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Abstract

In the rural health-care organization of China, township hospitals ensure the delivery of basic medical services. Particularly damaged by the economic reforms implemented from 1975 to the end of the 1990s, township hospitals efficiency is questioned, mainly with the implementation since 2003 of the reform of health insurance in rural areas. From a database of 24 randomly selected township hospitals observed over the period 2000-2008 in Weifang prefecture (Shandong), the study examines the efficiency of township hospitals through a two-stage approach and the calculation of the Malmquist index. As curative and preventive medical services delivered at township hospital level use different production processes, two data envelopment analysis models are estimated with different orientation chosen to compute scores. Following Simar and Wilson (2007), as the traditional two-stage methodology is not relevant, we used a double bootstrap strategy. Results show that technical efficiency declines over time. Moreover, township hospitals are less efficient in the production of preventive services than in the production of curative ones. Several variables explained efficiency (township hospitals' and environment's characteristics) but our results suggest that in the context of China, the efficiency of township hospitals is also influenced by unobservable factors.

JEL Classification: G22, I1, I38, O12.

KEY WORDS: Data Envelopment Analysis, Technical Efficiency, Double bootstrapping, China, New Rural Cooperative Medical Scheme, Township Hospitals.

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The Chinese rural healthcare system has deeply evolved since the 1950s. From 1950 to 1975, China achieved significant improvements in health outcomes, thanks to the definition of an efficient three-tier system of healthcare delivery and a successful community-based rural health insurance scheme (Hsiao 1995; World Bank 1997). However, economic transition (1975-1990) caused the disorganization of these two pillars of the rural healthcare system (Liu et al. 1996; Wagstaff et al. 2009)[1]. First, the Cooperative Medical System (CMS) collapsed. While in 1975 quasi-universal coverage was achieved in rural areas, less than 10% of the rural population was still insured in the 1990s (World Bank 1997). Second, the three-tier system, composed by village health stations, township and county hospitals (from lower level to upper one), was disrupted. Efficiency of township hospitals (THs) has declined, due to the economic reforms experienced (Hsiao 1995; Liu et al. 2003). The budget decentralization (1979) and the management reform of THs (1983) led them to look for profitable activities (Hillier and Shen 1996; Liu et al. 1996). As a consequence, negative externalities came to light: the quality of healthcare declined, healthcare prices increased, expensive technologies were overused, drugs were overprescribed, the average length of stay increased and preventive activities were neglected to privilege expensive curative activities (Eggleston et al. 2008, Hillier and Shen 1996; Hsiao 1995; World Bank 1997). The collapse of the CMS disturbed the referral system. Moreover, as THs suffered from bad reputation, patients bypassed them to go directly to county hospitals (World Bank 1997). Thus, THs' activities fell off. This phenomenon was enhanced by the increase of the rural income (Liu et al. 1996).

Since 2003, the implementation of the New Rural Cooperative Medical System (NRCMS) served mainly two objectives. The first one is to offer a comprehensive insurance system to the rural population, in order to lower the financial barrier to access to the healthcare system and to improve the rural population's health (Wagstaff et al. 2009). The second one is to make attractive the THs, which suffered from the economic liberalization, by re-orientating patient toward this level (personal communication from Weifang Health Bureau).

Township hospitals play an important role in the rural healthcare system: they represent the main providers of primary healthcare in rural areas (Hillier and Shen 1996). They constitute the intermediate level of healthcare facilities and ensure the link between village health stations and county or above level hospitals. They supervise healthcare delivery at the level of village health stations, and play the role of gate keeper, to orientate patients toward higher health facilities levels. They offer a wide-ranging set of general medical services: they deliver curative and preventive activities, from vaccinations, laboratory test to outpatient visits, basic surgical interventions and inpatients care.

The question of their efficiency is crucial, as regard to their strategic position into the healthcare delivery chain and the changes they experienced over the preceding years, but also to a context of scarce resources, vertical and horizontal competition and health insurance reform. By targeting THs, more especially than others health facilities, the NRCMS can influence their efficiency, mainly through contracts and as the demand addressed to them will augment. Identifying the main determinants of THs' efficiency can help the design of relevant policies.

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[1] For more details about the evolution of the healthcare system in China, please see: Eggleston et al. (2008), Hillier and Shen (1996), Hsiao (1984; 1995), Liu et al. (1996), Liu et al. (2003), Wagstaff et al. (2009), World Bank (1997) and Yip and Hsiao (2008).

