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Research Article

Does Excess Capacity Occur in Chinese Software Industry? An Integrated DEA Approach and its Statistical Tests

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Abstract: This study proposes a new integrated Data Envelopment Analysis (DEA) approach for performance evaluation. Based on economic data of listed companies of software industry in Shanghai and Shenzhen Stock Exchanges, this study first establishes an index system which reflects the status of capacity and operational efficiency. Then, integrated DEA models as well as Synthetic Average method, Borda method, Copeland method and fuzzy Borda method (SABCB Method) are used to calculate the operational efficiency and status of returns to scale. The empirical analysis concludes: (1) in general, operational efficiency of Chinese software industry is acceptable; (2) input redundancy and output shortage occur in the majority of companies. Some companies have been in the region of decreasing or constant returns to scale and excess capacity could now be observed; (3) improving capability of independent innovations continuously and transforming existing business processes are a pressing task for many software companies who want to take the international financial crisis as opportunities.

Keywords: Data envelopment analysis, excess capacity, operational efficiency, SABCB method, software industry

INTRODUCTION

In the increasingly updating information age, software industry as a core of information industry and the basis of economic and social information has become the focus of the world and an important force for promoting economic and social developments recently. Many information technology specialists agree that software industry has been in a mature stage in the last few years (Léger and Louis, 2009). In 2008, Chinese software industry as a whole maintained a rapid growth momentum and reported an income of more than 750 billion Yuan and a yearly increase of nearly 30%. It is worth noting that software outsourcing services recorded a sale of more than 20 billion Yuan with a more than 100% annual increase. However, due to the financial crisis, the worldwide software industry is undergoing profound changes, challenges and opportunities. Though technological progresses on cost control and network upgrading are still necessary, the development momentum in emerging market is relatively stronger. As a consequence of the recent financial crisis, many companies reduce or abandon their budgets for software purchases, which impose a serious impact on some software giants. From January to July in 2009, Chinese software industry obtained total software revenue of 513.9 billion Yuan with an annual increase of 22.2%. The increases from January to June and the first quarter in 2009 were down 0.6 and 1.7% respectively, 10.2% lower than the same periods last year. Since future sales growth in Chinese software industry seems dismal, the task that improves business operational efficiency comprehensively, promotes economic structural optimization, changes the mode of growth and achieves sustainable development remains arduous. Therefore, it is necessary to commence studies focusing on how to improve the operational efficiency of software related business in China. We should take building up a sustainable competitive advantage as the goal and seek a lasting power that could promote sound and rapid developments of Chinese software industry. As international competitions become increasingly fierce, if the development approach in Chinese software industry which relies on foreign core technology cannot be changed fundamentally and the operating efficiency cannot be improved continually, in the long run, such a low-end model of development will become increasingly struggling. We consider the enhancement of operational efficiency as the direction for software related business, which is the only way for the great development of the entire industry from our point of view.

Overall, compared to that of foreign countries, the development of Chinese software industry is still at an early stage. The economic theory and empirical research related to Chinese software industry are still very

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Table 1: The comprehensive evaluation index system of computer manufacturer production efficiency

Index type	Index name	Indicators coding	Standard deviation coefficient
Input indicators	Illiquid assets	(I)LDZC	2.87
	fixed assets	(I)GDZC	2.08
	Staff salaries	(I)ZGXC	3.90
	Management costs	(I)GLFY	2.32
	Finance costs	(I)CWFY	4.04
Output Indicators	Total profit	(O)LRZE	3.38
	Net income from investments	(O)TZSY	2.06

limited. We cannot apply the industrial policy experience from manufacturing industry directly into software industry. However, according to the development characteristics of software industry at all stages, we need to adopt targeted relevant industry policies. Therefore, reducing redundant input and avoiding inadequate output, as well as avoiding "excess capacity" will be an important issue. In order to increase operational efficiency and promote scientific and technological innovation, we established a practical evaluation system to construct the early-warning mechanism of "excess capacity". We believe that it is an important way to set a more operable software industry "excess capacity" early-warning system and to evaluate operating efficiency through a comprehensive analysis of macro- and micro-scale. At the same time, we need to improve and integrate a comprehensive evaluation method, make every enterprise in the industry as a complex system, consider the interaction of multi-level factors and verify the effectiveness and feasibility of evaluation system through evidence, which is an important way to carry out software industry evaluation.

