

Efficiency Evaluation of China's New Rural Cooperative Medical System Using DEA method

Wei Zheng (Peking University, China)

Chunyan Zhang (University of Wisconsin-Madison, USA)

Abstract: Health insurance is the key to providing people with protections against physical and financial losses caused by illnesses. However, in many developing countries, there are rarely any commercial health insurance provided to the low-income class, especially those who are living in rural areas and those who cannot afford the high premium. In 2003, China initiated the New Rural Cooperative Medical System (NRCMS). It is a heavily subsidized voluntary health insurance program to reduce the financial risk from catastrophic diseases in rural China. In this study we apply the Data Envelopment Analysis (DEA) method to evaluating the relative efficiency of NRCMS in different provinces and regions of China. We find that NRCMS in the east, central and west China shows different patterns of inefficiency. At the end of the paper, we suggest approaches that the government can use to improve the NRCMS.

Keywords: new rural cooperative medical System, data envelopment analysis, technical efficiency

1. Introduction

1.1 China's Cooperative Medical System

China's old Rural Cooperative Medical System (RCMS) was established in the 1950s by agricultural collectives, farmers and local physicians. This system was inadequately funded due to low governmental subsidies and low premiums paid by farmers. It once covered more than 90% of the rural population in mid 1970s (Feng et al. 1995). However, as the rural economy structure fundamentally changed from collective agriculture to the household responsibility system in 1980s, the system lost its economic foundation in the rural area. The coverage rate shrank to only 9.5% in 1998 (Liu 2004). Without adequate rural health insurance, the problems of illness and low accessibility to health care in rural areas have become the major concern of the public and the government.

In 2003, the pilot program of New Rural Cooperative Medical System (NRCMS) started in some areas in China and gradually became a national program. It is a heavily-subsidized, voluntary health insurance program to reduce the financial risk from catastrophic diseases in rural China. According to "Opinions on the Establishment of New Rural Cooperative Medical Care System (2003)" prepared by the Ministry of Health and the Ministry of Finance of China, NRCMS is managed by local governmental institutions. A medical aid system is also established, making the cooperative medical service affordable to poverty-stricken rural residents through exempting them from co-payment of medical service or making them eligible for subsidized premiums. In addition, rural cooperative medical supervision

commissions and audit departments are set up to supervise the efficiency of the system.

There are three significant differences between the old system and new system: First, NRCMS is financed on the county level rather than on the small village-level as the old system was financed. Counties have the flexibility to make their own policies while following the basic rules of the system. Second, NRCMS focuses on large medical expenditure and inpatient medical expenditure, while the old RCMS focused on prevention and outpatient service. Third, the government plays an important role in NRCMS. The old system was financed by village collectives and farmers, with very limited government financial supports. In NRCMS, the central government and the local governments (including provincial government, municipal government, county government and township government) heavily subsidize the system every year with guidelines from the central government, thus the premium paid by farmers can be as low as 10 RMB in most counties. Table 1.1 is an example of Xiangtan City, which is a city with 4 counties (including 2 county-level cities) in Hunan Province in middle south China. This table shows that the subsidies from the governments take a large proportion of the fund and increases from 20 RMB in 2005 to 80 RMB in 2009.

Table 1.1 Financing structure of NRCMS in Xiangtan City (RMB) 2005-2009

| Year | Farmer | Local* Governments | Central Government | Total |
|------|--------|--------------------|--------------------|-------|
| 2005 | 10 | 10 | 10 | 30 |
| 2006 | 10 | 20 | 20 | 50 |
| 2007 | 10 | 20 | 20 | 50 |
| 2008 | 10 | 30 | 40 | 80 |
| 2009 | 20 | 40 | 40 | 100 |

Data source: NRCMS Annual Report of Xiangtan, 2009

* Local governments include the provincial government, the municipal government, and the county government. The subsidy weights are 3:1:1 in Xiangtan in 2009.

By the end of 2008, the number of counties that participated in NRCMS has reached 2,729, covering a rural population of 815 million, with a coverage rate of 91.5%. The number of beneficiaries of reimbursement in 2008 was 585 million, which is 71.8% of the enrollees. In the same year, the total fund raised was 78.5 billion RMB and the payout was 66.2 billion RMB¹ (Ministry of Health of China 2009).

Like in any other health system, the policy maker would like to make good use of all the resources, which can be measured by “technical efficiency” (TE, also termed overall technical efficiency), that is, achieving better results (outputs) with minimal costs (inputs) (Farrell 1957). However, there are limited literatures that evaluate the efficiency of China’s NRCMS. Based on a survey conducted by a research team at the Chinese Academy of Social Sciences, Wang (2007) concluded that the new rural medical system has been successful up to now but also has some problems, such as high financing costs and limited benefits. Some researchers tried to establish comprehensive evaluation indices for NRCMS, such as feasibility and validity indices (Du 2006; Wang 2004; Wang 2005), and multiple evaluation system (Li 2007). However, to our knowledge, no national efficiency evaluation work has been presented. Evaluating the efficiency of the NRCMS is important to both the government and people who are covered in this system. This will help government learn from the past and modify the program to make it more efficient and sustainable.

1.2 Overview of DEA

¹ The average annual exchange rate was: 1 dollar=8.19 RMB in 2005, 1 dollar=7.81 RMB in 2006, 1 dollar=7.52 RMB in 2007, and 1 dollar=6.94 RMB in 2008. Data source: Website of People’s Bank of China.

In this paper we will use the Data Envelopment Analysis (DEA) method to study the relative efficiency of NRCMS in different provinces and regions of China. The non-parametric technique, DEA, is a useful tool to estimate the efficiency of a multi-input and multi-output system. The common way to evaluate the efficiency of a system is to construct an efficiency frontier and then use the linear combinations of observed inputs and outputs to estimate the efficiency frontier, which was first introduced by Charnes et al. (Charnes, Cooper, and Rhodes 1978, 1981, 1979; Banker 1984; Charnes et al. 1985), built on the early work of Farrell (Farrell 1957; Farrell and Fieldhouse 1962). DEA has marked advantages over the traditionally used ratio analysis and regression techniques. DEA can handle multiple-input and multiple-output models without requiring the assumption of a functional form relating inputs to outputs, and inputs and outputs can have very different units. (Sherman 1984).

