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The competitiveness and development strategies of provinces in China: a data envelopment analysis approach

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Abstract This paper explores the development strategies of Chinese provinces by synthesizing the dimensions of a competitiveness index and the Data Envelopment Analysis model. After documenting the close relationship between real GDP *per capita* and competitiveness, we introduce a production approach to study competitiveness and develop various possible strategies facing a province. In particular, while coastal provinces should consider innovating new technologies and institutions to improve competitiveness, western provinces may adopt a proportional development strategy that simultaneously enhances every aspect of its competitiveness. Further, the proportional development strategy for competitiveness is found to reduce regional disparity. The policy implications from our framework could not have been achieved had the analysis been solely based on the conventional methods of studying the competitiveness index.

Keywords Competitiveness · Data envelopment analysis · Proportional and disproportional development strategies · Chinese economy · Regional inequality

JEL Classification C61 · D29 · O29 · O53

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1 Introduction

China's rapid economic growth of more than 8 % per year in recent decades has not been equally shared among provinces, with Guizhou and Tibet, in particular, lagging behind the rest in economic development and *per capita* income growth. Uneven development causes social and political instability (Lee 2007; Wang and Hu 1999). Hence, the mechanism through which provinces, especially less developed ones, can advance their economies, is imperative for China's sustainable development in the future.

This paper broaches the development strategies of provinces in China from the perspective of competitiveness. Though controversial, the concept of competitiveness explores more aspects of an economy than a narrow focus on GDP and factor inputs (Krugman 1996).[1] We postulate that the long-term growth of a province's income *per capita* depends on such factors as institutions, market structure, production inputs and technology. These factors can be summarized by a competitiveness index. Thus a more competitive province is expected to have a higher productivity. A competitiveness index has many dimensions. Treating these dimensions as outputs in a production process, we exploit the notion of productive efficiency to extract information for policy makers, which cannot be otherwise obtained from conventional studies on the competitiveness index alone.

Our framework also examines regional disparity from the perspective of competitiveness, an issue noticed by Chinese government officials since 1999 when then Party Secretary Jiang Zemin initiated a Western Development Program (WDP) to counteract the exacerbating regional

[1] A detailed summary of the theoretical discussions of competitiveness was provided by Cho and Moon (2000).

disparity. In 2004, the central government advanced the concept of a Pan-Pearl River Delta region to promote economic growth in southern and southwestern China (Sun and Fan 2008). Academic studies on regional disparity usually focus on income disparity or output and consumption inequality (Chen and Zheng 2008; Cheng 1996; Lam and Liu 2011; Tsui 1996; Yao and Liu 1998). By decomposing multiplicative inequality indices (Cheng and Li 2006), we use the production approach to obtain new insights into the inequality of competitiveness among provinces.

The paper proceeds as follows. Section 2 discusses the relation between competitiveness and GDP *per capita*. Section 3 describes the modified model borrowed from the literature of efficiency and productivity analysis. Section 4 applies the model to provincial competitiveness of China, thereby yielding policy implications presented in Sect. 5. Section 6 investigates regional disparity in competitiveness. Section 7 concludes.

2 Competitiveness and GDP per capita

We adopt the view similar to the World Economic Forum (Schwab 2013) that provincial competitiveness is the set of institutions, policies, and factors that determine the level of productivity of a province. Thus, competitive provinces are expected to be more productive and have larger potential to attract capital to sustain and enhance economic growth. This implies that a more competitive economy should have a higher *per capita* income, leading to our first question:

Question 1 *Does a higher level of competitiveness generate a higher real GDP per capita of a province?*

The annual reports on overall competitiveness of China's provinces (Li et al. 2007–2009) contain a comprehensive source of data on the provincial competitiveness of China.[2] We extract the competitiveness index data from these reports for the period 2005 to 2008. These reports have nine main dimensions of provincial competitiveness for 31 provincial level administrative units.[3] Table 9 in the Appendix contains information of all dimensions. In addition, we derive provincial real GDP *per capita* (*rgdppc*) at the 2005 constant price using the China Stock Market and Accounting Research Database (CSMAR) developed by Shenzhen GTA. The descriptive statistics of the provincial competitiveness index and its nine dimensions are provided in Table 1 below.

[2] These reports are only available in Chinese. Data and definitions are available upon request.

[3] These administrative units include 22 provinces, 4 direct-control municipalities and 5 autonomous regions.

In the above table, *rgdppc* is the provincial real GDP *per capita*, y is the competitiveness index, and y_i is the ith dimension of y, $i = 1, \ldots, 9$. The average scores of the nine dimensions remain roughly at the same level during our sample period.

Extant studies of China's development typically focus on real GDP *per capita*, by connecting it with structural break (Smyth and Inder 2004), geographic factors (Bao et al. 2002) and capital deepening, labor deepening, and productivity growth (e.g. Zhu 2012). Here we investigate how provincial competitiveness may move with GDP *per capita*. Specifically, the correlation coefficient between provincial competitiveness index (y) and GDP *per capita* is as high as 0.85, which is consistent with Cho et al. (2008) who find national competitiveness is highly correlated with GDP *per capita*.

We regress the logarithm of *rgdppc* on the logarithm of y to obtain a fixed-effect equation whose parameter estimates are statistically significant at $\alpha = 0.01$ (Table 2).

This equation uses dummy variables to control for time, regional and administrative differences. The variables *y2006*, *y2007*, *y2008* are time dummies with reference to year 2005; *noneast* is a regional dummy with reference to the eastern region[4]; *dcm* is a dummy for direct-control municipalities[5] and *ar* for autonomous regions.[6] The estimated coefficient of $ln(y)$ is highly significant and positive, yielding our first result:

Result 1 *Provincial competitiveness affects provincial real GDP per capita positively.*

Based on Result 1, competitiveness improvement is beneficial to an economy. However, exactly how the improvement can be achieved is not immediately obvious. There are three possible scenarios. First, the competitiveness of a province is already at the maximum. In other words, no further improvement on any dimension is possible without introducing new institutions and technologies. Second, the competitiveness improvement of a province can be realized by tradeoffs among dimensions. Finally, all dimensions of competitiveness can be increased simultaneously. As the policies under each scenario can greatly vary, studying the competitiveness index and its dimensions alone may not provide the necessary information useful for policy development. Our proposed remedy

[4] Eastern region (east): Beijing, Tianjin, Hebei, Jiangsu, Shanghai, Zhejiang, Shandong, Fujian, Guangdong, Hainan, Liaoning, Heilongjiang, Jilin. In this and later regression equations, the difference between effects of central and western regions are statistically insignificant. So we classify provinces into east and non-east only.

[5] Direct-control municipalities (dcm): Beijing, Tianjin, Shanghai, Chongqing.

[6] Autonomous regions (ar): Inner-Mongolia, Guangxi, Tibet, Ningxia, Xinjiang.

