is defined by the truncation of the normal distribution with zero mean and variance ${\sigma_U}^2$.

The estimated TE of city i at time t is:

$$TE_{it} = \exp(-U_{it}) = \frac{Y_{it}}{Y_{it}^*} = \frac{F(X_{it};\beta)\exp(V_{it} - U_{it})}{F(X_{it};\beta)\exp(V_{it})} = \exp(-z_{it}\delta - W_{it})^9 \tag{3}$$

In the empirical estimations, a Translog production function is proposed which is consistent with the available studies. In addition, a dummy variable-*SAR* is inserted into the model to capture the special pattern that Hong Kong and Macau may equip with in their growth discipline. Similar to Movshuk (2004), the Cobb-Douglas production function, which can be seen as a restricted Translog production function, is considered in the estimation for comparison purpose.

$$\begin{aligned} \log(RGDP_{it}) &= \beta_1 + \beta_2\log(K_{it}) + \beta_3\log(L_{it}) + \beta_4\log(K_{it})^2 + \\ &\beta_5\log(L_{it})^2 + \beta_6\log(K_{it})\log(L_{it}) + \beta_7 t + \beta_8\text{Log}(K_{it})t + \\ &\beta_9\text{Log}(L_{it})t + \beta_{10}t^2 + \beta_{11}SAR_{it} + (V_{it} - U_{it}) \end{aligned} \tag{4}$$

where *RGDP* is real gross domestic product, *K* and *L* are the capital stock and labour stock, *t* is time trend and *SAR* is the dummy variable for Hong Kong and Macau. Due to data limitation, human capital which is regarded as another key input to production is not studied separately.

When the conventional BC model cannot distinguish individual heterogeneity from inefficiency, alternative models developed in Greene (2005) (G model) and Wang and Ho (2010) (WH model) are also employed with an intention to segregate the observed individual heterogeneity from inefficiency. With individual heterogeneity, Equation (1) can be rewritten as:

$$Y_{it} = \alpha_i + X_{it}\beta + V_{it} - U_{it} \tag{5}$$

where α_i is the fixed effect to reflect city *i*'s unobservable heterogeneity. In Greene (2005), maximum likelihood estimations have been undertaken based on Equation (5). The insertion of the fixed effect dummies, however, has brought about the incidental parameter bias to the estimation results. Subject to the drawbacks of such, Wang and Ho (2010) has introduced the first-difference and within-transformation methods and in the later transformation, the sample mean is deducted from each observed in the panel and as described by the authors, it can remove the time-invariant individual effect from the model. Equation (5) is then transformed into:

$$y_{it} = x_{it}\beta + V_{it} - U_{it} \tag{6}$$

where the small letters refer to transformed variables in which the sample mean has been subtracted from each individual observation[10].

In the technical inefficiency estimation, it is specified as:

$$U_{it} = \delta_1 + \delta_2 \log\frac{I_{it}}{Y_{it}} + \delta_3 \log OPEN_{it} + \delta_4 \log TOURIST_{it} + \delta_5 \log SERVICE_{it} + \delta_6 SAR_{it} + \delta_7 \log Y_{it} \tag{7}$$

where *I/Y* is the ratio of GFCF to GDP, *OPEN* is the sum of exports and imports to GDP, *TOURIST* is the ratio of total tourists arrivals[11] to population size, *SERVICE* is the ratio of service sector's output to GDP, *SAR* remains to be the dummy for the Special Administrative Regions and *Y* is the RGDP of the sampling cities at base year price. With this specification, it is able to address the influences of investment, trade openness, development in tourism industry, economic transition and economic capacity to technical efficiency.

4.2. Data

This study covers seven event hosting cities in China including Beijing, Tianjin, Shanghai, Guangzhou, Shenzhen, Hong Kong and Macau. All of them have invested to prepare to organize mega international or regional sporting or other events in the period of 2001-2010. Zhuhai, which has not hosted any events but locates in the neighbourhood is also addressed for comparison purpose. The sampling period initiates from 1990 until 2010. The statistics for cities in the Mainland are extracted from National Statistical Bureau's various issues of *Statistical Yearbook of China*, *Statistical Yearbook of Guangzhou*, *Statistical Yearbook of Shenzhen*, *Statistical Yearbook of Zhuhai* and *China Compendium of Statistics 1949-2008*. The statistics for Hong Kong and Macau are collected from various issues of *Hong Kong Annual Digest of Statistics* and *Yearbook of Statistics of Macau*. Year 2000 is used as the base year and all the nominal figures have been converted to base year price.