This study deals with the analysis of the technical efficiency of THs in the production of healthcare services. With a sample of 24 THs, randomly selected and observed over the period 2000-2008, a two-stage approach is applied: i) technical efficiency is computed from Data Envelopment Analysis (DEA); ii) technical efficiency scores are regress on a set of explicative variables. The double bootstrapping methodology suggested by Simar and Wilson (2000, 2003, 2007) is employed to assess the determinants of efficiency and avoid issues raised into the traditional two-stage methodology. As THs deliver curative and preventive activities, that use an independent technological process, two DEA models were defined: an output-oriented DEA model for the production process of curative activities, and an input-oriented one for the production of preventive activities. Finally, the availability of longitudinal data allows to calculate the Malmquist index and to understand the channels which drive the total factor productivity, in order to complete the diagnosis about THs' efficiency.

This paper consists of five sections. Section 1 exposes the two-stage methodology. The dataset is presented in section 2. Then, results are listed in section 3 and section 4 concludes.

1 Methodology

1.1 Estimation of the technical efficiency from DEA

DEA considers that the best practice observed in the sample, in terms of the maximum quantity of outputs produced for a given quantity of inputs or in terms of the minimum use of inputs to produce a fix amount of outputs, constitutes the efficiency frontier. Thus, this discrete piecewise frontier of production is estimated from a mathematical linear program (Charnes et al. 1995) and efficiency scores obtained refers to a relative measure of the technical efficiency of a production unit, as regard to achievement of the others (Charnes et al. 1978; Farrell 1957)[2]. Various specification choices are offered by the non-parametric deterministic approach. In this paper, variable returns to scale are assumed, as a managerial perspective is adopted (Jacobs et al. 2006). As longitudinal data are available, a choice must be made between estimating a frontier for each year or an overall frontier by pooling all data together (Mbangala and Perelman 1997). No technical change over the period is assumed by the former approach. However, this assumption is quite strong as regard to the period studied (2000-2008) and the units observed. Thus, the latter approach is used, and so nine "contemporaneous" frontiers (Tulkens 1986) are estimated.

Hollingsworth (2003) and O'Neill et al. (2008) present a literature review of DEA studies existing on hospitals units. Considering the teachings of these papers and the overall literature about DEA and hospital efficiency, we elaborate an original framework to study efficiency of THs. THs deliver two main types of medical activities: curative and preventive healthcare services, which are characterized by different production processes. As a consequence, two distinct DEA models are defined. Orientation chosen to estimate DEA scores are also different according to the production process considered. Concerning that of curative activities, one of

[2] DEA was described in many papers and manual books over the last decades. In this paper, the complete and mathematical presentation of the methodology is not given. For more details, please refers to this no-exhaustive list of works: Banker et al. (1984), Charnes et al. (1978), Charnes et al. (1995), Farrell (1957), Seiford and Thrall (1990) for a more complete overview of the approach.

the objectives assigned to THs is to maximize the volume of healthcare delivered, i.e. an output orientation is relevant. Concerning the production process of preventive activities, the level of production is previously defined by the government. The input orientation appears more suitable as THs can minimize their use of preventive resources in order to produce the target volume of preventive activities.

The definition of inputs consumed and outputs produced by THs are used for characterizing their production technologies. As our sample is relatively small, the number of outputs and inputs to be included in the analysis has to remain low. However, THs delivered a large set of curative and preventive activities. In order not to penalise hospitals that will complete most missions attributed to them when others will only focus on the most lucrative activities, we have to consider all the curative and preventive activities implemented. Therefore, on the one hand, the number of outputs used into the DEA framework needs to be minimize, but on the other hand the diversity of activities has to be taken into account. Consequently, we calculated two composite indexes using a workload equivalent weighting (for more details, see Coca 1995): an index for curative activities and another for preventives ones. The weighting system was suggested by a Chinese experts committee (Table 1) and already used in a previous study (Audibert et al. 2008). Due to the lack of information, case-mix is not taking into consideration. However this potential bias is not a relevant issue in our study as THs are homogeneous in terms of disease treated. They are located in the same prefecture and face similar disease pattern. They belong to the same hierarchical level in Chinese health delivery system and have therefore common missions defined by the government.. Furthermore, according to our data, severe cases are treated in county hospitals and THs mainly deal with respiratory and cardiovascular pathologies, diabete and injuries. Lastly, inpatient activity represents only a low share of curative activities delivered by THs (less than 5%).

Table 1 Workload equivalent weighting system

Curative Activities	Weight
Outpatient visits	1
Inpatient	3
Emergency visits	2
Medical visits	5.72
Laboratory tests	1
Radiography	1
Preventive Activities	Weight
# of actual vaccination	1.85
# of second class vaccinations	1.85

Source: Chinese experts committee.