Table 1 Descriptive statistics of the provincial data

	rgdppc (RMB)	y	y_1	y_2	y_3	y_4	y_5	y_6	y_7	y_8	y_9
(2005)											
Mean	16,203	26.05	18.27	35.49	23.91	23.79	23.82	17.15	14.78	41.69	17.62
Std.	10,948	9.13	15.31	8.71	6.12	14.05	11.95	8.92	9.54	11.90	7.15
Max	51,474	46.80	51.40	53.90	32.40	68.20	72.10	41.90	37.80	71.50	31.20
Min	5052	13.47	0.10	20.10	8.00	11.20	12.10	7.10	11.80	23.20	4.10
(2006)											
Mean	18,400	24.81	18.46	36.97	23.60	25.82	22.44	20.29	22.00	40.06	14.73
Std.	12,149	8.60	13.75	8.77	6.15	13.19	12.28	8.41	10.01	11.15	5.98
Max	57,003	43.14	50.40	57.00	32.80	71.00	74.80	42.60	45.50	66.40	26.90
Min	5690	12.95	0.10	18.10	8.40	13.50	6.30	10.50	0.20	19.30	0.30
(2007)											
Mean	20,739	24.3	18.56	32.12	24.73	27.83	26.11	17.16	20.72	38.63	13.62
Std.	13,486	8.55	13.45	7.19	6.07	14.25	12.44	8.46	10.39	11.57	6.06
Max	63,568	43.00	48.70	47.20	33.90	74.70	68.90	39.40	44.70	66.40	25.50
Min	6389	14.09	1.10	20.50	9.90	11.80	10.60	5.80	2.00	19.80	3.40
(2008)											
Mean	22,967	25.53	21.48	36.68	24.50	25.52	27.25	13.93	22.74	42.59	13.84
Std.	14,112	8.34	12.70	8.19	5.74	12.48	12.63	7.02	11.44	11.06	6.69
Max	66,211	43.62	49.40	54.00	34.60	70.80	70.30	35.20	46.80	66.70	26.60
Min	7578	14.18	1.40	20.70	11.80	14.50	14.60	1.50	1.90	22.10	1.30

borrows the insights provided by the literature of efficiency and productivity analysis.

3 The conceptual framework

A competitiveness index is a weighted average of some selected dimensions. Suppose the overall competitiveness of an economy has M dimensions,[7] denoted by y_m for $m = 1, \ldots, M$. Each dimension measures an aspect of the economy believed to link to its competitiveness. The value of a dimension indicates the respective level achieved by an economy. When two vectors of dimensions are proportional to each other, they are said to have the same *dimension mix*; otherwise they are said to have different dimension mixes.

To improve its competitiveness, a province may strengthen all dimensions proportionally without changing the dimension mix. We refer to this kind of policy as the *proportional development strategy*. Alternatively, the province can increase some particular dimensions at the expense of others during the process of competitiveness enhancement. This kind of policy will alter the dimension mix and therefore we refer to it as the *disproportional development strategy*. In some circumstances, a province can emphasize some dimensions while all dimensions are expanded simultaneously. This strategy is called a *hybrid development strategy*. The second research question thus arises:

Question 2 *Under what conditions is a particular strategy appropriate?*

Conventional studies on competitiveness do not answer this question. We propose treating the dimensions of competitiveness as outputs in a production process, thus establishing a framework for analyzing economic development strategies in general and, as detailed below, for China in particular.

3.1 The production approach to competitiveness

Given the limited knowledge and resources of a province, there exists a maximum proportion that can be achieved by a province along each dimension mix. Once the maximum has been achieved, further improvement can only be realized by allowing tradeoffs among various dimensions. Thus each province is like a firm that produces multiple outputs. Each dimension is akin to an output, implying that modeling the competitiveness of a province is similar to the modeling of production technology of a firm. This allows us to construct a frontier of competitiveness dimensions. When a province has the potential to raise all competitiveness dimensions, we can treat it as operating under inefficient production.

Let $y = (y_1, y_2, \ldots, y_M) \in \Re^{M}_{+}$ be the vector of M dimensions of competitiveness, where y_m is the mth

[7] A dimension is called a pillar by Schwab (2013, p. 4).

Table 2 The effect of competitiveness on real GDP per capita

ln(rgdppc)	Coefficient	t-value
Intercept	5.98***	31.65
ln(y)	1.13***	20.71
y2006	0.19***	5.67
y2007	0.33***	10.05
y2008	0.38***	11.68
noneast	−0.29***	−8.53
dcm	0.40***	10.7
ar	0.30***	8.91
Adj. $R^2 = 0.94$		
N = 124		

*** Significance at 1 % level

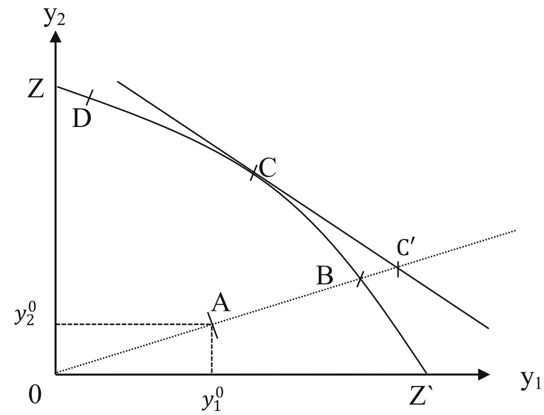

Fig. 1 Frontier of competitiveness dimensions

dimension of competitiveness. Assuming a "technology" plays a governing role behind these dimensions, a province can increase all dimensions proportionally up to this technology's limit. The set of all feasible vectors of dimensions is defined as $S = \{y$: y is a vector achievable by a province$\}$.[8] Since the dimensions are mainly ratios, the absolute size of a province is immaterial and "inputs" are not included.

For illustration, consider Fig. 1 that portrays only two competitiveness dimensions, y_1 and y_2. The curve ZZ' represents the "efficient frontier" for the generic province in terms of feasible maximum dimension mixes. Any combination of these two dimensions lying on the frontier has the highest possible level of competitiveness, given the ratio of these two dimensions. The feasible set S is the area between ZZ' and the positive portions of horizontal and vertical axes.

Consider point A inside the set S. A *proportional development strategy* could be signified by a movement from A to B along a given ray. In contrast, if point C is the target, then moving from A to C will involve a non-proportional increase in both dimensions under a *disproportional development strategy*. In addition, moving from point A to point D is also a *disproportional development strategy* that pushes the dimension y_2 at the expense of dimension y_1.

Let $y^0 = (y_1^0, y_2^0)$ be the competitiveness vector of any generic province. If the province does not lie on the frontier, the overall competitiveness can be improved through a *proportional development strategy*. Any possible proportional increase, however, is bounded by the set S. We measure the potential improvement in competitiveness through proportional development as:

$$E_p = max_\theta\{\theta : \theta y^0 \in S\}$$

The measure E_p is called the *efficiency of proportional competitiveness*. As $y^0 \in$ S and $\theta = 1$ is a possible solution, we have $E_p \geqq 1$. When $E_p = 1$, no further proportional development is possible and improvement must be achieved by an outward shift of the frontier. When $E_p > 1$, $100 \times (E_p - 1)$ is the potential percentage increase in the competitiveness index. If the province is operating at point A in Fig. 1, E_p measures the ratio of OB to OA.

3.2 Changing dimension mixes in the production approach

The dimensions' weights are analogues of output prices in production theory. Increasing competitiveness is comparable to increasing total revenue. We use w_m to denote dimension m's weight in the overall competitive index, C, so that $C = \sum_m w_m y_m$. The observed competitiveness for the province that operates at y^0 is therefore $C^0 = \sum_m w_m y_m^0$. Let $y^1 = E_p y^0$ be the dimension vector of the *maximum* expansion of y^0, and $C^1 = \sum_m w_m y_m^1$, the corresponding competitiveness. Thus $E_p = C^1/C^0$, the ratio between the competitiveness index of maximum proportional expansion on all dimensions and the observed overall competitiveness index.