LITERATURE REVIEW AND INDEX SYSTEM FORMULATION

Through the continuous developments and improvements for more than thirty years, Data Envelopment Analysis (DEA) which was first proposed by Charnes *et al*. (1978) has become a popular method to measure the relative efficiency of peer Decision Making Units (DMUs) with multiple inputs and outputs (Cook and Seiford, 2009; Chen *et al*., 2011). It is a good quantitative method to carry out evaluation of operational efficiency and early warning of capacity excess. The homogeneity of the decision-making unit requires the entities which constitute a group of DMUs to share the same goals or tasks, the same external environment, the same input and output indicators and the same dimension (Hauglanda *et al*., 2007). Software-related companies are in line with the requirements. However, their production capacity and operating efficiency are subject to the dynamic effects of some different factors. These factors not only constantly change themselves, but also affect and restrict each other. According to these factors, how to build up an indicator system securely is very important, because different indicators may produce different effects and not all businesses can be measured with the same indicators of success (Toledo-López, 2012). The choice of evaluation indicators is critical for evaluation of productivity, economic scale of operating efficiency, structure, growth and so on.

Here we design a comprehensive evaluation index system. Among inputs, fixed assets are the physical form of fixed capital. It plays a long-term effect on production process, reflecting the overall strength of enterprise. Liquid assets are also the essential component. Staff salaries mainly indicate the actual wages paid to employees and other cash payments to workers. Administrative expenses reflecting the administrative departments' management level primarily are spent in organizing and managing production and operation activities. Finance costs reflecting the financing capacity and debt structure are spent in raising production and operation. Among the output indicators, total profit is a very important economic indicator which measures the enterprise performance. Net income from investments is the net of business investment income minus investment losses. For corporate investor, it is a basic return from investment. While for the managers, it is a basis for management decision-making. Considering the ability of discriminating feature differences in evaluation indicators and objects, it is the key to distinguishing the strength of operational efficiency in different samples. If all samples are scored in a near-unanimous evaluation index, the evaluation index will not have the ability to discriminate and we cannot determine the strength of evaluation objectives. Therefore, we use standard deviation coefficient to identify the evaluation:

$$v_{\sigma} = \frac{\sigma}{\bar{x}} \times 100\% \quad (1)$$

In the formula, σ is the sample standard deviation, $\bar{x}$ is arithmetic mean of the sample. By calculation, we find that the absolute values of standard deviation coefficients in the various indicators over the years are relatively large (≥1). Hence, we believe that the indicator system is reasonable. The results are shown in Table 1.

QUANTITATIVE ANALYSIS OF INTEGRATED DEA

In this study, we use a data set which includes five inputs and two outputs as the evaluation sample of computer manufacturers. The data is collected from19

