# Efficiency Analysis of China's Economy Growth during 1981 – 2011

-From the perspective of sustainable development

Pinsan Xiong
Dongling School of Economics and Management
University of Science and Technology Beijing
BeiJing, China

***Abstract*—From the perspective of sustainable development and considering energy and environmental, this article applies Data Envelopment Analysis based on variable returns to scale to analyze the efficiency of China's economic growth from 1981 to 2011. From analysis we can know that (technical) efficiency of China's economic growth is relatively obvious from the 1980s to the early 1990s, but the efficiency has an unobvious improvement since the late 1990s. In fact, including capital, labor, energy and environmental, the efficiency not only reflected the economic growth, but also showed the sustainable development of China's economic. As a result, China's economy still not run out of "extensive" growth, and changing economic growth mode still has a long road.**

***Keywords- China's Economy; Efficiency Analysis; Energy and Environmental***

## I. INTRODUCTION

In the condition of limited resources and fragile eco-environment, people have been constantly thinking about how to achieve sustainable development. Energy shortage and environmental pollution is getting worse in China, and has become the biggest obstacle for sustainable economic development. Thus, considering energy consumption and environmental pollution, and evaluating the efficiency of China's economy growth, is very important to adjusting China's economy and achieving sustainable development.

Efficiency is used to examine the relationship between input and output indicators. In 1957, based on the study of optimal utilization of resources by Gerard Debreu (1952) and Tjalling Koopmans (1951), Michael Farrell decomposed efficiency into two components through the model of variable returns to scale. Technical Efficiency (TE) reflects the maximum output capacity under given input or the minimum input capacity under given output, and allocative Efficiency (AE) reflects the best mix capacity of elements input under given prices. In 1993, Knox Lovell and Peter Schmid have defined technical efficiency as the capacity of maximum output under given input or minimum input under given output, which has laid the foundation of method's development of efficiency measure.

In condition of single input and single output, efficiency is often described as the ratio of output and input. In condition of multiple inputs and multiple outputs, efficiency is general showed as the ratio of collective outputs and collective inputs, which also known as Total Factor Productivity (TFP). Presently, methods of measuring efficiency with multiple outputs and inputs used commonly Stochastic Frontiers Analysis (SFA) which based on random frontier production function, Data Envelopment Analysis (DEA) which based on non-parametric frontier, Malmquist Index Analysis which based on panel data and so on. Generally, using SFA to estimate efficiency requires a strict function forms and distribution assumptions. In contrast, DEA based non-parametric frontier doesn't require specific functional forms and indicators processing and used more widely in efficiency evaluating of multiple outputs and inputs.

## II. MODEL AND DATA

In 1978, Abraham Charnes etc proposed DEA based on non-parametric frontier to analyze efficiency. In 1984, R.D. Banker, A. Charnes and W.W. Cooper proposed the model of BC2, which based on variable returns to scale. The method is based on the evaluation which was set up by economist Farell private enterprise evaluation work, to project on a single input and single output developed on the basis of the concept of efficient , for the evaluation of multiple output system developed on the basis of the relative effectiveness of efficiency evaluation method. The method mainly is unchanged by the people or output decision unit, with the aid of mathematical programming the DMU projection to the DEA frontier, and by comparing the deviation from the frontier of decision making unit DEA to evaluate their relative effectiveness. Compared with the traditional method, DEA has the following advantages:

1.DEA dedicated to the optimization of each decision making unit . By means of N optimization operation for each DMU(suppose you have n DMU). rather than to a collection of DMU whole single optimization, in order to get the evaluation more practical value.

2.The weight of DEA to all decision making units of the input and output index as a variable (known as the variables) were evaluated by means of operation, rather than the subjective judgment or other methods to determine the weight of index, so then to avoid the weight error, which makes the evaluation results more objective.

3.The DEA method can be directly used statistical computing, unlike the general statistical evaluation model, which need to index system of index to define or correlation analysis in advance, so as to avoiding the establishment of evaluation index system and a certain investment index of a

 

to output indicators of the contribution rate of complex mental labor, what make the evaluation the method more concise and easy to operate.