Assuming the weights correctly reflect a policymaker's preferences, then the target of the policymaker is to find a feasible combination of dimensions to maximize the competitiveness index. The maximum value of C is

$$C^* = max_y\left\{\sum_{\mathrm{m}} \mathrm{w_m y_m} : y \in \mathrm{S}\right\} = \sum_m w_m y_m^* \geqq \sum_m w_m y_m^1 = C^1 \quad (1)$$

where y^* denotes the optimal solution for attaining C^*. The

[8] Other than assuming the set S is closed and bounded, no other assumptions are necessary in this section. The empirical part, convexity and strong disposability are assumed as in most conventional applied research.

potential for increasing the observed competitiveness may then be measured by:

$$O_c = \frac{C^*}{C^0} \geqq \frac{C^1}{C^0} = E_p \geqq 1. \quad (2)$$

We call $O_c \geqq 1$ the *overall efficiency of competitiveness*. While $O_c = 1$ implies that a province has already attained its highest possible level of competitiveness, compared to other provinces, $O_c > 1$ implies that $100 \times (O_c - 1)$ % of the competitiveness index can be increased via the dimension vector y^*. It can be easily deducted that:

$$O_c = \frac{C^*}{C^1} \cdot \frac{C^1}{C^0} = \frac{C^*}{C^1} \cdot E_p. \quad (3)$$

Let $E_d = \frac{C^*}{C^1}$ so that $O_c = E_d \cdot E_p$. It naturally follows that $E_d \geqq 1$.

The index E_p measures the increase in the degree of competitiveness by proportional expansion along the given dimensions, and E_d measures the gain in competitiveness by moving from y^1 to y^*. If $E_d > 1$, then the change must be achieved by a disproportional change in the given dimension mix of y^0 and *a disproportional development strategy* is necessary to attain the maximum degree of competitiveness. We call E_d the *efficiency of dimension mix competitiveness*. This model is similar to the output-oriented technical efficiency of a firm.[9] As shown in Fig. 1, $O_c = OC'/OA$ and $E_d = OC'/OB$. For all the three measures above, a larger value means a worse performance in competitiveness, mirroring more room for improvement.

The answer to Question 2 leads to our second result:

Result 2 *All provinces fall into the following four mutually exclusive and exhaustive cases*:

(a) *When $E_p > 1$ and $E_d = 1$: A proportional development strategy is appropriate.*

(b) *When $E_p = 1$ and $E_d > 1$: a disproportional development strategy is appropriate.*

(*c*) *When $E_p > 1$ and $E_d > 1$: A hybrid development strategy is appropriate.*

(*d*) *When $E_p = 1$ and $E_d = 1$: For the most competitive province, innovation is required.*

3.3 The uncontrollable nature of the dimensions of competitiveness

There is a major difference between the technology of production and the technology of competitiveness. Similar to production technology, the technology of competitiveness models the substitutability among dimensions. Unlike outputs in production, however, a desired level of each dimension is a policy target, not always under full control of the government.

In the case of a firm, once inefficiency is identified, the firm owner, in principle, can hire an appropriate manager to eliminate that inefficiency. Thus for a given input vector, the output vector can be chosen directly by the firm within the restriction of the technology.

In contrast, the dimensions of competitiveness of a province are partially controlled by the provincial government only. The feasibility set S indicates the achievable limits of competitiveness dimensions. The dimensions are policy targets, rather than what can be fully determined by any organization. To be sure, the government can influence these dimensions. Dimension 5 (competitiveness in knowledge-based economy) is a good example to illustrate this idea. In this dimension, technology factors include R&D expenditure, number of patents, added value in high-tech industry, etc. The amount of R&D expenditure can be determined by the government that can mobilize public resources in this area. The number of patents and added value in high-tech industry are not directly controllable. Nevertheless, they can be influenced. For example, ensuring sufficiently high income level and comfortable accommodations of researchers by public funding can stimulate the number of patents. Tax reliefs encourage the establishment of high-tech firms. Whether a certain level of a competitiveness dimension can be achieved depends on the efforts of the government and the economic interactions within the province.

In conclusion, the *efficiency of proportional competitiveness* (E_p) and the *efficiency of dimension mix competitiveness* (E_d) help identifying a strategy of policy directions for the government, but not policy outcome.

4 Empirical findings on provincial competitiveness

Consider K provinces, each with the dimension vector y^k, $k = 1, \ldots, K$. Following the general Data Envelopment Analysis (DEA) convention in Charnes et al. (1978) and Farrell (1957), the empirical set of feasible dimensions of competitiveness is constructed by the convex disposal hull of the observed data as in (4).

$$S = \left\{ y\colon \sum_{k=1}^{K} z_k y^k \geqq y, \quad \sum_{k=1}^{K} z_k = 1, \quad z_k \geqq 0, \quad k = 1, \ldots, K \right\} \quad (4)$$

The set S in (4) is similar to the empirical variable-returns-to-scale technology set in the DEA literature. The dimensions of competitiveness are treated as outputs of provinces. The scores of the nine dimensions are expressed as

[9] The counterparts of these O_c, E_d and E_p are revenue efficiency, allocative efficiency and technical efficiency. (Coelli et al. 2005, pp. 54–56).

ratios or have been adjusted for size so that information along the lines of the inputs in the production process is not needed. An output-oriented DEA model without input is equivalent to an output-oriented DEA model with a single constant input (Kao et al. 2008; Lovell and Pastor 1999). The corresponding "efficiency" of proportional competitiveness for province j can be found by solving the following standard linear programming problem,

$$E_p^j = max_\theta \left\{ \theta\colon \sum_{k=1}^{K} z_k y^k \geqq \theta y^j, \sum_{k=1}^{K} z_k = 1, \quad z_k \geqq 0, \quad k = 1, \ldots, K \right\} \tag{5}$$

The weights for dimensions used in our data are generated by applying the well-established Delphi method to minimize subjectivity (Li et al. 2007–2009). Under each dimension, there are different numbers of indicators, and weights are also generated form the Delphi method, but their weights are independent of weights for the nine dimensions. By doing so, the number of indicators under each dimension will not affect the integrating process at different levels. During their investigation, the *Questionnaire of Experts' Opinion on the Weighting system of Chinese Provincial Competitiveness Index* was distributed to experts from academic circles and government bodies. All experts were required to answer the questionnaire independently. The final weights for these nine dimensions are determined by incorporating all survey results. We have also presented these weights in Table 9 in the Appendix. Given these weights w_m, $m = 1, \ldots, M$, the maximum value of the objective function is given in (6) below:

$$C^{j*} = max_y \left\{ \sum_{m=1}^{M} w_m y_m\colon \sum_{k=1}^{K} z_k y^k \geqq y, \sum_{k=1}^{K} z_k = 1, z_k \geqq 0, \quad k = 1, \ldots, K \right\} \tag{6}$$

The overall efficiency of competitiveness and efficiency of dimension mix competitiveness are then

$$O_c^j = \frac{C^{j*}}{\sum_{m=1}^{M} w_m y_m^j}, \quad E_d^j = \frac{O_c^j}{E_p^j} \tag{7}$$

The linear programming problems and equations of (5), (6) and (7) are applied to the data of all provinces in each of the years between 2005 and 2008. We use the software GAMS to implement the above linear programs, thereby answering our next question:

Question 3 *What characteristics do different provinces have according to their performance in O_c, E_p and E_d ?*

We compute the overall efficiency of competitiveness for each province over the period 2005–2008. The geometric means of these efficiency scores by year are summarized in Table 3 to shed light on the general pattern, yielding the following observations. First, with the exception of 2007, the average score of overall competitiveness, O_c, declined from 1.98 to 1.79. This implies that on average a province could have raised its competitiveness index by 98 % to catch up with the best province in 2005, but the potential gain fell to less than 80 % by 2008. In other words, during these 4 years, China had improved its overall competitiveness. Second, the average score of the efficiency of dimension mix competitiveness, E_d, also shows an improvement, whereas the average score of the degree of proportional competitiveness, E_p, is basically unchanged. Thus, the fall in O_c, or improvement in overall competitiveness, is mainly attributed to E_d. Third, in each year the average value of E_d exceeds that of E_p.[10] This implies that, in China, on average, a larger portion of improvement in competitiveness can be achieved from changes in the dimension mix, via a *disproportional development strategy*.