Table 2: The standardized data

Company name	(I) LDZC	(I) GDZC	(I) ZGXC	(I) GLFY	(I) CWFY	(O) LRZE	(O) TZSY
CDZS	0.19	0.14	0.11	0.10	0.29	0.24	0.12
LCXX	0.38	0.22	0.11	0.23	0.21	0.23	0.18
JQRJ	0.10	0.18	0.12	0.20	0.32	0.27	0.12
NTXX	0.70	0.29	0.14	0.31	0.84	0.37	0.17
YYXT	0.69	0.39	0.16	0.40	1.00	0.33	0.12
ZGRJ	0.72	0.40	0.39	0.91	0.73	0.38	0.16
JZRJ	0.30	0.10	0.23	0.27	0.10	0.29	0.12
BXBG	0.70	0.19	0.29	0.51	0.16	0.50	0.17
BXRJ	0.70	0.19	0.29	0.51	0.16	0.50	0.17
DRJT	1.00	1.00	0.81	0.92	0.37	1.00	0.27
HSDZ	0.29	0.17	0.24	0.40	0.28	0.40	0.20
LHGF	0.18	0.28	0.12	0.15	0.40	0.14	0.16
YYRJ	0.67	0.49	1.00	1.00	0.16	0.90	1.00
XSJ	0.11	0.12	0.12	0.12	0.28	0.25	0.12
JDBT	0.14	0.42	0.11	0.16	0.65	0.10	0.10
HLRJ	0.16	0.10	0.12	0.14	0.22	0.24	0.13
SJXX	0.27	0.19	0.12	0.23	0.21	0.45	0.12
GDSC	0.17	0.26	0.13	0.15	0.34	0.21	0.14
DHRJ	0.64	0.19	0.10	0.19	0.34	0.47	0.12

Data sources: Standardize the data from genius financial database

listed companies in Chinese software industry in 2008. In terms of enterprises productivity and operating efficiency, we use different DEA models to measure their comprehensive scores respectively.

The Non-parametric data envelopment analysis method proposed by Banker *et al*. (1984) has been applied to frontier estimation and it has become the most basic and important technology among DEA models. They proposed a model for fixed-scale expansion of DEA analysis, taking into account the Variable Returns to Scale (VRS) case. That is, when not all the decision-making units run in their best size, measure of technical efficiency may be affected by Scale Efficiency (SE). VRS models, such as the Banker-Charnes-Cooper (BCC) model, allow the calculation of technical efficiency from economies of scale effects. By analyzing the different characteristics of 33 listed companies at present, we find some DMU may not run in their optimal size taking into account the status quo among them, as well as their external unfair competition and financial constraints. Therefore, we use the BCC model and its extension models: the input-oriented BCC model (BCC-I model), the output-oriented BCC model (BCC-O model), as well as the super-efficiency[1] BCC-I model and the super-efficiency BCC-O model. The BCC-I and the BCC-O models can give returns to scale characteristics of DMUs. Banker *et al*. (2004) gave several methods to determine the three types of returns to scale.

Since there is a negative indicator in financial costs, total profits and other indicators of data, we first conduct a non-dimensional raw data processing. x_i Represents the actual value, x_{maz} represents the upper limit of the indicator, x_{min} represents the lower limit of the indicator, $x^`_i$ represents x_i corresponding value after the non-dimensional treatment, then:

$$x_i' = 0.1 + 0.9 \times \frac{x_i - x_{\min}}{x_{\max} - x_{\min}} \tag{2}$$

As shown in Table 2, after the non-dimensional treatment, each x_i' ranges is from 0.1 to 1. We obtain the rank and specific scores according to four ways. They are shown from Table 3 to 6. Different returns to scale are shown in Table 7.

From the table we can see: large individual differences still exist among Chinese software related businesses. There is still much room for improvement for some companies. However, even though they are undergoing the rapid development in software industry, a trend of decreasing or constant returns to scale still exists. Moreover, output shortage and input redundancy also prevail in most companies. According to the BBC-I model, the number of the companies in the region of decreasing returns to scale is four, constant returns to scale is thirteen, increasing returns to scale is only three. In terms of the BBC-O model, the number of the companies in the region of decreasing returns to scale is four, constant returns to scale is fourteen, increasing returns to scale is only one. The results from the two models are largely consistent, which further illustrates most of the listed companies in software industry have achieved constant returns to scale status. Therefore, we should attach great importance to “excess capacity” and make the enterprise stronger by improving management efficiency, rather than simply enlarging business size. The sustainable development of software industry requires not only the enterprises to speed up their implements of technical innovation and transform existing business processes, but also government departments to take further actions to promote efficiency improvement in the software industry and prevent “excess capacity” at the same time. During the Chinese economic transition, if the software industry wants to maintain a long-term growth in the context of intensive international competition, it should strive to improve operational efficiency and avoid decreasing returns to scale through innovation. It is important to identify the