To measure the capital stock, the procedure suggested in Kohli (1978) is chosen which assumes the capital-to-output ratio is at the steady-state at which growth in capital equals the growth in output. The initial real output is assumed to be the average real output of the first five year of the official statistics, that is the average of 1952-56 for Beijing, Tianjin, Shanghai and Guangdong[12], 1961-65 for Hong Kong and 1982-86 for Macau. The average investment to output ratio and output growth in this period are used to approximate the steady states of these cities. The rate of depreciation is assumed to be 5 per cent per annum and the capital stock is composed as:

$$K_{it} = K_{i,t-1}(1-\theta) + \Delta K_{it} \quad (8)$$

where θ is depreciation, ΔK_{it} is the GFCF made by these cities at time t and the initial capital stock is estimated based on:

$$\frac{K}{Y}\left(\frac{\Delta Y}{Y} + \theta\right) = \frac{I}{Y} \quad \text{(Ha and Leung, 2001: 15)} \quad (9)$$

where K is initial capital stock, Y is output and I/Y is the ratio of GFCF to GDP.

After obtaining the initial capital stock, the accumulated domestic capital stock is composed based on Equation (8) and the GFCF. The initial capital stock of Guangzhou, Shenzhen and Zhuhai are measured based on their GDP shares in the Guangdong province and the capital stock of Guangdong in 1978.

5. Estimation Results and Discussion

5.1. Estimation Results

Before making the efficiency measurements, the likelihood ratio (LR) tests are conducted to examine the specification of Equation (4) and (7) and the results are summarized in Table 3.

The rejection of the first null implies that Translog production function is an adequate specification which is consistent with the previously mentioned

Table 3 LR Tests for the Parameters in the Translog Production Function

Null hypothesis	Test statistics	$\chi^2 0.95$	Conclusion
$\beta_1 = \beta_2 = \ldots = \beta_{11} = 0$	370766.70	19.05	Reject null
$\beta_4 = \beta_5 = \beta_6 = 0$, $\beta_7 = \beta_8 = \beta_9 = 0$	122.01	11.91	Reject null
$\beta_7 = \beta_8 = \beta_9 = \beta_{10} = 0$	130.18	8.76	Reject null
$\beta_{11} = 0$	12.75	2.71	Reject null
$\delta_1 = \delta_2 = \ldots = \delta_7 = 0$	25327.57	13.40	Reject null
$\delta_4 = 0$	12.33	2.71	Reject null
$\delta_6 = 0$	33.57	2.71	Reject null
$\delta_7 = 0$	5.30	2.71	Reject null

Note: $\chi^2 0.95$ is obtained from Kodde and Palm (1986).
Source: Author's calculation.

studies. The second null hypothesizes a significant Cobb-Douglas against a Translog specification and similar to Movshuk (2004), it is rejected. The third null which suggests no technological progress or a zero time trend is also rejected, indicating that technological advancement is achieved by the sampling cities. The forth null which proposes no difference between the SARs and the other Chinese cities is rejected. It exhibits that there is significant difference on the growth pattern between Hong Kong, Macau and the other Chinese cities, revealing that our dummy variable augmented Translog specification is adequate. The fifth null which assumes no technical inefficiency with all the δs to be zero is also rejected. It indicates that technical inefficiency is faced by the sampling cities. The last 3 null hypotheses test the significance of the ratio of tourist arrivals to population, the *SAR* dummy and the output level of the sampling cities. It is found that they are important factors to the technical inefficiency level.

The results of the efficiency analyses based on the BC model are summarized in Table 4. In the production function estimation, labour input is a significant determinant with positive contributions to the RGDP while capital stock, to our surprise, is an insignificant factor. It indicates the dominant role of labour input in the sampling cities, reflecting that labour-intensive may still be the most important production technique in most of the sampling cities in which manufacturing products and tourism services are their major outputs. Comparing with the Cobb-Douglas specification, the estimated coefficient

Table 4 Maximum Likelihood Estimates for the Parameters of Stochastic Frontier Production Function based on Equation (4) & (7).