To further explore our findings' policy implications, provinces are categorized according to their average values of E_d and E_p over the four sample years. The results are presented in Table 4. For easy exposition, the diagonal cells are shaded. In this table, moving from left to right across the row signals deterioration in dimension mix competitiveness, and moving down the column means deterioration in proportional competitiveness. Thus, the cells in the lower right corner of the table have low competitiveness, whereas the cells in the upper left corner have high competitiveness.

The four cells in the lower right corner of the table call attention to the least competitive provinces that mostly are Western provinces. In particular, Gansu, Guizhou and Tibet are the least competitive with $E_d > 1.6$ and $E_p > 1.6$. By contrast, the two cells in the upper left corner indicate the most competitive provinces, with Shanghai, in particular, being the most competitive.

We summarize the patterns in the above table as follows:

1. Most efficient provinces: $E_d = E_p = 1$

Shanghai is the only province in this group. Since the feasibility set constrains the relation between competitiveness and the dimensions, further improvement in competitiveness is possible only through the "technological" changes necessary to expand the feasible set. For further improvement in competitiveness, Shanghai can either learn from other advanced cities like New York and

[10] It can be shown that the relationship Ed > Ep holds statistically significantly at 1 % level.

Table 3 Average efficiency of competitiveness index and its decomposition

	2005	2006	2007	2008
O_c	1.98	1.85	1.86	1.79
E_d	1.59	1.46	1.51	1.43
E_p	1.24	1.27	1.23	1.24
Number of provinces with $E_p = 1$	9	7	9	7
Provinces with $O_c = 1$	Shanghai	Shanghai	Shanghai	Shanghai

Since all number used in this paper is already adjusted for province size and other heterogeneity of provinces, we do not account for economic weights for provinces

Table 4 Categorization of provinces

	Efficiency of dimension mix competitiveness (E_d)				
Efficiency of proportional competitiveness (E_p)	Scores	$E_d = 1$	$1 < E_d \leqq 1.3$	$1.3 < E_d \leqq 1.6$	$E_d > 1.6$
	$E_p = 1$	E-Shanghai	E-Beijing, E-Jiangsu, E-Zhejiang, E-Guangdong, E-Shandong.		W-Inner Mongolia
	$1 < E_p \leqq 1.3$			E-Fujian, E-Hebei , E-Tianjin, M-Henan, NE-Liaoning	NE-Heilongjiang, NE-Jilin, M-Shanxi W-Shaanxi, W-Xinjiang
	$1.3 < E_p \leqq 1.6$			E-Hainan, M-Anhui, M-Jiangxi, M-Hubei, M-Hunan, W-Sichuan , W-Guangxi , W-Chongqing	W-Qinghai, W-Yunnan
	$E_p > 1.6$			W-Ningxia	W-Gansu, W-Tibet , W-Guizhou

E eastern provinces, *W* western provinces, *NE* northeastern provinces, *M* central provinces

London or it can originate new technologies to upgrade its development. In 2003, the Mainland and Hong Kong Closer Economic Partnership Arrangement (CEPA) is established, transforming the economic and trade cooperation between Shanghai and Hong Kong from trading in manufactured goods to high-end services at an annual growth rate of approximately 20 % since 2004 (Horesh 2013). However, Horesh (2013) also observed that despite Shanghai's faster pace of development between 1992 and 2012 as compared to Hong Kong, Shanghai is still widely seen as less global and entrepreneurial. For further internationalization, Shanghai can learn from Hong Kong to diversify its services sector and improve its capacity for innovation and global reach. To become world cities such as New York, London, Tokyo, Paris, Shanghai should further focus on economic liberalization, strengthening market institutions, building regional linkages and creating production new space for industrial consolidation and investment promotion (Yusuf and Wu 2002). Openness, combined with policy measures that induce competitiveness, will most likely lead to outcomes that are in Shanghai's long-term interests.

2. Frontier provinces: $E_p = 1$, $E_d > 1$

All are eastern coastal provinces. It is not feasible for these competitive provinces to enhance all aspects simultaneously. *Disproportional development strategy* is appropriate. Since they are already on the frontier of the feasibility set, they should pay attention to innovating new technology to push the frontier outward. Since 2004, Zhejiang and Guangdong have reconsolidated their industrial structure. The Zhejiang government promoted replacing traditional agriculture with ecological and dedicated agriculture, as well as industries of high input, high cost and high emission with industries that produce high quality and environment friendly output. Similarly, Guangdong province moved its labor-intensive industries from the Pearl River Delta to the Eastern, Western and the Northern mountain areas. Meanwhile, high-quality personnel are attracted to work in developed areas. In short, Guangdong and Zhejiang are adopting the disproportional development strategies by specifically giving priority to a knowledge-based and coordinated development path.

3. Inefficient but close to frontier provinces: $1 < E_p \leqq 1.3$, $E_d > 1.3$

Both proportional and disproportional development strategies can improve competitiveness. Since these provinces are relatively close to the frontier, they should focus on *disproportional development strategy*.

4. Highly inefficient provinces: $E_p > 1.3$ *and* $E_d > 1.3$

Most are western provinces with vast room for improvement through proportionally expanding all dimensions in the short run and changing the dimension mixes in the long run. Since China launched its WDP, western regions have received support from the central government. For example,the fiscal transfer from the central government up to 2004 in western region rose from 28 to 34.4 %. Local governments also heavily invest in infrastructure (y_6) and improve the efficiency of government policies (y_7). For example, during 2005–2008, e-government was widely promoted in Guangxi and Chongqing, Ningxia strengthens social security system to cover retirement pension, medical care, unemployment, etc. (Yao and Ren 2009). Using our terminology, the western provinces have adopted the *disproportional development strategy* in the China Western Development. As to be discussed in Sect. 5.2, such strategy is inferior to the *proportional development strategy*.

Several observations emerge from the preceding discussion. First, in terms of provincial competitiveness, Western China lags far behind Eastern China. From the Central Government point of view, China may need to choose appropriate policies to remedy the regional unbalance. Second, coastal provinces, like Beijing, Jiangsu, Zhejiang, Guangdong, and Shandong are on the frontier though relatively efficient in dimension mix. Although they can improve competitiveness through changing dimension mixes, long-run improvement must involve innovations of new technologies. Finally, our model derives different provincial development directions, which is not possible in the conventional methods that study the competitiveness index and its dimensions alone. These observations form our answer to Question 3:

Result 3 *Shanghai is the most competitive province and western provinces lag far behind eastern provinces in terms of competiveness and its efficiency components.*

5 Boosting GDP per capita through competitiveness improvement

This section explores the relations among efficiency of competitiveness, GDP *per capita* and the development strategies of a province. To identify these relations, we define the *real GDP gap per capita*:

$$\delta^{kt} = rgdppc^{t}_{max}/rgdppc^{kt}.$$

where $rgdppc^{kt}$ is the real GDP *per capita* in RMB of province k in year t, and $rgdppc^{t}_{max}$ is the highest provincial real GDP *per capita* in RMB in year t among all provinces. Thus δ^{kt} measures the potential difference between the real GDP *per capita* of a province and that of its maximum peer province. For instance, $\delta^{kt} = 1.1$ means that should a province attain the maximum level, its real GDP *per capita* can be increased by 10 %.