4.The DEA method is emphasized in the assessment of population condition of decision-making unit. The "effective" production frontier analysis, rather than the general statistical model that focuses on the average state description, which makes the research results more "ideal".

5.DEA through the "best" DMU subset selection, can provide many effective plan management information for decision makers, so as to make the effectively seek in the "production" plan and determine the purpose of reducing the input index and output index number for a raise.

6.Application of different DEA models, it can be given the same drilling conditions of each DMU is effective management, technology or the original domain effectively different evaluation results, which makes the evaluation activities to further refinement.

Because of the characteristics of DEA, DEA has a very broad application areas in the reform of China's political system, economic system and technology system,DEA plays an important role at the improvement of China's macro management and macro-control efficiency.

In this model, there are n of decision making units (*DMU*), and each decision making unit has *m* types of input and *s* types of output. Using $x_{ij}$ and $y_{rj}$ represent respectively the input *i* and output *r* of $DMU_j$. The basic linear Planning expression as follows:

$$\begin{cases} \theta^* = \min[\theta - (\sum_{i=1}^{m} S^-{}_i + \sum_{r=1}^{s} S^+{}_r)] \\ S.t \begin{cases} \sum_{j=1}^{n} X_j \lambda_j + S^- = \theta X_0, S^- \geq \\ \sum_{j=1}^{n} Y_j \lambda_j - S^+ = Y_0, S^+ \geq 0 \\ \sum_{j=1}^{n} \lambda_j = 10, \lambda_j \geq 0, j = 1, 2..., n \end{cases} \end{cases}$$

Where, $X_j = (x_{1j}, x_{2j}, \ldots, x_{mj})^T$ and $Y_j = (y_{1j}, y_{2j}, \ldots, y_{sj})^T$ represent input and output of $DMU_j$ respectively, $X_0$ and $Y_0$ represent input and output of *DMU* evaluated respectively, $S^-$ is the slack of input and $S^+$ is the slack of output, and $\lambda$ is Coefficient of *DMU*.

In the model, the conditions for Pareto Effective are $\theta^*=1$ and $S^-= S^+=0$. Compared with decision making units of DEA efficiency, the relatively efficiency of other decision making units can be calculated. Three types of relative efficiency will be computed by the model. They are technical efficiency (*TE*), pure technical efficiency (*P*E) and scale efficiency (*SE*), where technical efficiency is the product of pure technical efficiency and scale efficiency.

In order to analyze the efficiency of China's economic growth, we select four indicators of input and one indicator of output. Output indicator is each year's GDP from 1981 to 2011, which is represented by Y (a hundred million Yuan). Input indicators are: the fixed assets of society and represented by K (a hundred million Yuan), the average employees of society and represented by L (ten thousand people), the total energy consumption and represented by E (ten thousand tons of coal), the total environment pollution caused by energy consumption and represented by P (ten thousand tons). Considering the statistics' difficult of environmental pollution caused by energy consumption, using "CO2" emissions instead in this paper. All data used is from ECI and database of IMF.