Variable	Parameter	Translog		Cobb-Douglas	
		Estimated value	t-statistics	Estimated value	t-statistics
		Production function			
Constant	β_1	0.07	0.14	2.11	305.94*
$LogK_{it}$	β_2	0.36	1.47	-0.003	-1.49
$LogL_{it}$	β_3	0.74	5.17*	-0.003	-1.81***
$Log(K_{it})^2$	β_4	-0.005	-0.053		
$Log(L_{it})^2$	β_5	-0.09	-0.73		
$LogK_{it}LogL_{it}$	β_6	0.06	0.37		
t	β_7	0.02	0.73	-0.00003	-0.44
$LogK_{it}t$	β_8	-0.01	-1.44		
$LogL_{it}t$	β_9	0.02	5.09*		
t^2	β_{10}	0.0006	1.71***		
SAR_{it}	β_{11}	0.63	5.25*	0.16	8.43*
		Technical inefficiency estimation			
Constant	δ_1	-0.39	-0.63	2.12	206.64*
$Log\frac{I_{it}}{Y_{it}}$	δ_2	-0.25	-2.57**	0.003	1.49
$LogOPEN_{it}$	δ_3	0.06	0.97	-0.002	-1.95**
$LogTOURIST_{it}$	δ_4	-0.19	-7.07*	0.003	3.23*
$LogSERVICE_{it}$	δ_5	0.66	4.66*	-0.007	-2.03**
SAR_{it}	δ_6	0.02	0.34	0.16	8.55*
$LogY_{it}$	δ_6	-0.03	-3.18*	-1.00	-448.28*
	σ^2	0.004	4.87*	0.000003	30.53*
	γ	0.99	1677.15*	0.0004	59.31*
Mean efficiency		0.910		0.997	

Note: *: At 1% level significance; **: At 5% level significance; ***: At 10% level significance.

Source: Author's calculation based on Equation (4) and Coelli (1996)'s FRONTIER 4.1 program.

for labour input observed from the Translog specification is relatively large. As indicated in Movshuk (2004)[13], it is caused by multicollinearity, which has also led to poor explanatory power for the squared and interaction terms. The strongly significant and positive SAR dummy reflects the higher level of RGDP enjoyed by Hong Kong and Macau, exhibiting that the SARs may have a growth discipline different from the cities on the Mainland side. In the Translog specification, γ is strongly significant with a value of 0.99. It indicates that over 90 per cent of the variance can be explained by the inefficiency effects, demonstrating the importance of technical inefficiency in the production process. In contrast, the Cobb Douglas specification carries poor significance with small estimated coefficients and is inferior to the Translog specification.

The technical inefficiency estimations are shown in the second half of Table 4. The investment to GDP ratio and the tourist arrivals to population ratio are found to be positively related to technical efficiency (or negatively related to the technical inefficiency). Capital investment injects additional resources to the production process which has made reallocation of inputs and technology for more outputs possible, leading to higher level of efficiency. Tourist arrivals, meanwhile, tends to bring about new and urgent demand to the hosting cities which requires the involved entities to timely fulfill the incoming demand and hence efficiency could be upgraded. When the investment ratio carries a larger estimated coefficient, it reveals that investment is more important than tourist arrivals in efficiency determination. In the mean time, cities with a big service sector and a high service sector share in their GDP have lower rather than higher efficiency level. It implies the presence of a large service sector alone cannot guarantee high efficiency, especially for the sampling cities in China with manufacturing outputs rather than service outputs as their comparative advantage. Prestige building economic restructuring to service oriented production may worsen rather than improve efficiency. In light of the role of trade transactions, when some export activities are subsidized under the current tariff rebates policies of China, importations of certain inputs or end products are compulsory to the resources lacking cities, the making of trade activities may have no direct linkage with efficiency. Then the openness ratio is an insignificant determinant in the inefficiency estimation. The significant RGDP factor refers to the presence of economies of scale, implying that larger cities with bigger RGDP tend to be more efficient due to their relatively abundant supply and better allocation of resources. Lastly, the insignificant *SAR* dummy reveals that Hong Kong and Macau as a whole is neither more efficient nor less efficient than the Mainland counterparts.

In respect of the drawbacks faced by the conventional BC model, the G model in fixed effect/dummy variable estimation and the WH model in within-transformation have also been utilized with their specification stated in Equation (5) and (6). The results of production function estimations in Translog specification are not shown for space saving while the results of the efficiency estimations are exhibited in Table 5.