5.1 Efficiency components

Recall that a larger value of efficiency score in E_p or E_d means a larger potential to increase the competitiveness index. As competitiveness affects real GDP *per capita* positively, we expect that δ^{kt} can be explained by the efficiency of proportional competitiveness E_p and the efficiency of dimension mix competitiveness E_d. We ask the following question:

Question 4 *Which component of the overall efficiency of competitiveness has a larger impact on real GDP gap per capita?*

To derive our answer, we estimate the following regression:[11]

$$\ln(\delta) = \beta_0 + \beta_1 \ln(E_p) + \beta_2 ln(E_d) + \beta_3 noneast + \beta_7 dcm + \beta_8 ar + \varepsilon;$$

where dummy variables are defined as before. We expect β_1 and β_2 to be positive, as confirmed by the estimates reported in Model 1 of Table 5:

The estimates of β_1 and β_2 are positive at any meaningful level of significance and $\hat{\beta}_1$ is greater than $\hat{\beta}_2$ at 5 % level of significance.[12] Since the real GDP gap *per capita*

[11] In this and the next regression equations, the superscript kt is omitted to simplify notations. Further, the year dummies are found to be jointly insignificant and thus discarded.

[12] This is done by testing the null hypothesis H_o: $\beta_1 \leq \beta_2$ against the alternative hypothesis H_1: $\beta_1 > \beta_2$. The test statistics is $(\hat{\beta}_1 - \hat{\beta}_2)$ with standard error $(se(\hat{\beta}_1)^2 + se(\hat{\beta}_2)^2 - \widehat{2cov}(\hat{\beta}_1, \hat{\beta}_2))^{0.5} = 0.1209$.

Table 5 The potential impacts of various development strategies

Dependent variable: ln(δ)			
Variable	Model 1	Model 2	Model 3
Intercept	0.55*** (16.68)	0.58*** (17.14)	0.57*** (17.50)
$\ln(E_p)$	1.22*** (16.11)	1.29*** (16.18)	1.27*** (16.44)
$\ln(E_d)$	0.95*** (11.35)		
$\ln(g_1)$		1.12*** (2.64)	0.81*** (10.71)
$\ln(g_2)$		0.82*** (4.50)	0.81*** (10.71)
$\ln(g_3)$		0.62** (2.38)	0.81*** (10.71)
noneast	0.29*** (8.77)	0.30*** (8.75)	0.30*** (8.80)
dcm	−0.43*** (−11.07)	−0.45*** (−11.08)	−0.44*** (−11.25)
ar	−0.30*** (−9.02)	−0.31*** (−8.22)	−0.32*** (−9.21)
Adj. R^2	0.94	0.94	0.94
N	124	124	124

The coefficients of $ln(g_1)$, $ln(g_2)$ and $ln(g_3)$ are restricted to be equal in Model 3

*** (**) Significance at 1 % (5 %) level

(δ) reflects potential losses due to low competitiveness, increasing E_p by 1 % will raise the potential losses by 1.22 %. Said equivalently, eliminating 1 % of the inefficiency of proportional competitiveness will reduce the potential losses by 1.22 %.

Therefore, the answer to Question 4 is:

Result 4 *While improving both efficiency of proportional competitiveness (i.e., reduce the value of E_p to 1) and efficiency of dimension mix competitiveness (i.e., reduce the value of E_d to 1) brings the per capita real GDP gap of a province closer to its potential maximum (i.e., a smaller value of δ), the impact on per capita real GDP gap of E_p is larger than that of E_d.*

Result 4 suggests that expanding all dimensions proportionally should be done with priority in a *hybrid development strategy*.

5.2 Boosting GDP per capita through changing the dimension mix

When changing dimension mix can improve competitiveness, which directions should a province go? To simplify discussion, the nine dimensions are further classified into three groups in Table 6,[13] with each group reflecting a particular type of policy, thereby answering the next question that attracts policy makers' attention:

Question 5 *Which dimensions should be emphasized in the disproportional development strategy?*

To answer this question, we first assess the impacts of the above three groups on the competitiveness index in the disproportional development strategy and define the following three variables:

$$g_1 = \frac{E_p \cdot y^0 + \sum_{m=2,3,6} w_m\left(y_m^* - E_p y_m^0\right)}{E_p \cdot y^0}$$

$$g_2 = \frac{E_p \cdot y^0 + \sum_{m=1,4,8} w_m\left(y_m^* - E_p y_m^0\right)}{E_p \cdot y^0}$$

$$g_3 = \frac{E_p \cdot y^0 + \sum_{m=5,7,9} w_m\left(y_m^* - E_p y_m^0\right)}{E_p \cdot y^0}$$

Using g_1 as example, $E_p{\cdot}y^0$ is the vector of dimension on the frontier when all observed dimensions are expanded proportionally. $y*$ is the vector when the maximum value of the competitiveness index is attained. A disproportional policy is needed for a province to shift from $E_p{\cdot}y^0$ to $y*$. The corresponding values of competitiveness at $E_p{\cdot}y^0$ and $y*$ are $\sum_{m=1}^{9} w_m(E_p y_m^0)$ and $\sum_{m=1}^{9} w_m y_m^*$, respectively. The potential increase in the value of competitiveness from the *disproportional development strategy* is equal to $\sum_{m=1}^{9} w_m(y_m^* - E_p y_m^0)$. The term $\Sigma_{m=2,3,6} w_m(y_m^* - E_p y_m^0)$ equals the change of value of overall competitiveness due to the disproportional variations of the dimensions in group 1. The value of g_i thus measures the percentage change of the competitiveness when the dimensions in group $i = 1$, 2, 3 are changed.[14] For instance, if $g_i = 1.1$, the contribution of the dimensions in group 1 in the *disproportional development strategy* is 10 % increase in the value of the competitiveness index.

Based on the definitions of the components of each group, we can call these components, factor-driven (g_1),

[13] In Schwab (2013), the twelve pillars are classified into basic requirement subindex, efficiency enhances subindex and innovation and sophistication factors subindex. Since the dimensions we adopted in this paper are very different from Schwab's pillars, our classification is different.

[14] Note that $(g_1 - 1) + (g_2 - 1) + (g_3 - 1) = E_d - 1$.

Table 6 Group categorization

Group names	Group definition	Group annotation
Group 1: Factor-driven group	y_2 (industries) y_3 (sustainable development) y_6 (development and environment)	In this group, the three dimensions can be increased by allocating more resources into these dimensions
Group 2: Structure-driven group	y_1 (macroeconomy) y_4 (finance) y_8 (development level)	In this group, the three dimensions can be increased by improving the structure of the economy such as market competitiveness, industrialization, government expenditure, etc.
Group 3: Government-driven group	y_5 (knowledge-based) y_7 (government functions) y_9 (coordinated development)	In this group, the three dimensions can be increased by better government participation in the economy such as education level, development strategy, urban–rural disparity, etc.

structure-driven (g_2) and government-driven (g_3), which can be increased by policies of injecting more resources, improving the structure of the economy, and improving the functions of the government, respectively. By comparing their effects on real GDP *per capita*, different policy emphases can be addressed under the disproportional development strategy.

The three components of each province are listed in Table 10 in the Appendix for the years 2005 and 2008. It is found that g_1 is the smallest component for all provinces, implying that factor-driven category is the least important for raising real GDP *per capita* because it has the least potential in increasing provincial competiveness. Thus boosting investments in industries, infrastructure and general education is ineffective to raise China's income *per capita*. In comparison, the structure-driven component, g_2, dominates in determining competitiveness improvement in both years whereas the government functioning, g_3, is the second largest component.