Table 3: Results based on BCC-I DEA model

DMU	Score	Excess LDZCS-(1)	Excess GDZCS-(2)	Excess ZGXCS-(3)	Excess GLFYS-(4)	Excess CWFYS-(5)	Shortage LRZES+(1)	Shortage TZSYS+(2)
CDZS	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LCXX	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
JQRJ	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NTXX	0.95	0.15	0.06	0.00	0.05	0.52	0.00	0.00
YYXT	0.67	0.00	0.09	0.00	0.11	0.35	0.05	0.00
ZGRJ	0.40	0.00	0.00	0.00	0.13	0.06	0.00	0.00
JZRJ	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BXBG	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BXRJ	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DRJT	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HSDZ	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LHGF	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
YYRJ	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
XSJ	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
JDBT	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HLRJ	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SJXX	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
GDSC	0.92	0.00	0.06	0.00	0.00	0.00	0.00	0.00
DHRJ	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Data from: Calculate the data after using DEA BCC-I according to genius financial database

Table 4: Results based on BCC-O DEA model

DMU	Score	Excess LDZCS-(1)	Excess GDZCS-(2)	Excess ZGXCS-(3)	Excess GLFYS-(4)	Excess CWFYS-(5)	Shortage LRZES+(1)	Shortage TZSYS+(2)
CDZS	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LCXX	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
JQRJ	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NTXX	0.97	0.18	0.07	0.00	0.06	0.56	0.00	0.00
YYXT	0.68	0.07	0.18	0.00	0.16	0.68	0.00	0.00
ZGRJ	0.59	0.00	0.00	0.00	0.44	0.41	0.00	0.03
JZRJ	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BXBG	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BXRJ	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DRJT	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HSDZ	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LHGF	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
YYRJ	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
XSJ	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
JDBT	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HLRJ	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SJXX	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
GDSC	0.93	0.00	0.06	0.00	0.00	0.01	0.00	0.00
DHRJ	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Data from: Calculate the data after using DEA BCC-O according to genius financial database

Table 5: Results based on BCC-I super-efficiency DEA model

DMU	Score	Excess LDZCS-(1)	Excess GDZCS-(2)	Excess ZGXCS-(3)	Excess GLFYS-(4)	Excess CWFYS-(5)	Shortage LRZES+(1)	Shortage TZSYS+(2)
CDZS	1.20	0.13	0.04	0.01	0.00	0.06	0.01	0.00
LCXX	1.40	0.28	0.07	0.00	0.09	0.00	0.12	0.00
JQRJ	1.20	0.00	0.09	0.03	0.11	0.10	0.00	0.00
NTXX	0.95	0.15	0.06	0.00	0.05	0.52	0.00	0.00
YYXT	0.67	0.00	0.09	0.00	0.11	0.35	0.05	0.00
ZGRJ	0.40	0.00	0.00	0.00	0.13	0.06	0.00	0.00
JZRJ	1.79	0.00	0.00	0.13	0.05	0.00	0.15	0.08
BXBG	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BXRJ	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DRJT	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HSDZ	1.02	0.00	0.00	0.01	0.12	0.12	0.00	0.00
LHGF	1.17	0.00	0.16	0.00	0.00	0.22	0.12	0.00
YYRJ	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
XSJ	1.32	0.00	0.00	0.04	0.00	0.08	0.00	0.00
JDBT	1.05	0.00	0.31	0.00	0.06	0.40	0.14	0.02
HLRJ	1.16	0.04	0.00	0.00	0.01	0.00	0.02	0.00
SJXX	1.66	0.00	0.03	0.00	0.10	0.02	0.00	0.02
GDSC	0.92	0.00	0.06	0.00	0.00	0.00	0.00	0.00
DHRJ	1.51	0.65	0.06	0.00	0.02	0.29	0.00	0.01