Now DEA has been applied to various fields, such as project evaluation, policy evaluation in education systems(Ahn, Charnes, and Cooper 1988), energy sector(Ramanathan 2005), health sector(Sherman 1984), military service (A. Charnes 1984), and so forth. DEA is especially useful for evaluations of non-profit public programs (Charnes et al. 1985). Sherman (1984) performed a field-test of DEA by applying it to seven teaching hospitals in Massachusetts, and suggested that DEA can help identify and measure hospital inefficiency, providing a basis for directing management efforts toward increasing efficiency and reducing health care costs. Since then, there have been many literatures that used DEA to evaluate health systems or programs such as hospitals (Ozcan, Luke, and Haksever 1992; Grosskopf and Valdmanis 1987; O'Neill 1997; Hao and Pegels 1994), Health Maintenance Organizations (HMOs) (Rosenman, Siddharthan, and Ahern 1997; Brockett et al. 2004), and nursing homes

(Nyman and Bricker 1989), etc. Huang and McLaughlin (1989) applied DEA to evaluation of US rural primary health care programs. They compared DEA results with those from ratio analysis and regression analysis, and concluded that DEA can directly identify those efficient/inefficient units.

Our work is the first effort to evaluate the technical efficiency of China's NRCMS using DEA. The remainder of the paper is organized as follows. In Section Two we will introduce the methodologies we want to utilize. In Section Three, we will give a short description of the data we use. The Fourth Section includes the results and discussion. The indices from the models and their correlations with the policy and economic characteristics will be examined. Based on the results, we will also make some policy suggestions. The last Section is the conclusion.

2. Methods

DEA uses linear programming (LP) techniques to find the frontier, and measures the inefficient decision making units (DMU) by comparing them with more efficient units. A DMU is a producer or organization which uses inputs to produce outputs. All the DMUs are homogeneous and have common inputs and outputs. Efficiency is defined as the ratio of a weighted sum of outputs to a weighted sum of inputs, where the weights structure is calculated by LP. Therefore the efficiency we address here is relative efficiency, i.e., there should be at least one efficient DMU. In addition, DEA evaluates the efficiency by comparing the outputs produced and inputs used by DMUs, so the efficiency here is called technical efficiency, which is consistent with the efficiency concepts in engineering and economics.

For a DMU in a system with m inputs x and s outputs y , the efficiency is:

$$E = \frac{\sum_{r=1}^s u_r y_r}{\sum_{i=1}^m v_i x_i}, \quad (1)$$

where v_i is the weight for input x_i and u_r is the weight for output y_r . A DMU is inefficient if it could have produced more outputs with the given inputs, or if it could have used fewer inputs to produce the same level of outputs. According to equation (1), a DMU whose technical efficiency score is less than 1 ($TE < 1$) is inefficient.

The basic DEA models include the CCR model (Charnes, Cooper, and Rhodes 1978) and the BCC model (Banker, Charnes, and Cooper 1984). The two models are different in the assumption of return to scale: the former assumes constant return to scale (CRS) and the latter assumes variable return to scale (VRS). The following is the (input-oriented) CCR model:

LP:

$$\begin{aligned} \max_{v,u} \quad & \theta = \frac{u'y_0}{v'x_0} \\ \text{s.t.} \quad & \frac{u'Y}{v'X} \leq 1 \\ & v, u \geq 0 \end{aligned}$$

Dual Problem:

$$\begin{aligned} \min_{\lambda, \theta, s^-, s^+} \quad & \theta \\ \text{s.t.} \quad & \theta x_0 - X\lambda - s^- = 0 \\ & Y\lambda - s^+ = Y_0 \\ & \lambda, s^-, s^+ \geq 0, \end{aligned} \quad (2)$$

where θ is the efficiency score. x_0 is an m -dimensional input vector and y_0 is an s -dimensional output vector for the unit we evaluated. X is an $m \times n$ matrix of inputs and Y is an $s \times n$ matrix of outputs. v and u are vectors of weights for input vectors and output vectors, respectively. s^- and s^+ are the slacks of the inputs and outputs, which measure how far the inputs or outputs are from the ideal values when the DMU is efficient.

The $n \times 1$ vector λ denotes the weights of the efficient peers in the reference unit. The BCC model has one more constrain: $e'\lambda = 1$, where e is a vector of ones. Conveniently, we can use $e'\lambda$ to check the returns to scale property of each DMU. If $e'\lambda < 1$, then the DMU is increasing returns in scale; if $e'\lambda = 1$, then the DMU is constant returns to scale; if $e'\lambda > 1$, the DMU is decreasing returns to scale.(Banker, Charnes, and Cooper 1984)

There are many extended DEA models nowadays to meet the nature of different production-technologies. In general, these models differ in their orientations (input-oriented, output-oriented, non-oriented, etc.), returns to scale (CRS, VRS, etc.), types of measure (slack-based, Radial measure, etc.), and so forth.² Input-oriented efficiency measurement compares the actual input level for a given DMU to the best practice input level, holding the outputs constant, and vice versa. The choice of orientation depends mainly on the extent to which inputs, outputs or both are controllable. We will apply the non-oriented model because of our concern for both minimization of the cost and maximization of the output. The dual problem of this type of model is(Cooper, Thompson, and Thrall 1996):

$$\begin{aligned}
 & \min_{\lambda, \theta, \phi, s^-, s^+} \theta / \phi \\
 & s.t. \quad \theta x_0 - X\lambda - s^- = 0 \\
 & \quad \quad Y\lambda - \phi y_0 - s^+ = Y_0 \\
 & \quad \quad \lambda, s^-, s^+ \geq 0,
 \end{aligned} \tag{3}$$

where ϕ is the scalar index for the output of the DMU we are evaluating. This model allows all inputs and outputs to vary simultaneously in the proportions prescribed by θ and ϕ .

In this paper, we will also study the two components of technical efficiency (TE): pure

² A list of most of the models is available from <http://www.deazone.com/models/index.htm>.

technical efficiency (PTE) and scale efficiency (SE). TE scores can be obtained from the CCR model (Charnes, Cooper, and Rhodes 1978). PTE can be obtained from the BCC model (Banker, Charnes, and Cooper 1984), and we obtain SE by $SE=TE/PTE$. TE measures how efficient the input resources are utilized with the given techniques. PTE reflects the efficiency without impact of scale. The scale efficiency measures the impact of scale size on the productivity of the assessed unit. When the scale efficiency is low, it means the impact of scale size on productivity is more adverse. Low PTE can be improved by controlling the input level or expanding the output level, while low SE can be improved by changing the structure of inputs. Note that when using the same data set, the CCR-Input, CCR-Output and CCR-Non-oriented models have the same efficiency value, but different slacks and weights.