As a whole, the estimated coefficients of the technical efficiency determinants and the mean efficiency composed by the G model are larger than those measured by the WH model. It matches with the findings in Wang and Ho (2010) that the dummy-variable model tends to overestimate the magnitude of the inefficiency determinants and the technical efficiency index.[14] Among the three models employed in our analyses, the mean technical efficiency estimated by the G model is the largest, followed by that measured by the BC model. At the level of over 90 per cent, the technical efficiency composed by these two models may have been over-stated. The mean efficiency derived from the WH model is the lowest given that the time-invariant individual effect is fully segregated from the efficiency index.

In light of the role of various inefficiency determinants, the estimation results summarized in Table 5 are not distinguished from those derived from the BC model, except that some variations on the level of significance are found due to the segregation of time-invariant heterogeneity. The investment to GDP ratio remains to be a significant contributor to technical efficiency

Table 5 Maximum Likelihood Estimates for Technical Efficiency based on the G Model and the WH Model and the Efficiency Specification in Equation (7)

	G Model (Greene (2005))		WH Model (Wang and Ho (2010))
$Log\frac{I_{it}}{Y_{it}}$	-4.73 (-2.68)*	-2.81 (-4.44)*	-1.04 (-2.69)*
$LogOPEN_{it}$	-1.03 (-0.86)	-0.48 (-1.37)	0.17 (0.82)
$LogTOURIST_{it}$	-2.52 (-4.22)*	-0.63 (-3.95)*	0.05 (0.38)
$LogSERVICE_{it}$	11.80 (3.99)*	4.09 (4.62)*	4.48 (2.49)**
$LogY_{it}$	0.19 (1.17)	0.14 (0.92)	0.02 (0.97)
SAR_{it}	2.11 (3.05)*		
Mean efficiency	0.952	0.943	0.849

Note: t-statistics in parentheses; *: At 1% level significance; **: At 5% level significance.

Source: Author's calculation based on the STATA codes developed in Wang and Ho (2010).

as investment helps to strengthen the process of resources' reallocation-led efficiency improvement. The service sector's output to GDP ratio, meanwhile, has posted a negative impact on efficiency as before. As explained, policies' driven economic restructuring could increase the share of service sector in total output. Nevertheless, it may bring about inefficiency if the new structure has violated the comparative advantage of a city. Depicted in Table 4, the RGDP is a significant and positive contributor to technical efficiency in the BC model. When the G model or the WH model is employed, the unobserved individual effect inherited in GDP is either controlled by the city specific dummy variable or has been removed by the within-transformation process. Then RGDP has become an insignificant factor in Table 5. The *SAR* dummy, which is inserted to capture the individual discipline of the Special Administrative Regions, is found to be significant in the G model which is partially attributed to the incidental parameter bias faced by this model. On the contrary, it is an obstacle to the convergence process of the maximum likelihood estimation in the WH model and has to be dropped. This finding reflects that all the unobserved and time-invariant individual effect, such as the time-invariant special feature faced by the SARs, could have been properly removed by the within-transformation process. Similar to the BC model, the tourist arrivals to population ratio is a significant efficiency contributor in the two G models. It can probably be explained by: 1) the unobserved time-invariant individual effect (such as the attractiveness to tourists of a city which is determined by its time-invariant endowments in tourism resources) which is not fully segregated from the estimated technical inefficiency in the BC and G models; and 2) the estimation bias faced by the G model. Consequently, direct linkage is observed between technical efficiency and tourist arrivals ratios but such linkage cannot be found in the more refined WH model. Furthermore, the seemingly contradicting role between tourist arrivals to population and service sector output to RGDP on technical efficiency shown in the BC and G models can no longer be observed in the prevailing WH model.