Data from: Calculate the data after using DEA SUPER BCC-I according to genius financial database

Table 6: Results based on BCC-O super-efficiency DEA model

DMU	Score	Excess LDZC S-(1)	Excess GDZC S-(2)	Excess ZGXC S-(3)	Excess GLFY S-(4)	Excess CWFY S-(5)	Shortage LRZE S+(1)	Shortage TZSY S+(2)
CDZS	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LCXX	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
JQRJ	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NTXX	0.97	0.18	0.07	0.00	0.06	0.56	0.00	0.00
YYXT	0.68	0.07	0.18	0.00	0.16	0.68	0.00	0.00
ZGRJ	0.59	0.00	0.00	0.00	0.44	0.41	0.00	0.03
JZRJ	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BXBG	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BXRJ	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DRJT	1.24	0.34	0.57	0.00	0.09	0.17	0.00	0.60
HSDZ	1.02	0.00	0.00	0.01	0.12	0.11	0.00	0.00
LHGF	1.19	0.00	0.13	0.00	0.01	0.14	0.13	0.00
YYRJ	6.04	0.03	0.31	0.72	0.52	0.00	0.33	0.00
XSJ	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
JDBT	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HLRJ	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SJXX	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
GDSC	0.93	0.00	0.06	0.00	0.00	0.01	0.00	0.00
DHRJ	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Data from: Calculate the data after using DEA SUPER BCC-O according to genius financial database

Table 7: Returns to scale of each enterprise

Model	DEA BCC-I Model		DEA BCC-O Model	
RTS	RTS	RTS of Projected DMU	RTS	RTS of Projected DMU
CDZS	Constant		Constant	
LCXX	Constant		Constant	
JQRJ	Constant		Constant	
NTXX		Constant		Constant
YYXT		Increasing		Constant
ZGRJ		Decreasing		Decreasing
JZRJ	Constant		Constant	
BXBG	Constant		Constant	
BXRJ	Constant		Constant	
DRJT	Decreasing		Decreasing	
HSDZ	Decreasing		Decreasing	
LHGF	Constant		Constant	
YYRJ	Constant		Constant	
XSJ	Constant		Constant	
JDBT	Increasing		Increasing	
HLRJ	Constant		Constant	
SJXX	Constant		Constant	
GDSC		Increasing		Decreasing
DHRJ	Constant		Constant	

Data from: calculate the data after using DEA BCC according to genius financial database

different case-specific sources for innovation impulses and an extended conceptual framework for corporate innovation management and an advanced front-end innovation approach (Brem and Voigt, 2009). Industry management departments should make a series of development plans and adopt effective measures for low efficient enterprises to ensure a fast development of the whole industry.

EVALUATION RESULT TEST

An approach to treating data variations involves the characterization of the production function by way of classical statistical inference methodology (Cooper *et al*., 2001). Banker (1993, 1996) gave a statistical foundation of data envelopment analysis and conducted hypothesis test using data envelopment analysis. Data envelopment analysis was used to evaluate contextual variables affecting productivity and to analyze trends in technical and allocative efficiency afterwards (Banker and Natarajan, 2008; Banker *et al*., 2003). Stochastic DEA for restructure strategy was applied to a Japanese petroleum company (Sueyoshi, 2000). Others also applied statistical methods to corresponding performance evaluation of DEA (Pastor *et al*., 2002; Cooper *et al*., 2004; Horsky and Nelson, 2006; Tsionas and Papadakis, 2010).

Since the BCC models we apply have different emphases, evaluation results are also different. Here we use a comprehensive and integrated approach to test the mentioned evaluation results.