Each of the three components can be larger or smaller than one. A value larger than one means the increase in this category can potentially increase the competitiveness index, and therefore increase real GDP *per capita*. Conversely, a value smaller than one means this category has currently been over emphasized and reallocating resources from this group to other groups can increase competitiveness. Using Beijing in 2008 as an example, the values of factor-driven, structure-driven, and government-driven component are 1.02, 1.04 and 0.98, respectively. Thus shifting resources from the government-driven sector to the structure-driven sector may raise the competitiveness of Beijing and therefore its real GDP *per capita*.

To reach a more general conclusion, the logarithm of δ is regressed on the logarithm of E_p and these three components, along with the previously defined dummy variables. The estimated results are presented under Model 2 in Table 5. All estimated coefficients of $ln(g_1)$, $ln(g_2)$and $ln(g_3)$ are significant at $\alpha = 0.05$. However, an F-test indicates the hypothesis that these three coefficients are equal cannot be rejected at $\alpha = 0.10$. Model 3 in Table 5 presents the estimated regression equation that restricts these three coefficients to be equal. We now state the answer to Question 5:

Result 5 *All three groups of dimension mix components have significant impacts on real GDP gap per capita. Since their impacts are statistically equal, the group of dimensions to choose depends on the position of a province in the feasibility set.*

We summarize our findings as below:

1. When $E_p > 1$ and $E_d = 1$, adopting the *proportional development strategy* can narrow the gap between the real GDP *per capita* of a province and the maximum level.
2. When $E_p = 1$ and $E_d > 1$, the *disproportional development strategy* is desirable. All factor-driven, structure-driven, and government-driven policies are equally effective to raise real GDP *per capita*, as long as they can raise the overall competitiveness. Which one to choose depends on the position of a province in the feasibility set.
3. When $E_p > 1$ and $E_d > 1$, the *hybrid development strategy* is appropriate. Since the estimated coefficient of $ln(E_p)$ is significantly higher than that of $ln(E_d)$, the *proportional development strategy* is more effective to raise the real GDP *per capita*. A province should pay more attention to all dimensions of competitiveness before its potential has been exhausted.

5.3 Comments on two policies

The financial Tsunami in 2008 hit many sectors of the Chinese economy, with ensuing efforts by the central government and local authorities in China to revive the economy. This section analyzes two policies from the competitiveness point of view to illustrate the usefulness of our framework introduced herein.

This first policy is the big push from the central government. In 2008, Premier Wen Jiabao announced that four trillion RMB would be injected to the economy. This policy greatly increased fixed investment of the whole economy. Two consequences of this policy on the Chinese economy ensue:

Consequence 1: Fixed investment drastically increased.
Consequence 2: The share of state-owned enterprises in the whole economy increased.[15]

Consequence 1 means resources are allocated into the factor-driven category which has been shown to be least important in improving competitiveness. Consequence 2 actually means more loans of local governments and lower level of marketization. This lowers the value of the structure-driven category. Thus resources are used inefficiently, at the expense of harming the highest potential of improving competitiveness. In short, the four trillion RMB investment was an ineffective competitiveness policy.[16]

The second policy is the "Empty out the cage of old birds for new ones [*teng long huan niao*]" policy in the Guangdong province. For simplicity, we call this policy "new bird policy". The purpose of this policy is to replace low-end, labor-intensive and polluting manufacturing enterprises with high-tech production and research and development centers. From Table 4, Guangdong's efficiency scores are $E_p = 1$ and $E_d > 1$. Without technological progress, changing the dimension mix along the frontier, rather than proportionally expanding all dimensions, is necessary to improve competitiveness. The new bird policy means enhancing Group 3 by increasing resources to develop a knowledge-based economy (y_5) and sacrificing Group 1 by decreasing emphasis in macroeconomic conditions (y_1). In Table 10, the three components of competitiveness for Guangdong are 0.99 for s_1, 1.02 for s_2, and 1.05 for s_3. This implies that the Guangdong authority should reduce the factor-drive group (Group 1) in favor of the other two groups. In particular, the government-driven group (Group 3) has the highest potential to improve competitiveness. Hence the new bird policy can be justified from the point of view of improving competitiveness.

6 Regional competitiveness disparity

The previous section demonstrates that raising competitiveness can raise real GDP *per capita*. What we do not know is whether *proportional* or *disproportional development strategy* is more suitable to reduce regional disparity. Section 4 shows that, on average, the losses due to inefficient dimension mix (E_d) are larger than that of inefficient proportional competitiveness (E_p). The following question naturally emerges:

Question 6 *Is inequality in E_d the main source of overall competitiveness inequality?*

6.1 Decomposing the inequality of overall competitiveness

To examine the disparities in competitiveness among China's regions, we use the entropy-based Theil index. Let $\boldsymbol{x}$ denote an N-dimensional vector of observations, x_i, with mean $u = \frac{1}{N}\sum_{i=1}^{N} x_i$. One version of Theil's measure of inequality (Cheng and Li, 2006), among these N observations is:

$$T(x) = \frac{1}{N}\sum_{i=1}^{N} ln\left(\frac{u}{x_i}\right).$$

The closer is the index to zero, the greater is the equality among observations. This index is zero if and only if the value of x_i is the same for all. In our present application, $\boldsymbol{x}$ denotes one of the vectors of O_c, E_d and E_p over the $N = 31$ provinces.

The method developed by Duro and Esteban (1998) and Cheng and Li (2006) enables us to decompose the inequality of O_c in terms of the inequalities of its multiplicative components, E_d and E_p. Let the means of O_c, E_d and E_p be O_{cu}, E_{du}, and E_{pu}. The decomposition of the inequality O_c is as follows:

$$\begin{aligned} T(O_c) &= \frac{1}{N}\sum_{i=1}^{N} ln\left(\frac{O_{cu}}{O_{ci}}\right) \\ &= \frac{1}{N}\sum_{i=1}^{N} ln\left(\frac{E_{du}}{E_{di}}\cdot\frac{E_{pu}}{E_{pi}}\cdot\frac{O_{cu}}{E_{du}E_{pu}}\right) \\ &= T(E_d) + T(E_p) + ln\left(\frac{O_{cu}}{E_{du}E_{pu}}\right) \end{aligned} \quad (8)$$

In (8), the interaction term, $ln\left(\frac{O_{cu}}{E_{du}E_{pu}}\right)$ is a residual indicating the correlation between E_d and E_p. Specifically, the interaction is positive (negative) when E_d and E_p are positively (negatively) correlated. When this term is zero, E_d

Table 7 Interprovincial competitiveness index and its decomposition

	T(O_c)	T(E_d)	T(E_p)	Interaction
2005	0.0495	0.0125	0.0250	0.0120
2006	0.0511	0.0146	0.0217	0.0148
2007	0.0491	0.0152	0.0191	0.0148
2008	0.0448	0.0129	0.0173	0.0147

[15] Uner the institutions of China, private enterprises are extremely difficult to benefit from that four trillion RMB injection.

[16] This analysis focuses on the impacts of Premier Wen's policy on provincial competitiveness. Potential positive effects on other aspects of the economy, especially in the short run, are not considered.

and E_p are uncorrelated. The measure $T(\boldsymbol{x})$ is always positive and a larger number will indicate greater inequality.

The general interprovincial competitiveness inequality is summarized in Table 7. Except for 2006, the values of interprovincial inequality of overall efficiency of competitiveness are falling, thus suggesting a lower degree of inequality. While inequality in E_d has been increasing until 2007, inequality in E_p has been decreasing, with the interaction component remaining almost unchanged. Therefore, the improvement in inequality mainly stems from the lower inequality of E_p among provinces.