In light of the estimated technical efficiency, as exhibited in Table 6, the performance of the sampling cities is not bad and most of them have achieved efficiency level of over 80 per cent or even above 90 per cent. Shenzhen has the highest level of average technical efficiency in the sampling period at 0.977, followed by Tianjin at 0.970. This is different from the results in Yu (2008) and Zhou, Li and Li (2010)[15] derived from the conventional BC model in which the time-invariant individual effect is combined with efficiency. Zhuhai, which has not invested to host any mega events in the sampling period has also achieved a high level of average efficiency with the third rank. Despite the hosting of a mega international event – the Olympic Games, the technical efficiency of Beijing cannot out-perform the other cities in the sample with the lowest rank on the Mainland side and this finding is

Table 6 Estimated Technical Efficiency of Chinese Cities by the WH Model

	Beijing	Tianjin	Shang-hai	Guang-zhou	Shen-zhen	Zhuhai	Hong-Kong	Macau
Average value	0.823	0.970	0.880	0.918	0.977	0.935	0.393	0.901
1990-2000	0.868	0.972	0.908	0.935	0.979	0.937	0.452	0.909
2001-2010	0.772	0.967	0.848	0.900	0.974	0.932	0.327	0.892

Note: The full details of the estimated technical efficiency are shown in the Appendix.
Source: Author's calculation based on the STATA codes developed in Wang and Ho (2010).

consistent with the available literatures[16]. For the SARs, the average technical efficiency of Macau is higher than that of Hong Kong, but is lower than most of the Chinese cities except Beijing and Shanghai. The surprisingly low efficiency level of Hong Kong, meanwhile, is closely related to its slow pace of RGDP growth. The RGDP of the territory, for example, has been expanding at an average annual rate of just 1.83 per cent which is significantly slower than the sample average growth rate of 12.11 per cent. Simultaneously, the capital stock of the Hong Kong has been accumulating at the speed of 4.87 per cent per annum which is close to 1/3 the sample average growth rate of 12.83 per cent. The disproportionate output growth derived from capital accumulation has consequently brought about a poor estimated efficiency index for Hong Kong. Lastly, when the efficiency indices in the two sub-periods are compared, it is observed that the performance in the event decade is inferior to that of the pre-event decade for most of the sampling cities which will be further elaborated in the discussion section.

5.2. Discussion

In the light of our central question of whether hosting a mega event can boost technical efficiency, given that none of the event hosting cities can upgrade their technical efficiency in the event decade, there is no evidence to support the hypothesis of event-led efficiency improvement. Although hosting a mega event seems to involve huge amount of capital investment, perhaps part of these infrastructure investments should be carried out by the local authorities sooner or later. Instead of bringing about significant amount of extra fiscal injections, hosting an event can at most push the infrastructure projects ahead of their original schedules. Moreover, hosting a mega event may have brought about the problem of investment diversion[17] in which non-event related projects are sacrificed to redirect resources to event related investments. As a whole, the net increase in investment may be very limited and may have hindered the growth pace of efficiency in the event decade. As for the deterioration in technical efficiency in the event decade, empirical evidence suggests that the GFCF to GDP ratio in the event decade has fallen short of the level in the pre-event decade, with Tianjin as the only exception. Such sluggish growth in investment has restricted the growth pace of technical efficiency in the event decade, leading to the result of no improvement or even deterioration in efficiency. Furthermore, the hosting cities may have difficulties in taking full advantages of the event to develop their tourism industries. Thus the progress in tourists' attraction in the event decade is depressive and may have become another cause to the decline in efficiency.

The estimation results reveal that service sector output to GDP ratio is a source of inefficiency. It reflects that the secondary sector may still be the comparative advantage for the cities on the Mainland side. Policies' driven economic restructuring in the event preparation period toward the service sector may have violated the efficiency principle, bringing about worsened rather than improved efficiency level, contributing to the rejection of the event-led efficiency improvement hypothesis. As for the openness ratio, its insignificant role can be explained by the inelastic demand for imports faced by the sampling cities due to resources shortage, incoming FDI related economic activities or the tariff rebates exporting activities. In addition, when most of the event hosting cities has a high and stable openness ratio since the beginning of the sampling period, a high openness ratio cannot explain variations in technical efficiency and hence becomes statistically insignificant.