However, when there are excessive inputs and outputs as opposed to observations, a considerable number of observations may be characterized as efficient. To overcome this weakness and rank the DMUs, we will use the super-efficiency model developed by Andersen and Petersen(1993). The difference between the super-efficiency model and basic-efficiency model is that in the super-efficiency model, the DMU_0 , or the DMU evaluated, is eliminated from the reference set. So problem (3) becomes

$$\begin{aligned}
 & \min_{\lambda, \theta, \phi, s^-, s^+} \theta / \phi \\
 & s.t. \quad \theta x_0 - \lambda \sum_{j=1, \neq 0}^n x_j - s^- = 0 \\
 & \quad \lambda \sum_{j=1, \neq 0}^n y_j - \phi y_0 - s^+ = Y_0 \\
 & \quad \lambda, s^-, s^+ \geq 0 \quad .
 \end{aligned} \tag{4}$$

Since the reference set excludes the evaluated DMU, the DMU which has a technical

efficiency score equal to 1 will have a score equal or larger than 1. For example, a DMU which has a score of 1.10 means even if this DMU increases its input by 10 percent, it will still be evaluated as efficient. Because inefficient units do not alter the efficient frontier, the technical scores of inefficient units are the same in the super-efficiency DEA model as in standard DEA models. Thus the ranking of all DMUs can be obtained by the super-efficiency model. One problem of the super-efficiency DEA model is that it may be infeasible when the assumption other than CRS is applied or when there is a zero in dataset (Zhu 1996; Seiford and Zhu 1999). However, in our study, this problem is eliminated when we use non-oriented model developed by Cooper, Thompson and Thrall (1996).

We will use the super-efficiency models (namely super-CCR and super-BCC model) to get the efficiency scores. The traditional CCR model and BCC model are use included as complementary models to support our analysis. A second-stage analysis is applied after we have the efficiency scores from both standard DEA and super-efficiency DEA models. We will also use Tobit and OLS regressions to identify the environmental variables that influence the efficiency scores. We will apply Tobit regression to traditional DEA model and OLS to super-efficiency DEA model.

3. Data and Variables

3.1 Data sources

Three-year data (2005, 2006, and 2007) from 31 provinces and province-level municipalities are available from our data sources, which include the *National statistical*

yearbook on NRCMS and *Health Statistical Yearbook* reported by the Center for Statistic Information of the Ministry of Health, People’s Republic of China. However, the data of Tibet are not complete, so we only use data from 30 provinces and province-level municipalities. In December 2004, the Ministry of Health began to apply the standardized “NRCMS Basic Information Report (Trial)”, which reports the data of participations, financing, reimbursements, administration expenditures, etc. (see Table 3.1) Other data about the background of each province are available in provincial and national yearbooks. Input and output variables will be carefully selected to represent the current status of the system, which is elaborated in the next section.

Table 3.1 Main content of data sets

| Data set | Content |
|---------------------|--|
| Participation data | The number of covered counties, administrative villages, families, farmers, etc. |
| Financing data | The amount of fund and the structure of the fund. |
| Reimbursement data | The inpatient/outpatient reimbursements, physical examination expenditures, number of beneficiaries, etc. |
| Administration data | The number of county-level personnel and the structure of income/expenditures of the administration institution. |

3.2 Choice of input and output variables

Table 3.2 Description of input and output variables

| Input | |
|-------|---|
| PCPIN | per capita premiums paid by individual (RMB) =Overall premiums paid by individuals / number of enrollees |
| PCGOV | per capita premiums paid by government subsidies (RMB) =(Overall subsidies from central government + overall subsidies from all levels of local governments + other subsidies) / number of enrollees |

| | |
|----------|--|
| PCADCOST | per capita administration cost(RMB) Overall administration cost / number of enrollees |
| PCADPSN | number of administration personnel (county level) for every 10,000 enrollees =Overall number of administration personnel (county level) / number of enrollees(measured by 10,000) |
| Output | |
| ERLRATE | Enrollment Rate (%) |
| PCNREIM | per capita number beneficiaries from reimbursement (person-times) =overall number of beneficiaries from reimbursement / number of enrollees |
| LEVREIM | level of reimbursement per person-time (RMB/person-time) =overall amount of reimbursement / overall number of beneficiaries from reimbursement |

We consider four inputs and three outputs. (see Table 3.2) One type of inputs are funding inputs, including per capita premiums paid by individual (PCPIN) and per capita premiums paid by government subsidies (PCGOV). We distinguish the funding from individual and the funding from the government because they are used for different purposes in some regions. The premiums and subsidies from the government are used for reimbursement only, while individual premiums from one household are typically used for outpatient treatment and/or health checks. Since enrollees who are sponsored by government are included in PCPIN, the value can be lower than the minimal individual premium 10 RMB. The other type of inputs of NRCMS are the management expenditure, including the financial input and labor input, which can be reflected by “per capita administration cost”(PCADCOST) and “number of administration personnel (county level) for every 10,000 enrollees”(PCADPSN), respectively.

Although NRCMS utilize health resources, such as hospitals, physicians, and nurses, we do not count them in as inputs for the following two reasons. These indirect inputs are

non-controllable variables to NRCMS and accessible to both enrollees and non-enrollees, so health institutions (such as town-ship hospitals and county-level hospitals) and health personnel should be considered as environmental variables rather than inputs of NRCMS. Furthermore, health resources of one province can be shared by patients from other provinces, thus making ambiguous the connection between health resources and NRCMS within the province. This is common in China because numerous peasants move from rural areas to urban areas for non-agricultural jobs and higher incomes.

There are three output variables in our model to measure the performance of NRCMS. First, we use “enrollment rate” (ERLRATE) to measure how many of the rural population are enrolled in this system because coverage is one of the goals of NRCMS. Second, we use “per capita number beneficiaries from reimbursement” (PCNREIM) to represent the proportion of beneficiaries. Third, we use “level of reimbursement per person-time” (LEVREIM) to represent the extent to which people benefit from the system. Note that the “overall number of beneficiaries from reimbursement” in PCNREIM includes number of inpatient reimbursement, outpatient reimbursement and physical examination reimbursement. Some provinces provide more reimbursements of out-patient service and physical examination, which leads to large ranges and variations of the variable PCNREIM and LEVREIM.