Traditional input variables used in the literature concern human resources that may be disaggregated into specialist and generalist physicians, trained and other nurses, other medical personal, non-clinical staff, and equipment (Liu and Mills 2007 ; Preker and Harding 2003 ; Sloan 2000; Oneil et al. 2008 for a review). Inputs employed in the THs' production process differ as regard to the healthcare services delivered: curative or preventive. Human resources and equipment enter in the production process of curative activities. The former are measured by the number of curative and administrative staff while equipment includes the number of operational beds and a composite index which gets the endowment of the TH in equipments. It is computed from principal component analysis and incorporates the number of operational X-ray, echograph, endoscope and electrocardiagram. To produce preventive activities, only human resources are used and so two inputs are retained: the number of staff for preventive activities and staff for administrative purpose.

1.2 Estimation of the determinants of technical efficiency

Censored Tobit model is commonly used in the literature for assessing the determinants of efficiency scores computed with DEA. However, Simar and Wilson (2000, 2003 and 2007) highlighted two kinds of problems which invalidate this methodology: i) the correlation between outputs and inputs used for the assessment of efficiency scores which caused a correlation between independent variables and the error term in step two, ii) the error term in the Tobit model suffers from serial correlation as efficiency scores given by DEA are serially correlated. Both issues lead to invalid inference and inconsistent estimations. To mitigate biases, Simar and Wilson (2000, 2003, 2007) recommend the use of the Truncated Tobit. We used a program under Scilab 5.3.0 software to apply algorithm 2 (with 2000 replications) proposed by Simar and Wilson (2003, 2007)[3].

From a theoretical perspective, determinants of efficiency should be linked to a relevant model of THs behaviour. Although a Sloan-Steinwald model type (Sloan and Steinwald 1980) – which assumes that hospital utility is a function of services structure, quality and quantity of the output, satisfaction of patients, incentives to staff, profit and possibility of trade-offs between functions - seems relevant considering our survey and the discussions we had with the staff and the Health Bureau, it could not be tested. Explanatory variables of hospital efficiency used in the literature include a variety of hospital specific characteristics (more or less atypical such as the type of ownership, physicians as a share of medical staff, full-time-equivalent physicians to other full-time personnel, the number of referrals, financial characteristics (Audibert et al. 2008; Her 2008; Barbetta et al. 2007; Duggan 2000) and market factors (such as GDP, number of bed in private, density of health facilities, (Puenpatom and Rosenman 2008; O'Neill et al. 2008)). Experiments that link bonus to efficiency targets have also been used (Yip et al. 2010).

Two models are set up, one for efficiency scores calculated from the curative DEA model, one from the preventive DEA model. We consider two groups of factors expected to influence the technical efficiency of THs. The first group is related to physical and financial characteristics of THs. The nature, central or general, of the hospital can influence differently the technical efficiency. Central THs are bigger than general ones, in terms of the volume of outputs produced and of inputs available. This difference of size can influence differently the technical efficiency of THs. Moreover, the type of the TH is positively correlated with the population and the density in the township, variables which reflect the potential demand addressed to the TH and thus the technical efficiency of TH. The composition of the staff (balance between qualified and unqualified staff), the staff work load and staff incentives are also considered as important channels for technical efficiency (Puenpatom and Rosenman 2008; Yip et al. 2010). Variables are different according to the production process. We consider the proportion of qualified staff in the total staff for the regression on curative DEA model efficiency as high ratio is expected to have an attractive effect on patients. The number of households by preventive staff is used in the regression on preventive DEA model as the delivery of preventive activities is often much more managed by coverage rate considerations than by qualification of staff considerations. The efficiency of THs may be subjected to financial constraints (Preker and Harding 2003), creating a hard or a soft budget constraint (SCB). As pointed out by Kornai (2009; p. 119-120), SBC is "not a single event, (...) but a mental condition, present in the head – the thinking, the perception of a decision maker (...). There are grades of harness and softness", therefore indicators should be continuous, not discrete. Theoretical and empirical literatures provide us with

[3] The program to implement Simar and Wilson (2003, 2007) strategy was developed by Thierry Audibert whose contact will be given upon request.