TABLE I. DATA OF INPUTS AND OUTPUTS

| Time | *E* | *L* | *K* | *P* | *GDP* |
|---|---|---|---|---|---|
| 1981 | *60275* | *42361* | *29474* | *146599* | *9661* |
| 1982 | *59447* | *43725* | *29998* | *145031* | *9671* |
| 1983 | *62067* | *45295* | *30955* | *157897* | *10268* |
| 1984 | *66040* | *46436* | *32441* | *166567* | *11276* |
| 1985 | *70904* | *48197* | *34471* | *181342* | *13363* |
| 1986 | *76682* | *49873* | *37475* | *196495* | *16276* |
| 1987 | *80850* | *51282* | *40973* | *206728* | *16971* |
| 1988 | *86632* | *52783* | *44564* | *220790* | *18701* |
| 1989 | *92997* | *54334* | *48309* | *236756* | *21741* |
| 1990 | *96934* | *55329* | *50832* | *240657* | *20672* |
| 1991 | *98703* | *64749* | *53120* | *245873* | *19247* |
| 1992 | *103783* | *65491* | *56058* | *258242* | *21782* |
| 1993 | *109170* | *66152* | *60263* | *269378* | *25304* |
| 1994 | *115993* | *66808* | *66210* | *287634* | *28953* |
| 1995 | *122737* | *67455* | *73478* | *305574* | *31824* |
| 1996 | *131176* | *68065* | *81539* | *331757* | *34279* |
| 1997 | *135192* | *68950* | *90378* | *346026* | *37057* |
| 1998 | *135909* | *69820* | *99684* | *346667* | *39997* |
| 1999 | *136184* | *70637* | *110481* | *332163* | *43091* |
| 2000 | *140569* | *71394* | *121608* | *331533* | *46434* |
| 2001 | *145531* | *72085* | *133684* | *340231* | *51168* |
| 2002 | *150406* | *73025* | *147447* | *348451* | *56159* |
| 2003 | *159431* | *73740* | *163923* | *369102* | *62125* |
| 2004 | *183792* | *74432* | *185537* | *434324* | *69290* |
| 2005 | *213456* | *75200* | *212072* | *509057* | *78501* |
| 2006 | *235997* | *75825* | *245878* | *560948* | *89199* |
| 2007 | *258676* | *76400* | *287797* | *610828* | *102791* |
| 2008 | *280508* | *76990* | *338551* | *653302* | *120526* |
| 2009 | *291448* | *77480* | *396897* | *698729* | *134464* |
| 2010 | *306647* | *77995* | *477275* | *747316* | *146993* |
| 2011 | *325000* | *78540* | *573196* | *799281* | *166123* |

## III. EMPIRICAL ANALYSIS

Overall, from 1981 to 2011, TEC, PE and SE of China's economic growth have changed little and are relatively stable with no big gap, which reach at 93.7%, 97.4% and 96.2% of the optimal state on average. Before 1995, technical efficiency of economic growth has fluctuations more and frequent, but which become less volatile and more stable after 1995.

PE of economic growth is low in 1990, 1991 and 1992, which reach at 0.912, 0.818 and 0.876 respectively. In other years, pure technical efficiency is relatively high, especially after 1994, which has been remained at a high level (>0.97). SE of economic growth has rose 4.88% on average from 1982 to 1989, and reached at the optimal state in 1989. From then on, Scale efficiency has been maintained at very high levels (>0.99), and changed little.

Generally, the change of technical efficiency of China's economic growth is relatively stable from 1981 to 2011, and with an annual raise 1.18%. From 1982 to 1988, economic growth and technical efficiency are also at the stage of rapid increasing basically, and the average annual raise of 4.97%. In 1990 and 1991, technical efficiency had a sharp decline, and reached at 8.90% and 10.42% respectively. In 1994 and 1995, technical efficiency had return to the level of 1989, and changed little in following years. Overall, the years of technical efficiency reach at the optimal state are 1989, 1994, 1995, 2003, 2005, 2009 and 2011.