Table 3.3 Descriptive statistics for input and output variables (90 DMUs)

| | Mean | Median | Standard Deviation | Minimum | Maximum |
|----------|--------|--------|--------------------|---------|---------|
| PCPIN | 17.299 | 10.645 | 20.842 | 6.917 | 134.804 |
| PCGOV | 44.269 | 35.937 | 45.179 | 11.639 | 293.287 |
| PCADCOST | 1.521 | 1.301 | 0.729 | 0.458 | 4.838 |
| PCADPSN | 0.346 | 0.283 | 0.273 | 0.108 | 2.400 |

| | | | | | |
|---------|---------|--------|---------|--------|---------|
| ERLRATE | 80.509 | 82.350 | 9.426 | 51.990 | 99.280 |
| PCNREIM | 0.717 | 0.514 | 0.882 | 0.023 | 5.711 |
| LEVREIM | 117.401 | 65.474 | 148.184 | 20.779 | 854.260 |

3.3 Environmental variables

In order to explain the efficiency scores we obtain from DEA and super-efficiency DEA models, we regress them on several environmental variables and non-discretionary inputs, including GDP, percentage of rural population (PCTPOP), GDP per capita (GDPPC), per capita annual net income of rural households (Income), per capita consumption expenditure on health care and medical services of rural household (HealthExp), health care institution per thousand residents (PTHINST), number of employed persons in health institutions per thousand residents (PTHEP), government revenue (GREV). We also use a dummy “Region” to indicate the different regions (East=0, Central=1, West=2). A summary of statistics are listed in Table 3.4.

Table 3.4 Descriptive statistics for environmental variables (90 DMUs)

| Variable | Mean | Median | Standard Deviation | Minimum | Maximum |
|----------------------|----------|----------|--------------------|---------|-----------|
| GDP (10 million RMB) | 7817.584 | 5844.50 | 6532.264 | 543.32 | 31084.4 |
| PCTRPOP (RMB) | 0.53 | 0.58 | 0.20 | 0.11 | 0.84 |
| GDPPC (RMB) | 19.12 | 14.53 | 12.49 | 5.31 | 65.60 |
| Income (RMB) | 3992.32 | 3439.44 | 1823.27 | 1876.96 | 10144.62 |
| HealthExp (RMB) | 214.57 | 177.91 | 117.153 | 71.79 | 629.56 |
| PTHINST | 25.32 | 24.36 | 7.77 | 12.70 | 46.13 |
| PTHEP | 4.77 | 4.41 | 1.62 | 2.54 | 11.21 |
| GREV (10000RMB) | 63015.21 | 43653.46 | 56400.92 | 3382.22 | 278580.10 |
| Region | 1.07 | 1 | 0.82 | 0 | 2 |

Data source: *China Statistical Yearbooks* (2005-2008), National Bureau of Statistics of China; *National statistical yearbook on NRCMS* (2005-2007), Center for Statistic Information of the Ministry of Health.

There are two ways available to obtain DEA efficiency. The first way is to combine all the DMUs from three years and obtain 90 DMUs, and the second way is to run the model for each year separately. The first way is problematic as the efficiency frontier each year is different (Nunamaker 1983). Therefore we will use the second way and apply the model for each year separately.

4. Result and Discussion

4.1 Efficiency scores of traditional DEA models and Super-efficiency DEA models

Table4.1 Results of the traditional DEA models (30 DMUs) (TE: overall technical efficiency; PTE: pure technical efficiency; SE: scale efficiency)

| Region DMU | | 2005 | | | 2006 | | | 2007 | | |
|------------|--------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| | | TE | PTE | SE | TE | PTE | SE | TE | PTE | SE |
| East | Beijing | 0.522 | 0.531 | 0.983 | 0.372 | 0.372 | 1.000 | 0.427 | 0.427 | 1.000 |
| China | Tianjin | 1.000 | 1.000 | 1.000 | 0.408 | 0.408 | 1.000 | 0.577 | 0.577 | 1.000 |
| | Liaoning | 0.818 | 1.000 | 0.818 | 1.000 | 1.000 | 1.000 | 0.944 | 0.945 | 0.999 |
| | Shanghai | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| | Jiangsu | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| | Zhejiang | 0.583 | 0.583 | 1.000 | 0.817 | 0.817 | 1.000 | 0.736 | 0.736 | 1.000 |
| | Fujian | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| | Shandong | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| | Guangdong | 1.000 | 1.000 | 1.000 | 0.852 | 1.000 | 0.852 | 1.000 | 1.000 | 1.000 |
| Central | Hebei | 0.801 | 0.801 | 1.000 | 0.82 | 0.820 | 1.000 | 0.880 | 0.88 | 1.000 |
| China | Shanxi | 0.973 | 1.000 | 0.973 | 0.933 | 0.968 | 0.964 | 0.893 | 0.893 | 1.000 |
| | Jilin | 0.754 | 0.823 | 0.916 | 0.902 | 0.961 | 0.939 | 0.878 | 0.878 | 1.000 |
| | Heilongjiang | 0.648 | 0.648 | 1.000 | 0.936 | 0.936 | 1.000 | 1.000 | 1.000 | 1.000 |
| | Anhui | 0.988 | 0.988 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| | Jiangxi | 0.827 | 0.827 | 1.000 | 0.898 | 0.898 | 1.000 | 0.989 | 0.989 | 1.000 |
| | Henan | 1.000 | 1.000 | 1.000 | 0.947 | 0.947 | 1.000 | 1.000 | 1.000 | 1.000 |
| | Hubei | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.845 | 0.845 | 1.000 |
| | Hunan | 0.763 | 0.763 | 1.000 | 0.881 | 0.881 | 1.000 | 0.886 | 0.886 | 1.000 |
| | Hainan | 0.764 | 0.764 | 1.000 | 0.916 | 0.997 | 0.919 | 1.000 | 1.000 | 1.000 |
| West | Neimenggu | 0.913 | 0.913 | 1.000 | 0.873 | 0.873 | 1.000 | 0.845 | 0.845 | 1.000 |
| China | Guangxi | 0.730 | 1.000 | 0.730 | 0.853 | 1.000 | 0.853 | 0.944 | 1.000 | 0.944 |
| | Chongqing | 0.924 | 0.946 | 0.977 | 1.000 | 1.000 | 1.000 | 0.936 | 1.000 | 0.936 |
| | Sichuan | 0.727 | 0.863 | 0.842 | 0.985 | 1.000 | 0.985 | 0.986 | 1.000 | 0.986 |
| | Guizhou | 0.760 | 1.000 | 0.760 | 0.892 | 1.000 | 0.892 | 0.986 | 1.000 | 0.986 |

| | | | | | | | | | |
|----------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Yunnan | 1 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| Shaanxi | 0.919 | 0.919 | 1.000 | 0.958 | 1.000 | 0.958 | 1.000 | 1.000 | 1.000 |
| Gansu | 0.930 | 1.000 | 0.930 | 1.000 | 1.000 | 1.000 | 0.962 | 0.962 | 1.000 |
| Qinghai | 1.000 | 1.000 | 1.000 | 0.951 | 0.951 | 1.000 | 0.957 | 1.000 | 0.957 |
| Ningxia | 0.798 | 0.819 | 0.974 | 0.881 | 0.881 | 1.000 | 0.879 | 0.879 | 1.000 |
| Xinjiang | 0.684 | 0.685 | 0.999 | 0.804 | 0.804 | 1.000 | 0.737 | 0.737 | 1.000 |
| Average | 0.861 | 0.896 | 0.963 | 0.896 | 0.917 | 0.979 | 0.910 | 0.916 | 0.994 |