SABCB integrated approach measurement: In order to resolve the problem of multi-method evaluation inconsistency, many scholars use a variety of methods to build up an integrated portfolio. However, different

Table 8: Results based on SABCB Method

Integrated method	Synthetic average method		Borda method		Copeland method		Fuzzy Borda method	
Company name	Score	Ranking	Score	Ranking	Score	Ranking	Score	Ranking
CDZS	16.75	6	4	1	-10	3	114.8	6
LCXX	17.25	4	4	1	-10	3	127.6	4
JQRJ	16.5	8	4	1	-10	3	107.7	7
NTXX	4	16	3	16	-12	16	6.0	16
YYXT	2	18	1	18	-16	18	1.0	18
ZGRJ	1	19	0	19	-18	19	0.0	19
JZRJ	18	1	4	1	-10	3	138.0	1
BXBG	15.25	14	4	1	-10	3	73.0	14
BXRJ	15.25	14	4	1	-10	3	73.0	14
DRJT	16	10	4	1	-10	3	75.4	12
HSDZ	15.75	12	4	1	-8	2	81.7	11
LHGF	16.75	6	4	1	-5	1	107.2	8
YYRJ	16.25	9	4	1	-10	3	73.2	13
XSJ	17	5	4	1	-10	3	121.5	5
JDBT	15.75	12	4	1	-10	3	86.1	10
HLRJ	16	10	4	1	-10	3	93.2	9
SJXX	17.75	2	4	1	-10	3	136.4	2
GDSC	3	17	2	17	-14	17	3.0	17
DHRJ	17.5	3	4	1	-10	3	132.7	3

Data from: According to Table 3-Table 6

Table 9: Results based on Kendall's consistency coefficient test

N	4
Kendall's W	0.790
Chi-Square	56.905
df	18
Asymp. Sig.	0.000

Data from: Calculated by using the SPSS 17.0 according to Table 8.s

integration methods may lead to different evaluation values, which is likely to create new inconsistencies. To solve this problem, we should determine which combination of evaluation methods is more effective in what circumstances (Cooper *et al*., 2001). The relative effectiveness of the indicators which use a single DEA model is inadequate when evaluating DMUs. In order to achieve the complementary advantages among various methods and obtain more reasonable and scientific evaluation results, we combine Synthetic Average method, Borda method, Copeland method and fuzzy Borda method (SABCB method) to evaluate the results from the BCC model and its extended models. After acquiring the evaluation values of integrated measurement, we then obtain the results by the size of integrated measure value. Here we illustrate new assessment values of production efficiency shown in Table 8.

Measurement results test: Since the integrated evaluation is set up on the basis of single evaluation results, its scientific rationality depends on the rationality of these single evaluation results directly. We need to test these groups of evaluation results and decide their consistency. Only when the original method is consistent, will the integrated assessment method is effective. Thus, we should check its consistency before applying the integrated evaluation method. If there are a variety of sorting methods, we need to adopt Kendall consistency coefficient to examine the integrated evaluation method. The result shows that the Kendall's W coefficient is 0.790 (Table 9) and the approximate p-value of $\chi 2$ statistic is equal to 0, therefore the null hypothesis is rejected. The results of the four evaluation methods are consistent, which demonstrates that "excess capacity" has been first emerged in Chinese software industry. Due to the improvements in operational efficiency affected by "excess capacity", it is necessary to take macro-control to raise the threshold for entering the industry.

CONCLUSION

First of all, we establish an evaluation index system of production capacity and operational efficiency evaluation in Chinese software industry. This system will be incorporated into comprehensive evaluation system of the enterprises of this industry. Secondly, we should set up the evaluation index system scientifically through following the principles of combining systematic and unique evaluation as well as combining static and dynamic evaluation, then explore some innovation indicators, integrated indicators and system indicators which could analyze productivity and essential characteristics of them. Again, it is necessary to verify the results from comprehensive evaluation. We use multiple methods of comparison and analysis, including comparison with other studies, comparison among different methods as well as comparison with the actual effects, to establish the dynamic evaluation system to achieve the dynamic of "excess capacity" early warning.