As a whole, the estimation results find the efficiency level of the event hosting cities to diverge by the end of the sampling period. The standard deviation of the efficiency indices across cities has increased from 0.156 in 1990 to 0.186 in 2000 and 0.22 in 2010. Amongst, Tianjin, Guangzhou, Shenzhen and Macau have attained a score of over 0.9. The high level of initial efficiency can be viewed as the pre-requisite to the success in applying and hosting a mega event. As a city in the neighbourhood, Zhuhai has an efficiency level similar to that of Shenzhen and Macau. It implies that hosting an event is not the only means to achieve higher technical efficiency. In light of the deterioration in efficiency suffered by Beijing and Hong Kong in the event decade, Beijing has made substantial investments to accelerate its economic transition to improve the environmental quality to prepare for the Olympic Games[18]. In the process, lots of industrial plants were forced to close or reallocate, leading to an increase in service sector's GDP share "artificially" by more than 10 percentage points from 64.83 per cent in 2000 to 75.11 per cent in 2010. This variation is also the largest among all the sampling cities. Such non-profit oriented and politically driven transition can partially explain the deterioration in technical efficiency faced by Beijing. As for Hong Kong, it is the only *laisser faire* financial centre in China in which capital mobility is fully liberalized. In addition, the territory is fully specialized in the provision of services (such as financial services, stock trading and real estates' transactions) with the highest service sector's GDP share in the sample at 92.9 per cent. Consequently, Hong Kong has been adversely affected more seriously by the Asian financial crisis and the slide in property price for the period of 1998-2003 as well as the global financial crisis in 2008 than any other cities in the sample. Serious deterioration in technical efficiency is then resulted in the event decade.

6. Conclusion and Implications

This study is organized to examine the contributions of mega events to the economies of the hosting cities. In practice, the efficiency performance of municipalities, cities and the SARs of China which have invested to organize mega events, comprising of the Olympic Games, Expo, Asian Games and East Asian Games has been assessed. Adopting the Battese and Coelli (1995) model, Greene (2005) model and Wang and Ho (2010) model, the technical efficiency, which is the deviation of actual output from frontier output has been estimated for Beijing, Tianjin, Shanghai, Guangzhou, Shenzhen, Zhuhai, Hong Kong and Macau with and without segregating the time-invariant individual effect from efficiency. Shenzhen and Beijing are found to be the best and the worst performing cities on the Mainland side whereas Hong Kong is the territory with the lowest efficiency in the sample. When only three of the event hosting cities, namely Shanghai, Shenzhen and Macau, can achieve slight improvement in technical efficiency, there is insufficient evidence to support the hypothesis that hosting a mega event contributes to strengthen technical efficiency. In fact, certain event hosting cities may at most reallocate and reschedule their public investments and the net growth in capital injections may be limited. These cities may not be able to take full advantages of the mega event and have failed to achieve a substantial growth in incoming tourists. At the same time, certain projects commenced in the event preparation phase may be policies' driven and could be regarded as inefficient. Because of such, the sampling Chinese cities are not able to achieve significant efficiency improvement after hosting a mega event. Nevertheless, it is believed that the event hosting cities may have already attained a benchmark level of efficiency at the time of application to become qualified organizers.

As a whole, hosting a mega event can only bring about short-lived welfares to economic growth and is not able to deliver significant efficiency improvement to the local economy. In the preparation phase, if investment is made to improve or renovate the "outlook" of the city for prestige and city branding, then its long term economic contributions is in doubt. Besides, infrastructures and venues designed to accommodate visitors of mega events will normally contain a huge capacity and probably limited function. After the event, it may be hard for the local population to fully utilize these facilities which may eventually become “white elephant’ projects, bringing about inefficiency and maintenance problems to the hosting city. In fact, the media has reported that most of the new stadiums built for the Beijing 2008 Olympic Games have faced a loss in their operations with steadily declining visitors (Business Insiders, 2012). Part of the venues constructed for unpopular sport activities have even been suspended (BBC, 2012). For this reason, the local authorities should not view hosting a mega international event as a short cut to better efficiency or a means to upgrade permanently the performance of the economy. Over-optimistic on the expected economic contributions or misjudgments in the costs and benefits analyses could bring about disappointment and likely budgetary pressure and even fiscal deficit to the local economy or the country.