Table 4.2 Results of the super-efficiency DEA models (30DMUs) (TE: overall technical efficiency; PTE: pure technical efficiency; SE: scale efficiency)

| Region | DMU | 2005 | | 2006 | | 2007 | |
|---------------|--------------|-------|-------|-------|-------|-------|-------|
| | | TE | PTE | TE | PTE | TE | PTE |
| East China | Beijing | 0.522 | 0.531 | 0.372 | 0.372 | 0.427 | 0.427 |
| | Tianjin | 1.506 | 1.736 | 0.408 | 0.408 | 0.577 | 0.577 |
| | Liaoning | 0.818 | 1.022 | 1.105 | 1.127 | 0.944 | 0.945 |
| | Shanghai | 3.131 | 4.039 | 2.475 | 3.801 | 2.537 | 4.239 |
| | Jiangsu | 1.384 | 1.384 | 1.377 | 1.377 | 1.445 | 1.445 |
| | Zhejiang | 0.583 | 0.583 | 0.817 | 0.817 | 0.736 | 0.736 |
| | Fujian | 1.554 | 1.554 | 3.053 | 3.053 | 2.719 | 2.901 |
| | Shandong | 1.529 | 1.529 | 1.315 | 1.339 | 1.216 | 1.216 |
| | Guangdong | 1.369 | 1.701 | 0.852 | 1.127 | 1.263 | 1.382 |
| Mid- China | Hebei | 0.801 | 0.801 | 0.82 | 0.82 | 0.88 | 0.88 |
| | Shanxi | 0.973 | 1.003 | 0.933 | 0.968 | 0.893 | 0.893 |
| | Jilin | 0.754 | 0.823 | 0.902 | 0.961 | 0.878 | 0.878 |
| | Heilongjiang | 0.648 | 0.648 | 0.936 | 0.936 | 1.032 | 1.034 |
| | Anhui | 0.988 | 0.988 | 1.034 | 1.05 | 1.192 | 1.215 |
| | Jiangxi | 0.827 | 0.827 | 0.898 | 0.898 | 0.989 | 0.989 |
| | Henan | 1.098 | 1.193 | 0.947 | 0.947 | 1.029 | 1.029 |
| | Hubei | 1.18 | 1.204 | 1.005 | 1.011 | 0.845 | 0.845 |
| | Hunan | 0.763 | 0.763 | 0.881 | 0.881 | 0.886 | 0.886 |
| Hainan | 0.764 | 0.764 | 0.916 | 0.997 | 1.55 | 1.55 | |
| West China | Neimenggu | 0.913 | 0.913 | 0.873 | 0.873 | 0.845 | 0.845 |
| | Guangxi | 0.73 | 1.032 | 0.853 | 1.049 | 0.944 | 1.067 |
| | Chongqing | 0.924 | 0.946 | 1.129 | 1.129 | 0.936 | 1.09 |
| | Sichuan | 0.727 | 0.863 | 0.985 | 1.044 | 0.986 | 1.036 |
| | Guizhou | 0.76 | 1.021 | 0.892 | 1.022 | 0.986 | 1.043 |
| | Yunnan | 1.473 | 1.475 | 1.129 | 1.129 | 1.145 | 1.145 |
| | Shaanxi | 0.919 | 0.919 | 0.958 | 1.016 | 1.004 | 1.014 |
| | Gansu | 0.93 | 1.01 | 1.017 | 1.018 | 0.962 | 0.962 |
| Qinghai | 1.091 | 1.091 | 0.951 | 0.951 | 0.957 | 1.023 | |

| | | | | | | |
|----------|-------|-------|-------|-------|-------|-------|
| Ningxia | 0.798 | 0.819 | 0.881 | 0.881 | 0.879 | 0.879 |
| Xinjiang | 0.684 | 0.685 | 0.804 | 0.804 | 0.737 | 0.737 |
| Average | 1.038 | 1.129 | 1.051 | 1.127 | 1.081 | 1.164 |

It can be seen from both Table 4.1 and 4.2 that the average efficiency scores increase from 2005 to 2007. One third of the DMUs are relatively efficient every year. In Table 4.1, the average TE score is 0.86 in 2005, which means that we can reduce the cost by 14 percent to retain the same output level as observed in 2005. Table 4.1 also shows that the pure technical efficiency (PTE) is on average lower than the scale efficiency (SE), which means the main source of inefficiency is from the pure technical aspect. For those DMUs which have TE scores less than 1 but PTE scores equal to 1, their inefficiency comes mainly from the scale inefficiency, such as Liaoning and Guangxi in 2005, Guandong and Sichuan in 2006, Guangxi and Chongqing in 2007. Some inefficient provinces such as Guangxi and Guizhou have high PTE (=1) every year, which implies there are more problems in the scale of NRCMS, suggesting that the scale of the system should be adjusted in these provinces.

Table 4.2 gives the super-efficiency scores of the efficient DMUs. It shows that Shanghai, which is the largest municipality in east China, ranks as one of the most efficient units in each evaluated year. When we examine the inputs and outputs of Shanghai, we find that it retains the highest level of inputs: per capita premiums paid by individual from 2005 to 2007 were 100.59, 129.18 and 134.80 (RMB), respectively; per capita premiums paid by government subsidies from 2005 to 2007 were 203.53, 244.04 and 293.29 (RMB), respectively. It also had the highest per capita number beneficiaries from reimbursement in China. By contrast, in some provinces, such as Jilin province in central China, the per capita premiums paid by individual were only around 10 RMB and per capita subsidies ranged from 16 to 41 from

2005 to 2007, and its TE scores were only around 0.75 to 0.9. Generally, less developed areas tend to have lower efficiencies than more developed areas.

It is interesting to find that Beijing, the capital of China, is among the DMUs with the lowest efficiency scores. Both Beijing and Shanghai are large municipalities and receive no central government subsidy³, but they are at two opposite ends of the efficiency spectrum of NRCMS. The difference can be explained by the structures of inputs and outputs of these provinces. From the results of the models, we find the movement of the input/output variables for each province toward the efficiency frontier, i.e. how to increase the efficiency. Now we take the case of Beijing in 2005 for an instance, the CCR-DEA model suggests that the improvement of efficiency can be done by increasing its outputs (coverage rate and reimbursements levels) when compared to its reference DMUs.