We believe that Chinese software industry should participate in the international division of labor based on our own national conditions; national strength and comparative advantages. The industry should form a multi-faced development model that owns core technology, controls key technology and standards in all aspects of the industry, to win in some fields and play a leading role in the world. If Chinese software industry wants to make a competitive advantage, it is the key to continuing optimizing its industrial structure. We should utilize the opportunities from the financial crisis, attract high-level Chinese talents who are now working in developed countries and realize the rationalization and sophistication of industry structure gradually. We should give some deeper thoughts to make industry stronger, not just make it bigger.

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REFERENCES

Banker, R.D., 1993. Maximum likelihood, consistency and data envelopment analysis: A statistical foundation. Manag. Sci., 39(10): 1265-1273.

Banker, R.D., 1996. Hypothesis test using data envelopment analysis. J. Prod. Anal., 7(1): 139-159.

Banker, R.D. and R. Natarajan, 2008. Evaluating contextual variables affecting productivity using data envelopment analysis. Oper. Res., 56: 48-58.

Banker, R.D., A. Charnes and W.W. Cooper, 1984. Some models for estimating technical and scale inefficiencies in data envelopment analysis. Manag. Sci., 30(9): 1078-92.

Banker, R.D., S. Janakiraman and R. Natarajan, 2003. Analysis of trends in technical and allocative efficiency: An application to Texas public school districts. Eur. J. Oper. Res., 154(2): 477-491.

Banker, R.D., W.W. Cooper, L.M. Seiford, R.M. Thrall and J. Zhu, 2004. Returns to scale in different DEA model. Eur. J. Oper. Res., 154: 345-362.

Brem, A. and K.I. Voigt, 2009. Integration of market pull and technology push in the corporate front end and innovation management: Insights from the German software industry. Technovation, 29(5): 351-67.

Charnes, A., W. Cooper and E. Rhodes, 1978. Measuring the efficiency of decision-making units. Eur. J. Oper. Res., 2(6): 429-44.

Chen, J.X., M.R. Deng and S. Gingras, 2011. A modified super-efficiency measure based on simultaneous input–output projection in data envelopment analysis. Comput. Oper. Res., 38(2): 496-504.

Cook, W.D. and L.M. Seiford, 2009. Data Envelopment Analysis (DEA): Thirty years on. Eur. J. Oper. Res., 192(1): 1-17.

Cooper, W.W., S. Li, L.M. Seiford, K. Tone, R.M. Thrall and J. Zhu, 2001. Sensitivity and stability analysis in DEA: Some recent developments. J. Prod. Anal., 15(3): 217-46.

Cooper, W.W., H. Deng, Z.M. Huang and S.X. Li, 2004. Chance constrained programming approaches to congestion in stochastic data envelopment analysis. Eur. J. Oper. Res., 155(2): 487-501.

Hauglanda, S.A., I. Myrtveitb and A. Nygaardc, 2007. Market orientation and performance in the service industry: A data envelopment analysis. J. Bus. Res., 60(11): 1191-7.

Horsky, D. and P. Nelson, 2006. Testing the statistical significance of linear programming estimators. Manag. Sci., 52(1): 128-35.

Léger, P.M. and Q. Louis, 2009. Post-merger performance in the software industry: The impact of characteristics of the software product portfolio. Technovation, 29(10): 704-13.

Pastor, J.T., J.L. Ruiz and I. Sirvent, 2002. A statistical test for nested radial DEA models. Oper. Res., 50(4): 728-35.

Sueyoshi, T., 2000. Stochastic DEA for restructure strategy: An application to a Japanese petroleum company. OMEGA-Int. J. Manag. Sci., 28(4): 385-98.

Toledo-López, A., R. Díaz-Pichardo, J.C. Jiménez-Castañeda and P.S. Sánchez-Medina, 2012. Defining success in subsistence businesses. J. Bus. Res., DOI: 10.1016/j.jbusres.2012.02.006.

Tsionas, E.G. and E.N. Papadakis, 2010. A Bayesian approach to statistical inference in stochastic DEA. OMEGA-Int. J. Manag. Sci., 38(5): 309-14.