TABLE II. EFFICIENCY OF CHINA'S ECONOMIC GROWTH

| Time | *TEC* | *PE* | *SE* |
|---|---|---|---|
| 1981 | *0.728* | *1.000* | *0.728* |
| 1982 | *0.719* | *1.000* | *0.719* |
| 1983 | *0.737* | *0.968* | *0.761* |
| 1984 | *0.772* | *0.936* | *0.825* |
| 1985 | *0.861* | *0.969* | *0.889* |
| 1986 | *0.965* | *1.000* | *0.965* |
| 1987 | *0.920* | *0.950* | *0.968* |
| 1988 | *0.932* | *0.948* | *0.984* |
| 1989 | *1.000* | *1.000* | *1.000* |
| 1990 | *0.911* | *0.912* | *0.999* |
| 1991 | *0.816* | *0.818* | *0.998* |
| 1992 | *0.876* | *0.876* | *1.000* |
| 1993 | *0.954* | *0.954* | *1.000* |
| 1994 | *1.000* | *1.000* | *1.000* |
| 1995 | *1.000* | *1.000* | *1.000* |
| 1996 | *0.992* | *0.992* | *0.999* |
| 1997 | *0.986* | *0.988* | *0.998* |
| 1998 | *0.983* | *0.985* | *0.998* |
| 1999 | *0.977* | *0.977* | *1.000* |
| 2000 | *0.973* | *0.974* | *0.999* |
| 2001 | *0.988* | *0.989* | *0.999* |
| 2002 | *0.997* | *0.998* | *0.998* |
| 2003 | *1.000* | *1.000* | *1.000* |
| 2004 | *0.997* | *0.997* | *0.999* |
| 2005 | *1.000* | *1.000* | *1.000* |
| 2006 | *0.994* | *0.994* | *1.000* |
| 2007 | *0.991* | *0.992* | *1.000* |
| 2008 | *1.000* | *1.000* | *1.000* |
| 2009 | *1.000* | *1.000* | *1.000* |
| 2010 | *0.987* | *0.987* | *1.000* |
| 2011 | *1.000* | *1.000* | *1.000* |

## IV. CONCLUSION

From analysis we can know that (technical) efficiency of China's economic growth is relatively obvious from the 1980s to the early 1990s, and has a 2.71% improvement on average every year. Since the late 1990s, the efficiency has an unobvious improvement, and with a number of 0.003% annually. On the other hand, the efficiency of China's economic growth in 2011 is the same with 1994 and 1995, which means the efficiency of China's economic growth without any increase since 1996. The result is very different with that calculated based on single factor of energy.

From the perspective of factor input, even though energy consumption of China's economic growth has dropped a lot driven by the policy in recent years, but the corresponding inputs of the other factors also increased a lot. Unit of GDP energy consumption decreased, but capital investment increased, emissions of pollutants increased, especially the rapid growth of capital investment, making the efficiency improvement based on multi-factor calculation is not obvious. In addition, during a long time, China's industry structure model of depending on industry and demand structure model of depending on export and investment, which lead to depending of the economic growth on energy consumption and environment pollution, and affect the efficiency improvement of economic growth.

In fact, including capital, labor, energy and environmental, the efficiency not only reflected the economic growth, but also showed the sustainable development of China's economic. As a result, we can see that, China's economic development relies mainly on large input of resources since the late 1990s rather than on the driving of productivity improvement. In other words, China's economy still not run out of "extensive" growth, and changing economic growth mode still has a long road.

## REFERENCES

[1] D.J.Aigner, C.A.K.Lovell, P.Schmidt, “Formulation and estimation of empirical application function on models,” Journal of Econometrics, vol.6,1st, 1977, pp.21-37.

[2] R.D.Banker, A.Charnes, W.W.Cooper, “Some models for estimating technical and scale inefficiencies in data envelopment analysis,” Management Science, vol.30, 9th, 1984, pp.1078-1092.

[3] A.Charnes, W.W.Cooper, E.Rhodes, “Measuring the efficiency of decision making units,” Europe Journal Operational Research, 2nd, 1978, pp.429-444.

[4] D.W.Caves, L.R. Christensen, W.E.Diewert, “The Economic Theory of Index Numbers and the Measurement of Input, Output, and Productivity,” Econometrica, vol.5o, 6th, 1982, pp.1393-1414.

[5] C.J.O'Donnell, “DPIN Version 1.0: A Program for Decomposing Productivity Index Numbers,” Centre for Efficiency and Productivity Analysis Working Papers, University of Queensland, 2010.

[6] M.J. Farrell, “The measurement of Productive Efficiency”, Journal of the Royal Statistical Society Series A, 3th., 1957, pp. 253-290.

[7] Gerard Debreu, “The Coefficient of Resource Utilization”, Econometrics, 1951, (3), 273-292.

[8] T.C. Koopmans, “Efficient Allocation of Resources”, Econometrics, 4th, 1951, pp.455-465.

[9] K.C.A. Lovell, Peter Schmidt, “The Measurement of Productive Efficiency”, New York: Oxford University Press, 1993.