4.2 Stability

To check the stability of the models, we applied the 90 DMUs model. We find that very few DMUs changed their rankings in terms of efficiency over the three years. We also checked the model by deleting one variable or replacing it with another variable. For example, we substituted LEVREIM with another variable “level of inpatient and outpatient reimbursement per person-time”, which excluded the physical examination reimbursements and other reimbursements). Only limited changes of the rankings and values of efficiency scores were observed.

4.3 Comparison of the distribution of efficiency scores in different regions

³ Details see section 4.3.

According to the report from the Ministry of Health, we divide the 30 provincial units into three regions: east, middle and west, as shown in Table 4.1 and 4.2. The reason of this grouping is that the central government subsidy policies are different in these three regions. There are very low or no central government subsidies for east China, while the subsidies for central China and west China are higher. For example, in 2005, 9 DMUs, including Beijing, Tianjin, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong and Guangdong, received no central government subsidy. In 2006-2007, three DMUs, including Beijing, Tianjing and Shanghai, received no central government subsidy. As compensation, the local government subsidies are quite high in counties that are not eligible for central government subsidies since those counties generally have strong financing ability.

Table 4.3 Descriptive statistics for input and output variables with respect to region groups

| | | Mean | Median | Standard Deviation | Minimum | Maximum |
|---------|----------|---------|--------|-----------------------|---------|---------|
| East | PCPIN | 32.106 | 21.694 | 33.896 | 8.947 | 134.804 |
| | PCGOV | 74.493 | 44.944 | 73.299 | 11.639 | 293.287 |
| | PCADCOST | 1.718 | 1.37 | 1.105 | 0.458 | 4.838 |
| | PCADPSN | 0.215 | 0.204 | 0.087 | 0.108 | 0.372 |
| | ERLRATE | 83.488 | 85.49 | 9.676 | 57.91 | 99.28 |
| | PCNREIM | 1.076 | 0.747 | 1.502 | 0.023 | 5.711 |
| | LEVREIM | 212.735 | 81.678 | 233.656 | 26.752 | 854.26 |
| Central | PCPIN | 10.782 | 10.51 | 1.278 | 6.917 | 13.475 |
| | PCGOV | 31.174 | 34.114 | 10.001 | 16.532 | 43.477 |
| | PCADCOST | 1.31 | 1.215 | 0.406 | 0.578 | 2.135 |
| | PCADPSN | 0.363 | 0.364 | 0.145 | 0.195 | 0.808 |
| | ERLRATE | 79.078 | 80.66 | 8.611 | 51.99 | 92.07 |
| | PCNREIM | 0.466 | 0.389 | 0.284 | 0.091 | 1.311 |
| | LEVREIM | 95.281 | 80.3 | 58.353 | 22.52 | 256.55 |
| West | PCPIN | 11.107 | 10.006 | 2.97 | 9.31 | 22.009 |
| | PCGOV | 31.443 | 35.163 | 10.943 | 15.881 | 54.085 |

| | | | | | |
|----------|--------|--------|--------|--------|---------|
| PCADCOST | 1.552 | 1.36 | 0.513 | 0.767 | 2.714 |
| PCADPSN | 0.438 | 0.332 | 0.399 | 0.163 | 2.4 |
| ERLRATE | 79.372 | 82.3 | 9.65 | 57.76 | 94.5 |
| PCNREIM | 0.65 | 0.553 | 0.288 | 0.147 | 1.308 |
| LEVREIM | 59.509 | 46.491 | 45.214 | 20.779 | 276.849 |

Table 4.3 is a summary of statistics in the three regions of China. It can be seen that the average inputs and outputs are higher in the east. However, the variations are also larger in the east. For example, the minimal per capita premiums paid by individuals (PCPIN) is only 8.947 (Liaoning province in 2006) while the maximal value is 134.81(Shanghai in 2007). Both the central and west China have lower input and output levels and smaller variation.

Table 4.4 Comparison of TE and PTE in different regions (TE: overall technical efficiency; PTE: pure technical efficiency; SE: scale efficiency)

| Region | Year | TE | | | | PTE | | | |
|---------------|--------------------------|--------|--------|--------|-----------|--------|--------|--------|-----------|
| | | 2005 | 2006 | 2007 | 2005-2007 | 2005 | 2006 | 2007 | 2005-2007 |
| East China | Average 1* | 0.880 | 0.828 | 0.854 | 0.854 | 0.902 | 0.844 | 0.854 | 0.867 |
| | Average 2** | 1.377 | 1.308 | 1.318 | 1.335 | 1.564 | 1.491 | 1.541 | 1.532 |
| | Number of Efficient DMUs | 6 | 5 | 5 | 16 | 7 | 6 | 5 | 18 |
| | Proportion 1* | 20.00% | 16.67% | 16.67% | 17.78% | 23.33% | 20.00% | 16.67% | 20.00% |
| | Proportion 2** | 66.67% | 55.56% | 55.56% | 59.26% | 77.78% | 66.67% | 55.56% | 66.67% |
| Central China | Average 1 | 0.852 | 0.923 | 0.937 | 0.904 | 0.861 | 0.941 | 0.937 | 0.913 |
| | Average 2 | 0.880 | 0.927 | 1.017 | 0.941 | 0.901 | 0.947 | 1.020 | 0.956 |
| | Number of Efficient DMUs | 2 | 2 | 4 | 8 | 3 | 2 | 4 | 9 |
| | Proportion 1 | 6.67% | 6.67% | 13.33% | 8.89% | 10.00% | 6.67% | 13.33% | 10.00% |
| | Proportion 2 | 20.00% | 20.00% | 40.00% | 26.67% | 30.00% | 20.00% | 13.33% | 30.00% |
| West China | Average 1 | 0.853 | 0.927 | 0.930 | 0.903 | 0.922 | 0.955 | 0.948 | 0.942 |
| | Average 2 | 0.904 | 0.952 | 0.944 | 0.933 | 0.979 | 0.992 | 0.986 | 0.986 |
| | Number of Efficient DMUs | 2 | 3 | 2 | 7 | 5 | 7 | 7 | 20 |
| | Proportion 1 | 6.67% | 10.00% | 6.67% | 7.78% | 16.67% | 23.33% | 23.33% | 22.22% |
| | Proportion 2 | 18.18% | 27.27% | 18.18% | 21.21% | 45.45% | 63.64% | 63.64% | 60.61% |