some evidence showing that SBC can decrease efficiency. Regarding THs, one of the most important factors of budget constraint comes from the current share of subsidies in total expenditures (excluding staff related expenditures) rather than from the deficit as deficit integrates a kind of informal “agreement” (guanxi) between each TH and the authorities (mainly Health Bureau and local municipalities). Therefore, a high proportion of subsidies may have a negative effect on efficiency as they lower the financial constraint of THs, creating a “soft budget” constraint”. Selecting the current amount of subsidies, instead of the lagged one, is relevant because the volume of subsidies cannot be anticipated by the TH as it is decided at the beginning of the year. A small share can pressure THs to be more efficient whereas an important one may dissuade them for improving their technical efficiency. The second group of factors is related to THs environment or market factors. Two variables are retained the density of village health stations (VHS) (number of VHS per 1000 households) and the proportion of the population insured by the NRCMS[4]. The density of village health stations can have two opposite effects on THs efficiency. A negative effect may be expected as village health stations and THs might compete for the delivery of preventive activities and basic medical consultations. A positive effect may occur when village health stations refer some patients to the TH level (Puenpatom and Rosenman 2008). As THs are a target of the reform of the NRCMS, it seems to be appropriate to estimate in which measure the insurance scheme can be a control level to impact the efficiency of THs.

We then also take into consideration the potential effect that the efficiency of a TH in a specific production process (for example, in the curative healthcare delivery) can have on the efficiency of this same TH in other production process (for example, in the preventive healthcare delivery). To assess potential additional effects between efficiency behaviour in different production technologies, efficiency scores of the curative DEA model are introduced into the regression of the determinants of preventive efficiency and vice versa.

1.3 The evolution of the productivity

The Malmquist Index measures a change, between t and t-1, in the total factor productivity (TFP) of each PU. It allows decomposing TFP change into two main components: the technical efficiency change (E) and the technical progress (T). The technical efficiency change reflects the movement of the PU with regard to the production frontier whereas the technological change measures the movement of the production frontier. In the case of existing variables return to scale, the technical efficiency change can be decomposed into the pure efficiency change (P) and the scale efficiency change (S). Table 2 summarizes the interpretation of each component of the TFP. The Malmquist is: $TFP = T*E= T*(P*S)$ (1)

[4] The level of development measured by the rural net income per capita in the township is not included as it is highly correlated with the coverage rate of the population by the NRCMS.

Table 2 Summary of the definition of the Malmquist Index and its components

Between t and t-1:	Malmquist (TFP)	Technical change (T)	Technical efficiency change (E)	Pure efficiency change (P)	Scale efficiency change (S)
>1	The TFP increased.	Productivity increased (productivity gain, the frontier moved upward).	E increased, the PU got closer to the border in t than it was in t-1.	Efficiency of TH increased.	The PU became more scale efficient.
=1	TFP, T, E, P or S are unchanged.				
<1	The TFP decreased.	Productivity decreased (productivity loss, the frontier moved downward).	E decreased, the PU moved away from the border.	Efficiency of TH decreased.	The PU became less scale efficient.

Source: Table was drafted from Jacobs, Smith and Street (2006).

2 Data

The study uses an original dataset, built from a survey conducted in collaboration with the Centre for Studies and Researches Center in International Development (CERDI) of Auvergne University, the Weifang Health Office, and the Medical University of Weifang. It is a longitudinal survey covering the period from 2000 to 2008 for Weifang prefecture, and containing 24 THs randomly selected and belonging to 6 counties. Table 3 presents the descriptive statistics of the variables used in estimations. 38% of THs are central ones, while the remainders are general ones. THs deliver principally curative health care, but the volume of both kinds of medical activities (preventive and curative) increases over the period. In average, they have 39 operational beds, 33 curative employees and 6 preventive ones. The volume of inputs increases over the period. Three periods should be considered observed according to the evolution of the NRCMS implementation: 2000-2002 refers to the pre-reform years, 2003-2005 is the period during which NRCMS coverage increased, universal coverage being achieved in 2006, and the last period covers the post-reform 2006-2008. From 2006, all townships have implemented the NRCMS and over the period 2006-2008, the NRCMS covered 95% of the population. Concerning the characteristics of THs, on average bonuses amount 8700 Yuan by curative staff, the share of qualified curative staff represent 15% of the total TH's staff and there are 3027 households by employee for preventive activities. The financial structure, measured by two indicators, looks like as follow: the share of subsidies in THs' total expenditures accounts for less than 10% over the period and decreases over time.