Appendix

Estimated Technical Efficiency of Chinese Cities by the WH Model

Year	Beijing	Tianjin	Shang-hai	Guang-zhou	Shen-zhen	Zhuhai	HK	Mac
1990	0.917	0.979	0.943	0.927	0.976	0.939	0.508	0.923
1991	0.892	0.979	0.929	0.932	0.979	0.923	0.492	0.924
1992	0.896	0.978	0.926	0.942	0.982	0.946	0.472	0.928
1993	0.896	0.978	0.925	0.947	0.986	0.954	0.452	0.924
1994	0.895	0.977	0.921	0.945	0.983	0.953	0.446	0.923
1995	0.882	0.974	0.923	0.942	0.978	0.946	0.445	0.916
1996	0.859	0.971	0.914	0.939	0.976	0.930	0.445	0.900
1997	0.847	0.969	0.900	0.933	0.976	0.926	0.459	0.899
1998	0.837	0.966	0.884	0.930	0.977	0.929	0.440	0.897
1999	0.821	0.962	0.869	0.929	0.979	0.935	0.416	0.896
2000	0.805	0.962	0.857	0.916	0.977	0.927	0.402	0.873
2001	0.794	0.960	0.858	0.909	0.975	0.923	0.393	0.860
2002	0.788	0.960	0.851	0.902	0.974	0.922	0.359	0.861
2003	0.800	0.963	0.859	0.904	0.976	0.921	0.340	0.879
2004	0.791	0.966	0.857	0.907	0.976	0.924	0.329	0.884
2005	0.785	0.968	0.859	0.900	0.979	0.936	0.325	0.911
2006	0.780	0.971	0.862	0.902	0.977	0.941	0.320	0.929
2007	0.778	0.972	0.853	0.898	0.973	0.942	0.303	0.930
2008	0.752	0.978	0.847	0.896	0.970	0.939	0.299	0.921
2009	0.729	0.969	0.821	0.892	0.972	0.937	0.301	0.889
2010	0.732	0.968	0.814	0.892	0.969	0.939	0.302	0.860

Source: Author’s calculation based on the STATA codes developed in Wang and Ho (2010).

Notes

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1. This research is supported financially by the Multi Year Research Grant of University of Macau.
2. In the Tokyo case, the GDP growth of Japan has boosted to 21.4 per cent per annum in the pre-event preparation phase. In the Seoul case, the GDP growth of Korea is able to stay at double digit pace per annum throughout the period of 1982 to 1990. Please see Wang (2002) for the details.
3. Yu (2004) is a study made by the Hong Kong Legislative Council Secretariat, Research and Library Services Division.
4. Qingdao city of Shandong province has co-hosted the Beijing 2008 Olympic Games to organize a number of sailing competitions. In consideration of the scale and popularity of these competitions, the geographical location of the city (unlike Tianjin, it is not in the neighbourhood of Beijing), as well as the data limitation problem, Qingdao is excluded from our discussion.
5. The 2008 Olympic Games was awarded to Beijing in July 2001 and it is believed that the planning process should start prior to the application. Then it has taken the city up to 8 years (2001 to 2008) to prepare for this event. Even after the Olympic Games, major stadiums are still important tourists' attractions.
6. The Macau economy has experienced double digit RGDP growth in the event decade due to the liberalization of its gaming sector and the introduction of "individual travel scheme" by the Chinese government.
7. Please see Battese and Coelli (1995) for the details.
8. Coelli, T. J. (1996), "A guide to FRONTIER 4.1: A Computer Program for Stochastic Frontier Production and Cost Estimation". (Centre for Efficiency and Productivity Analysis Working Paper No. 96/07)
9. The full specification of TE_{it} can be found in Battese and Coelli (1995)
10. Please see Wang and Ho (2010), p. 289, for the detailed specification of the model.
11. Overseas' tourists only.
12. The capital stock of Guangdong is firstly estimated when the city level data of Guangzhou, Shenzhen and Zhuhai are not available for longer time span.
13. "Another common effect of multicollinearity-unstable parameter estimates-also appeared…"(Movshuk, 2004: 144)

14. Please see Wang and Ho (2010), p. 296, for the details.
15. Zhou, Li and Li (2010) adopts the DEA approach and Shanghai is found to have the highest technical efficiency in China on the provincial level (without taking Shenzhen into account). The average technical efficiency of Shanghai is found to be 0.917 in Yu (2008) and 1.000 in Zhou, Li and Li (2010). (Yu, 2008: 16; Zhou, Li and Li, 2010: 14).
16. In Yu (2008), the estimated average technical efficiency of Beijing in the period 1978-2004 is 0.443 with a maximum value of 0.621. That of Tianjin is 0.452 and 0.812 respectively. They are ranked on the 9th & 8th place in Yu (2008) and 17th & 8th place in Zhou, Li and Li (2010) respectively.
17. Similar diversion problem such as consumption diversion has been mentioned in Madden (2006).
18. Please see China.org.cn (2006). "Beijing Wipes out Polluting Factories for the Olympics". Available at <*http://www.china.org.cn/english/environment/176039.htm*>

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