REEVALUATION OF PROVINCIAL ENERGY EFFICIENCY IN CHINA INCORPOATING HUMAN CAPITAL STOCK

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Overview

As one of the most cost-effective ways to saving energy and promoting low-carbon development, the accurate measurement of energy efficiency has great significance to the future direction of China's economic development. At present, measuring the energy efficiency has caught the attention of academics and policy makers. However, under the energy efficiency framework, the majority of existing literatures pay more attention to the treatment of undesirable output than that of the input variables. Especially, concerning the selection of labor input, the existing analysis generally use the number of employees as labor input, reflecting only quantitative labor information and ignoring the knowledge and skill embodied in workers; these traits embody human capital as defined in endogenous growth theory. Moreover, regarding to the undesirable output choosen, most studies just involve the CO_2, SO_2 emissions in the energy efficiency measurement, which may influence the accuracy of the energy efficiency measurement.

Obviously, the selection of the input-output indicators is critical to the accuracy of the results from the energy efficiency measurement framework. The human capital is wildly used as input factor in the classic Cobb-Douglas production function and caught attention in the filed of economic growth, resource utilization and environmental protection. However, to the best of our knowledge, human capital rarely receives attention as an input factor in the energy efficiency framework. So in this paper, under the super-efficiency DEA and Malmquist method framework, we regard the human capital stock as labor input, and a more comprehensive environmental pollution indicator as undesirable output to measure the energy efficiency of Chinese 29 provinces during the period of 2003-2011. Moreover, we compare the energy efficiency difference between the human capital and employee as labor input respectively.

Methods

In order to solve one possible consequence that multiple DMUs are in the frontier, making it impossible to judge which DMU performances best, in this paper, we adopt the super-efficiency DEA model to evaluate the energy efficiency, making the relative effective DMUs compare between each other possible.

Due to the super-efficiency DEA method can only reflect relative efficiency value of different provinces for a single year, unable to examine the efficiency changes in different time, in nature a kind of static analysis. While Malmquist Index method can be used to measure the efficiency changes in total factor productivity across time. The Malmquist Index can also be decomposed into technical efficiency change component and technological change component to clarify which contributes more in the dynamic energy efficiency performance.

Results

- The static energy efficiency (EE_2) regarding the employee as labor input presents difference between static energy efficiency (EE_1) when incorporating human capital as labor input respectively.
    - From the national perspective, the average static EE_1 score (0.990) is higher than static EE_2 (0.982), both failing to reach the production frontier.
    - In the eastern region, most provinces' static energy efficiency scores are above 1, and the EE_1, which ranges from 1.088 (2003) to 1.120 (2011), is catching up to EE_2 gradually.

- In the central region, most static energy efficiency scores are below 1. And the static EE_1 performance presents similar trend with static EE_2, at first, exists a catching-up effect, then surpass eventually.
- In the west region, the static EE_1 performance always better than static EE_2.

- In general, national static EE_1 has increased performance in the periods 2003-2008 and 2010-2011, and decreased performance in the periods 2008-2010.
- From a regional view, it can be found that the static EE_1 of east area increases in wave mode, while that of the central and west areas presents inverted-S shape and inversed-U shape respectively. The static EE_1 of central area gradually catches up with east area, and the efficiency gap between west area and east/central area decreases in wavy mode. The east region performs best while the central region performs worst in static EE_1.
- There exists σ convergence of the static EE_1 at the national level and different areas have different characteristics of divergence.
  - During the periods of 2003-2004 and 2007-2008, the static EE_1 gap of various provinces is gradually expanding and tend to be divergent, while during the periods of 2004-2007 and 2008-2011, the static EE_1 gap between regions is narrowing and presenting a trend of convergence.
  - The internal static EE_1 gap of the western region is the largest while that of the central region presents the smallest.
- The technological change contributes more apparently than the technical efficiency change dynamic energy efficiency performance.
  - The Malmquist index as a whole experiences a negative change (=0.957) during the sample period.
  - Among the 29 provinces, 21 provinces show increase in annual efficiency score, which reveals that these provinces are successful in catching up the frontier of best practice, while other 8 provinces fail to catch up with the production frontier.
  - All the provinces as a whole had a drop in their technology change scores over time, which means most of the provinces have negative shift in technology.

Conclusions

The static energy efficiency (EE_2) regarding the employee as labor input presents difference between static energy efficiency (EE_1) when incorporating human capital as labor input respectively, which can prove the point in this paper that even though the same number of employees, the personal ability to accept education and training is different, their effect on productivity and efficiency in the real production process is different obviously. The national level static EE_1 has increased performance in the periods 2003-2008 and 2010-2011, and performance decreases in the periods 2008-2010. The EE_1 performance shows diversity among the east, central and western regions.
Moreover, the σ convergence of static EE_1 shows diversity at the national and the three major regional levels. And technological change makes greater contribution than the efficiency change in the dynamic EE_1 performance.
Actually, except for technological change and efficiency change, there are also some other factors which may influence the regional efficiency difference, further research in the aspect of influencing factors can be carried out in empirical analysis.

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