Table 4.4 (continues)

| Region | Year | SE | | | |
|------------------|-----------------------------|--------|--------|---------|-----------|
| | | 2005 | 2006 | 2007 | 2005-2007 |
| East China | Average 1 | 0.978 | 0.984 | 1.000 | 0.987 |
| | Average 2 | | | | |
| | Number of Efficient DMUs | 7 | 8 | 8 | 23 |
| | Proportion 1 | 23.33% | 26.67% | 26.67% | 25.56% |
| | Proportion 2 | 77.78% | 88.89% | 88.89% | 85.19% |
| Central China | Average 1 | 0.989 | 0.982 | 1.000 | 0.990 |
| | Average 2 | | | | |
| | Number of Efficient DMUs | 8 | 7 | 10 | 25 |
| | Proportion 1 | 26.67% | 23.33% | 33.33% | 27.78% |
| | Proportion 2 | 80.00% | 70.00% | 100.00% | 83.33% |
| West China | Average 1 | 0.928 | 0.972 | 0.983 | 0.961 |
| | Average 2 | | | | |
| | Number of Efficient DMUs | 4 | 7 | 6 | 17 |
| | Proportion 1 | 13.33% | 23.33% | 20.00% | 18.89% |
| | Proportion 2 | 36.36% | 63.64% | 54.55% | 51.52% |

Note: * Average 1 is the average of standard DEA models; proportion 1 is the proportion of efficient DMUs in all regions.

** Average 2 is the average of super-efficiency models; proportion 2 is the proportion of efficient DMUs in the region.

Table 4.4 summarizes the distribution of efficiency in different region groups. The proportion of efficient DMUs is higher in east China. More than 50 percent of the east DMUs are efficient, while there are only about 24 percent of central and west DMUs are relatively efficient. However, when treating the super-efficient unit's efficiency score as 1, that is, using the traditional CCR model, we notice that the average efficiency scores of the east are not as high as that of the central and west, because of the extremely low-efficiency DMUs in this

group (for instance, Beijing, Tianjin). When measured by super-efficiency, the east presents higher average TE value because of the extremely high efficiency DMUs in this group (for instance, Shanghai and Fujian). Pure technical efficiency shows a different pattern. It can be seen from Table 4.4 that there are more efficient DMUs in the east and west than in the central region. Like the TE scores, the east has lower average pure technical efficiency scores because of the extremely low PTE values of some DMUs. Table 4.4 also indicates that the east suffers from pure technical inefficiency more than other regions, since the average PTE scores during the period 2005 - 2007 range from 0.854 to 0.902, but the corresponding SE scores range from 0.978 to 1.00, which are much higher than PTE scores.

Table 4.5 Returns to Scale of Inefficient DMUs (Decreasing: decreasing returns to scale; Increasing: increasing returns to scale; Constant: constant returns to scale)

| | 2005 | | 2006 | | 2007 | |
|------------------|--------------|------------|--------------|------------|-----------|------------|
| East China | Beijing | Decreasing | Beijing | Decreasing | Beijing | Decreasing |
| | Liaoning | Increasing | Tianjin | Decreasing | Tianjin | Decreasing |
| | Zhejiang | Decreasing | Zhejiang | Decreasing | Liaoning | Decreasing |
| | | | Guangdong | Increasing | Zhejiang | Decreasing |
| Central China | Hebei | Decreasing | Hebei | Decreasing | Hebei | Increasing |
| | Shanxi | Increasing | Shanxi | Decreasing | Shanxi | Decreasing |
| | Jilin | Increasing | Jilin | Increasing | Jilin | Decreasing |
| | Heilongjiang | Decreasing | Heilongjiang | Decreasing | Jiangxi | Decreasing |
| | Anhui | Decreasing | Jiangxi | Decreasing | Hubei | Decreasing |
| | Jiangxi | Decreasing | Henan | Decreasing | Hunan | Decreasing |
| | Hunan | Decreasing | Hunan | Decreasing | | |
| | Hainan | Decreasing | Hainan | Increasing | | |
| West China | Neimenggu | Decreasing | Neimenggu | Decreasing | Neimenggu | Decreasing |
| | Guangxi | Increasing | Guangxi | Increasing | Guangxi | Increasing |
| | Chongqing | Increasing | Sichuan | Increasing | Chongqing | Increasing |
| | Sichuan | Increasing | Guizhou | Increasing | Sichuan | Increasing |
| | Guizhou | Increasing | Shaanxi | Decreasing | Guizhou | Increasing |
| | Shaanxi | Decreasing | Qinghai | Decreasing | Gansu | Decreasing |
| | Gansu | Decreasing | Ningxia | Decreasing | Qinghai | Decreasing |
| | Ningxia | Increasing | Xinjiang | Decreasing | Ningxia | Decreasing |
| | Xinjiang | Decreasing | | | Xinjiang | Decreasing |

Table 4.5 provides further information about returns to scale (RTS) of the inefficient DMUs. We find that most inefficient DMUs show decreasing returns to scale (DRS) in all the three regions. Interestingly, there are more DMUs that represent increasing returns to scale (IRS) in the west than in either of two other regions. Nearly half of the inefficient DMUs in west China show IRS. Under the assumption of convex structure of the efficiency frontier, a DMU with IRS means the scale of NRCMS should be increased in this province, such as Guangxi, Chongqing, Sichuan, and Guizhou.

4.4 Environmental variable analysis

In this section, we will examine the relationship of environmental factors and the efficiency. Two types of regression will be applied. The first is to regress the efficiency scores (TE) on the environmental variables using Tobit regression. The second is the OLS regression using TE from super-efficiency models. We tried several forms of models (Table 4.6 and Table 4.7).

Table 4.6 Parameter estimates of Tobit Models explaining efficiency of NRCMS for 2005-2007 *

| | Tobit Model1 | | Tobit Model2 | | Tobit Model3 | | Tobit Model4 | | Tobit Model5 | |
|-----------|-------------------|---------|-------------------|---------|-------------------|---------|--------------|---------|-----------------|---------|
| | Coeff | t-ratio | Coeff | t-ratio | Coeff | t-ratio | Coeff | t-ratio | Coeff | t-ratio |
| GDP | -0.0000167 | -1.88 | -0.0000167 | -1.95 | -0.0000167 | -1.93 | | | | |
| PCTRPOP | -0.0826 | -0.84 | -0.0826329 | -0.85 | -0.08267 | -0.84 | -0.10966 | -1.1 | -0.11021 | -1.11 |
| GDPPC | 0.0189** | 2.91 | 0.0189* | 2.46 | 0.0188* | 2.33 | 0.02135** | 2.67 | 0.02124** | 3.3 |
| Income | -0.0001747** | -3.68 | -0.0001747** | -3.62 | -0.00017 | -4.01 | -0.0002** | -3.25 | -0.0002** | -4.18 |
| HealthEx | 1.96E-06 | 0.01 | 1.96E-06 | 0 | | | 2.67E-05 | 0.05 | | |
| PTHINST | -0.00178 | -0.73 | -0.0017762 | -0.93 | -0.00178 | -0.93 | -0.002 | -1.03 | -0.00199 | -0.79 |
| PTHEP | -0.09774** | -3.81 | -0.09774** | -4.38 | -0.0977** | -5.2 | -0.0949** | -4.04 | -0.0942** | -3.94 |
| GREV | 3.05E-06** | 2.53 | 3.05E-06 | 1.98 | 3.05E-06 | 1.93 | 1.06E-06 | 1.12 | 1.07E-06 | 1.88 |
| Region | -0.1449** | -3.42 | -0.1449** | -4.19 | -0.1448** | -4.13 | -0.1141** | -3.11 | -0.1127** | -3.21 |
| _cons | 1.827** | 10.8 | 1.827** | 11.08 | 1.827** | 11.79 | 1.7256** | 10.31 | 1.7197** | 12.15 |
| sigma | 0.136345 | | 0.136345 | | 0.136346 | | 0.140583 | | 0.14061 | |
| Pseudo R2 | 5.175 | | 5.175 | | 5.175 | | 4.8883 | | 4.8879 | |