The inequality of efficiency of proportional competitiveness $T(E_p)$ is larger than the inequality of efficiency of dimension mix $T(E_d)$ each year in the sample period.[17] Since changes in E_p involve *proportional development strategy,* the finding of $T(E_p) > T(E_d)$ implies that a development strategy with due consideration to all aspects is more effective to alleviate the inequality of competitiveness among provinces. To sum up, we have the following result:

Result 6 *The main source of competitiveness disparity is the inequality in the efficiency of proportional competitiveness* (E_p).

6.2 Inter-regional versus intra-regional inequality of competitiveness

Based on Shorrocks (1982) and Tsui (2007),we investigate the source of inequality from the perspectives of inter-region and intra-region. In view of the finding that the provinces in some regions are more inefficient than provinces in other regions, the following question arises:

Question 7 *Does inter-regional competitiveness inequality dominate intra-regional compeveness inequality?*

Suppose there are G regions and the number of provinces in the gth region is N_g. Let O^g_{cu} and T^g be the sample mean of overall efficiency of competitiveness (O_c) and the value of Theil's measure of region g, respectively. The formula of Shorrocks (1982) and Tsui (2007) is:

$$T(O_c) = T_b(O_c) + T_w(O_c)$$

where $T_b(O_c) = \sum_{g=1}^{G} \frac{N_g}{N} \ln\left(\frac{O_{cu}}{O^g_{cu}}\right)$ is the inter-region inequality and $T_w(O_c) = \sum_{g=1}^{G} \frac{N_g}{N} T^g$ is the intra-region inequality. The finding in Sect. 4 that highly inefficient provinces concentrate in the western area leads us to postulate that the inter-region inequality of competitiveness is higher.

[17] One can reject the null hypothesis of $T(E_p) \leqq T(E_d)$ in favor of the alternative hypothesis $T(E_p) > T(E_d)$.

Table 8 Inter-region and intra-region competitiveness inequality

	$T(O_c)$	$T_w(O_c)$	$T_b(O_c)$
2005	0.0495	0.0213 (43.12 %)	0.0281 (56.88 %)
2006	0.0511	0.0199 (38.89 %)	0.0312 (61.11 %)
2007	0.0491	0.0190 (38.76 %)	0.0301 (61.24 %)
2008	0.0448	0.0172 (38.31 %)	0.0276 (61.69 %)

The number in the parenthesis is share of either inter-region or intra-region competitiveness inequalities

The inequality of overall efficiency of competitiveness and its components are computed for each year in 2005 to 2008. The scores are summarized in Table 8. Generally, competitiveness inequality tends to decline over the 4 years with exception in 2006. The source of improvement coming from the intra-region inequality $T_w(O_c)$, continuously drop from 0.0213 in 2005 to 0.0172 in 2008. In contrast, the inter-region inequality in competitiveness $T_b(O_c)$ is larger than the intra-region inequality $T_w(O_c)$ in each year. Thus, we have:

Result 7 *The main source of inequality of competitiveness is the inter-region inequality of competitiveness in China.*

7 Conclusions

This paper is based on the premise that the knowledge of human beings imposes maximum values of the dimensions of competitiveness along each dimension mix. The feasibility set of competitiveness reflects this constraint. By incorporating the weights of the dimensions of competitiveness into the feasibility set, we decompose the improvement of competitiveness into proportional change in all dimensions and alternatively, a change in the dimension mix. This enables us to extract more policy implications from existing competitiveness index than what conventional studies of competitiveness can do.

We have found statistical evidence for the link between competitiveness and real GDP *per capita* in China. Borrowing the DEA methodology in the productivity and efficiency analysis literature, we identify three possible cases of improving competitiveness: expanding all dimensions at the same time, expanding some dimensions at the cost of shrinking others, and a combination of both. Our production framework of competitiveness provides important implications for policy makers.

We also found that provincial real GDP *per capita* is significantly affected by the efficiency of proportional competitiveness E_p and the efficiency of dimension mix E_d. In the case of changing dimension mix, our analysis shows that structure-driven and government-driven dimensions are more effective in raising real GDP *per capita*. Using pre-1997 data, Fan et al. (2003) conclude that structural changes have provided the main momentum for China's economy from the productivity perspective. In sympathy, we have shown that structural changes are also essential for enhancement in competitiveness.

In addition, we find that the *proportional development strategy* should dominate the *disproportional development strategy* before reaching the frontier of competitiveness for central and western provinces in China. There are three reasons: First, these provinces are far from reaching the frontier. Expanding all dimensions simultaneously is still possible and desirable. Second, when a province is inefficient in proportional competitiveness and dimension mix, the *proportional development strategy* can be more effective to increase its competitiveness. Finally, the inequality of efficiency of proportional competitiveness account for a larger portion of the inequality of overall provincial competitiveness. In summary, the *proportional development strategy* can better increase provincial real GDP *per capita* while controlling the inequality of competitiveness than the *disproportional development strategy*.

Appendix

See Tables 9 and 10.

Table 9 Information about dimensions

	Competitiveness dimensions	Brief description	Weights
y_1	Competitiveness in macroeconomy	1. Economic capability including indicators like provincial GDP, GDP growth rate, fixed capital investment etc.	0.15
		2. Economic structure including industry structural optimization, ownership structure, capital formation structure, trade structure etc.	
		3. Export-oriented level including trade volume, trade growth rate, real FDI, trade dependence etc.	
y_2	Competitiveness in industries	1. Agriculture factors such as agriculture added value, agriculture productivity, agriculture output *per capita* etc.	0.125
		2. Industry factors such as total assets, total value added, labor and capital productivity etc.	
		3. Service factors such as the numbers of employees, service added value etc.	
		4. Enterprise factors such as number of enterprises, average total assets, total times of capital turnover etc.	
y_3	Competitiveness in sustainable development	1. Resource allocation include annual water usage *per capita*, average forest usage *per capita*, average arable area *per capita* etc.	0.1
		2. Environment factors including forest coverage, industrial sewage disposal, waste gas treatment etc.	
		3. Human resources including population growth rate, literacy rate, average education level etc.	
y_4	Competitiveness in finance	1. Fiscal factors such as regional fiscal revenue, regional government expenditure, tax revenue *per capita* etc.	0.1
		2. Monetary factors such as total savings, average deposit *per capita*, tax revenue growth rate etc.	
y_5	Competitiveness in knowledge-based economy	1. Technology factors such as D & R expenditure, number of patents, added value in high-tech industry etc.	0.125
		2. Education factors such as education expenditure, number of students, number of teachers, and number of high education institutes etc.	
		3. Culture factors such as the number of book and journal publications, number of video publications, entertainment expenditure *per capita* etc.	
y_6	Competitiveness in development and environment	1. Infrastructure factors including electricity consumption *per capita*, average length of speed way, average number of internet user per ten thousand etc.	0.1
		2. Soft-environment factors including the growth rate of foreign owned enterprises, number of chartered brand per ten thousand, number of fire accidents per one hundred thousand etc.	