Table 4.7 Parameter estimates of OLS Models explaining efficiency of NRCMS for 2005-2007 *

| | OLS Model1 | | OLS Model2 | | OLS Model3 | | OLS Model4 | | OLS Model5 | |
|----------|-------------------|---------|-------------------|---------|-------------------|---------|-----------------|---------|------------|---------|
| | Coeff | t-ratio | Coeff | t-ratio | Coeff | t-ratio | Coeff | t-ratio | Coeff | t-ratio |
| GDP | -0.0000195 | -1.76 | -0.0000195 | -1.71 | -0.0000196 | -1.8 | | | | |
| PCTRPOP | -0.13567 | -1.08 | -0.1357 | -1.04 | -0.1316 | -1.03 | -0.176 | -1.36 | -0.172 | -1.31 |
| GDPPC | 0.02127* | 1.99 | 0.02127** | 2.52 | 0.02221** | 2.11 | 0.02337** | 2.18 | 0.02433** | 2.31 |
| Income | -0.00017** | -2.18 | -0.00017** | -2.68 | -0.00019** | -3.51 | -0.00015 | -1.9 | -0.00017** | -3.02 |
| HealthEx | -0.00027 | -0.36 | -2.73E-04 | -0.57 | | | -2.77 E-04 | -0.36 | | |
| PTHINST | -0.0012 | -0.52 | -0.0012 | -0.35 | -0.0012 | -0.56 | -0.0013 | -0.58 | -0.0014 | -0.63 |
| PTHEP | -0.1163** | -3.51 | -0.1163** | -3.49 | -0.1242** | -5.25 | -0.1114** | -3.24 | -0.11941** | -4.75 |
| GREV | 2.56E-06 | 1.51 | 2.56E-06 | 1.71 | 2.52E-06 | 1.52 | 2.37E-07 | 0.27 | 1.97E-07 | 0.22 |
| Region | -0.1895** | -4.14 | -0.1895** | -3.4 | -0.2032** | -4.4 | -0.1449** | -2.9 | -0.1587** | -3.21 |
| _cons | 2.0248** | 8.35 | 2.025** | 9.21 | 2.084** | 10.53 | 1.876** | 7.43 | 1.937** | 9.45 |
| R2 | 0.4316 | | 0.4316 | | 0.4293 | | 0.4109 | | 0.4085 | |

Note: * indicates significant at the five percent, ** significant at the one percent level, and bold indicates significant at the 10 percent. All the models are robust adjusted except models.

According to the Tobit and OLS regression results, we find that GDP per capita, GDP per capita (GDPPC), per capita annual net income of rural households (Income), number of employed persons in health institutions per thousand residents (PTHEP) and region are significant explanatory variables. GDP and government revenue (GREV) is not so significant. Environmental variables such as percentage of rural population (PCTRPOP), per capita consumption expenditure on health care, medical services of rural household (HealthEx) and health care institution per thousand residents (PTHINST) are insignificant even at the 0.10 level.

The result that larger GDPPC and government revenue brings better efficiency is not surprising, as the government has greater capability to finance NRCMS. Higher GDPPC also means better health care, medical facilities and medical personnel, which can benefit more

rural population. Higher per capita annual net income of rural households makes it possible to gather more individual premium, therefore it is positive and significant (at the 0.01 level). The regression models also suggest that more health workers will increase the efficiency. One rationale is that more health workers will make health service more accessible. As we expected, regions are significant and DMUs in east China have higher efficiency than the central and west. The dummy “Region” has a negative sign and is significant at the 0.01 level, which further proves our findings in Section 4.3 that NRCMS in east China generally had better efficiency.

5. Conclusion

In this paper, we studied the NRCMS efficiency of 30 province-level units in China from 2005 to 2007 using standard DEA models and super-efficiency DEA models. Although the east DMUs receive lower or no subsidy from the central government, NRCMS in east China is generally more efficient than in other regions. This implies that the financing ability of local government and farmers’ ability to pay premiums are playing important roles in the implementations of NRCMS. However, the variation of efficiency is larger within the east compared to other regions. For example, Beijing and Shanghai both received no central government subsidy, but Beijing has very low efficiency while Shanghai shows very high (super) efficiency. This implies that although the inputs are critical to the NRCMS, the structure of output is also an important issue. Hence it is a practical question for the DMU to find a balance between the number of reimbursements and level of reimbursements.

The decomposition of the relative technical efficiency suggests that the pure technical

inefficiency is the main source of overall inefficiency, and the structure of the inputs and outputs need to be adjusted in the east region. Analysis of the returns to scale of inefficient DMUs further indicates that the scale of NRCMS in the west region is too small to attain high efficiency. Thus, for the east China, the critical step is to improve the structure of NRCMS, adjust the reimbursement policy, and use the raised fund more efficiently. For the central China, the pure technical inefficiency is one problem as the proportion of DMUs with pure technical efficiency (PTE) is lower than in other regions. For the west regions, the whole scale of NRCMS should be increased. We suggest more investment from the government should be made to increase the scale of the NRCMS because of the limited financing ability of farmers in the west. Furthermore, the projection of inputs and outputs we obtain from the models indicates that the west should be aware of the abuse of resources on administration. One good sign from our research is that the efficiency is increasing, although not significantly, from 2005 to 2007.

The analysis of efficiency based on regression on the nondiscretionary inputs and environmental variables confirms our conclusion about the distribution of efficiency in different regions of China. The analysis also suggests that in this micro-insurance system, support from government and the individual capability to pay the premiums both have significantly positive effects on the performance of NRCMS.

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