Table 9 continued

	Competitiveness dimensions	Brief description	Weights
y_7	Competitiveness in government functions	1. Government development strategies including contribution of government personnel, fiscal contribution to social investment and GDP growth etc. 2. Government adjustment policies including price adjustment, controlling population growth, reducing rural–urban consumption disparity etc. 3. Government welfare systems including medicine insurance, unemployment insurance, and retirement pension etc.	0.1
y_8	Competitiveness in development level	1. Industrialization level including labor growth rate, the ratio of added value to GDP etc. 2. Urbanization level including average disposable income of urban residents, average living space of urban residents etc. 3. Marketization level including the ratio of output by private-owned economy and social total output, ratio of labor in non-state-owned enterprises and total labor force etc.	0.1
y_9	Competitiveness in coordinated development	1. Overall planning factors such as growth rate of social labor productivity, productivity of non-agricultural land etc. 2. Coordination factors such as rural–urban personal consumption disparity, rural–urban disposable income disparity etc.	0.1
y	Overall Economic competitiveness	The ultimate indicator of provincial competitiveness. It incorporates all dimensions with their corresponding weights	

Sources: Li et al. (2007–2009)

Table 10 Values of three components for provinces in 2005 and 2008

Province	2008			2005		
	Factor	Structure	Government	Factor	Structure	Government
Beijing	1.02	**1.04**	0.98	0.98	**1.05**	0.98
Tianjin	1.03	1.07	**1.08**	1.07	**1.22**	1.11
Hebei	1.02	**1.13**	1.13	1.08	**1.31**	1.16
Shanxi	1.16	**1.43**	1.31	1.12	**1.44**	1.23
Inner-Mongolia	1.01	**1.32**	1.30	1.07	**1.38**	1.27
Liaoning	1.01	1.12	**1.13**	1.10	**1.30**	1.16
Jilin	1.06	**1.24**	1.17	1.13	**1.44**	1.18
Heilongjian	1.05	**1.40**	1.23	1.10	**1.56**	1.23
Shanghai	1.00	1.00	1.00	1.00	1.00	1.00
Jiangsu	0.99	1.03	**1.04**	1.02	**1.06**	1.05
Zhejiang	1.01	1.08	**1.09**	1.03	**1.09**	1.07
Anhui	1.02	**1.16**	1.14	1.09	**1.34**	1.11
Fujian	1.04	**1.17**	1.14	1.11	**1.28**	1.18
Jiangxi	1.08	**1.21**	1.17	1.10	**1.35**	1.15
Shangdong	1.01	**1.17**	1.14	1.03	**1.17**	1.11
Henan	1.03	**1.26**	1.21	1.08	**1.36**	1.19
Hubei	1.03	**1.20**	1.15	1.09	**1.33**	1.10
Hunan	1.03	**1.25**	1.21	1.09	**1.35**	1.14
Guangdong	0.99	1.02	**1.05**	1.01	1.04	**1.07**
Guangxi	1.09	**1.29**	1.28	1.09	**1.32**	1.16
Hainan	1.01	**1.22**	1.21	1.08	**1.42**	1.20
Chongqing	1.07	1.19	**1.28**	1.09	**1.30**	1.14
Sichuan	1.04	1.19	**1.24**	1.05	**1.31**	1.16
Guizhou	1.02	**1.35**	1.28	1.06	**1.42**	1.17
Yunnan	1.06	**1.32**	1.29	1.06	**1.49**	1.27
Tibet	1.04	1.19	**1.35**	1.09	**1.30**	1.26

Table 10 continued

Province	2008			2005		
	Factor	Structure	Government	Factor	Structure	Government
Shaanxi	1.05	**1.37**	1.22	1.11	**1.49**	1.13
Gansu	1.01	**1.46**	1.27	1.09	**1.51**	1.09
Qinghai	1.02	**1.34**	1.30	1.03	**1.37**	1.16
Ningxia	1.02	1.22	**1.28**	1.03	**1.26**	1.14
Xinjiang	1.03	**1.32**	1.28	1.08	**1.48**	1.19

Bold number indicates the largest component

References

Bao S, Chang GH, Sachs JD, Woo WT (2002) Geographic factors and China's regional development under market reforms, 1978–1998. China Econ Rev 13(1):89–111

Charnes A, Cooper WW, Rhodes E (1978) Measuring the efficiency of decision making units. Eur J Oper Res 2(6):429–444

Chen M, Zheng Y (2008) China's regional disparity and its policy responses. China World Econ 16(4):16–32

Cheng YS (1996) A decomposition analysis of income inequality of Chinese rural households. China Econ Rev 7(2):155–167

Cheng YS, Li SK (2006) Income inequality and efficiency: a decomposition approach and applications to China. Econ Lett 91(1):8–14

Cho DS, Moon HC (2000) From Adam Smith to Michael Porter: Evolution of Competitiveness Theory. World Scientific Publishing Company Ltd, Singapore

Cho DS, Moon HC, Kim MY (2008) Characterizing international competitiveness in international business research: a MASI approach to national competitiveness. Res Int Bus Finance 22(2):175–192

Coelli T, Rao DSP, O'Donnell CJ, Battese GE (2005) An introduction to efficiency and productivity analysis, 2nd edn. Kluwer Academic Publishers Inc, Boston

Duro JA, Esteban J (1998) Factor decomposition of cross-country income inequality, 1960–1990. Econ Lett 60(3):269–275

Fan S, Zhang X, Robinson S (2003) Structural change and economic growth in China. Rev Dev Econ 7(3):360–377

Farrell MJ (1957) The measurement of productive efficiency. J R Stat Soc Ser A (General) 120(3):253–290

Horesh N (2013) Development trajectories: Hong Kong vs. Shanghai. Asian Pac Econ Lit 27(1):27–39

Kao C, Wu WY, Hsieh WJ, Wang TY, Lin C, Chen LH (2008) Measuring the national competitiveness of Southeast Asian countries. Eur J Oper Res 187(2):613–628

Krugman P (1996) Making sense of the competitiveness debate. Oxf Rev Econ Policy 12(3):17–25

Lam KC, Liu PW (2011) Increasing dispersion of skills and rising earnings inequality. J Comp Econ 39(1):82–91

Lee CK (2007) Against the law: labor protests in China's rustbelt and sunbelt. University of California Press, Berkeley

Li J, Li M, Gao Y (2007–2009) A report of overall competitiveness of China's provincial economy. Social Sciences Academic Press, Beijing (Chinese)

Lovell CAK, Pastor JT (1999) Radial DEA models without inputs or without outputs. Eur J Oper Res 118(1):46–51

Schwab K (2013) The global competitiveness report 2013–2014. World Economic Forum, Geneva

Shorrocks AF (1982) Inequality decomposition by factor components. Econometrica 50(1):193–212

Smyth R, Inder B (2004) Is Chinese provincial real GDP per capita nonstationary?: evidence from multiple trend break unit root tests. China Econ Rev 15(1):1–24

Sun M, Fan CC (2008) Regional Inequality in the Pan-Pearl River Delta Region,". In: Yeung Yueman, Shen Jianfa (eds) The Pan-Pearl River Delta: an emerging regional economy in globalizing China. The Chinese University Press, Hong Kong

Tsui KY (1996) Economic reform and interprovincial inequalities in China. J Dev Econ 50(2):353–368

Tsui KY (2007) Forces shaping China's interprovincial inequality. Rev Income Wealth 53(1):60–92

Wang S, Hu A (1999) The Political Economy of Uneven Development: The Case of China. M.E. Sharpe, Armonk

Yao S, Liu J (1998) Economic Reforms and Regional Segmentation in Rural China. Reg Stud 32(8):735–746

Yao H, Ren Z (2009). Annual report on economic development in Western region of China. Social Sciences Academic Press, Beijing (Chinese)

Yusuf S, Wu W (2002) Pathways to a world city: Shanghai rising in an era of globalization. Urban Stud 39(7):1213–1240

Zhu X (2012) Understanding China's growth: past, present, and future. J Econ Perspect 26(4):103–124