Table 3 Descriptive statistics of outputs, inputs and explicative variables

	2000-2008	2000-2002	2003-2005	2006-2008
Curative DEA Model				
Curative activities index	45592.45	38263.35	39344.70	59169.3
Number of operational beds	38.67	33.29	35.49	47.24
Number of curative staff	32.59	28.90	30.81	38.07
Number of administrative staff	6.39	5.57	6.58	7.04
Equipment index	110.00	73.76	90.27	165.97
Preventive DEA Model				
Preventive activities index	20832.48	15463.87	18893.61	28139.97
Number of preventive staff	6.36	5.83	6.08	7.15
Number of administrative staff	6.39	5.57	6.58	7.04
Explicative variables				
Hospital level (share of central THs)	0.38	0.38	0.38	0.38
Share of qualified curative staff	0.15	0.14	0.15	0.17
Bonuses (in 10000 Yuan) by curative staff	0.87	0.93	0.76	0.92
Number of households by preventive staff	3026.76	2739.34	3017.56	3323.38
Share of subsidies	0.08	0.11	0.07	0.06
Number of HS by households	2.39	2.41	2.49	2.28
Share of covered population by NRCMS	44.20	0.00	37.37	95.23

Source: authors' database.

3 Results

3.1 Technical efficiency scores of THs

Fig.1 shows the average evolution and the standard deviation of efficiency scores[5] over the 2000-2008' period, and Table 4 presents the results of the Mann-Whitney U test for different specifications. Five main results can be highlighted.

(i) First, during the whole period the average technical efficiency from the curative DEA model is higher than the average technical efficiency from the preventive DEA model (Fig.1). It means that THs exploit in a more efficient way their curative production process than their preventive one. THs "waste" more resources to produce preventive activities than to deliver preventive healthcare. Standard deviations increase over the period, and more particularly from 2003, the year of NRCMS implementation indicating that technical efficiency of THs tends to be less homogenous over time.

(ii) Regarding curative activities, the technical efficiency increases from 2000 to 2002, and its average level being) is quite good ((included in the interval [0.75; 0.85]).

(iii) After 2002 up to 2008, TE moved back from 0.85 to 0.7. A Mann-Whitney U test confirms that technical efficiency scores are different between period 2000-2003 and period 2004-2008 (Table 4).

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[5] DEA calculation in output orientation leads to scores comprised between [1; +∞ [, thus they reflect inefficiencies. In this section, we transform the score by taking their inverse in order to interpret in terms of efficiency, which is comprised into the interval [0; 1].

(iv) According to Fig.1, preventive technical efficiency remained quite stable at a level of 0.7 until 2006. Then, it decreases to 0.55, a low level of efficiency. Between these two periods, technical efficiency scores are significantly different (Table 4).

(v) The Mann-Whitney test also suggests that being a central or a general TH is not a source of difference in technical efficiency for preventive or curative activities (Table 4).

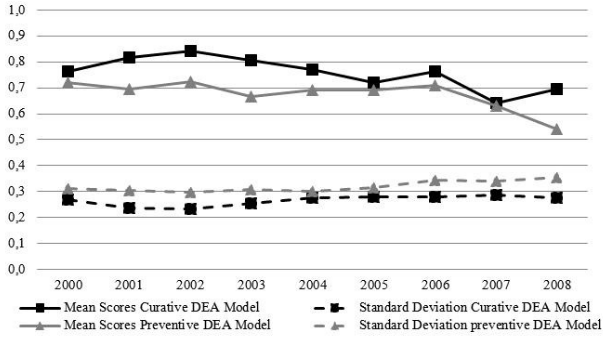

Fig.1 Evolution of THs' technical efficiency scores over the period 2000-2008

Table 4 Mann-Whitney U Tests for comparison of technical efficiency scores according to three criteria

	Curative DEA model	**Preventive DEA model**
NRCSM/No NRCMS	0.2520	0.1525
Central THs/General THs	0.5777	0.5607
2000-2003/2004-2008	0.0332	-
2000-2006/2007-2008	-	0.0238

Note: the p.value of the test is listed. H0 is rejected when the probability is lower than 5%.

3.2 The determinants of technical efficiency

Algorithm 2 of Simar and Wilson (2003, 2007) is applied to estimate the determinants of THs' technical efficiency in producing curative and preventive activities (Model 1 and model 2 respectively). Results suggested after 2000 replications are summarized in Table 5.

(i) *Curative activities.* Among all the variables selected on a theoretical ground and expected to explain the efficiency of THs when curative activities are considered, three variables has a significant effect: the bonuses by curative staff, the density of VHS by household and the share of insurance coverage. Results indicate that financial incentives given to staff have a positive effect on technical efficiency of THs (Table 5[6]). When the density of village health station increases, the efficiency of THs improves. It suggests that village health stations refer patients to TH level, as logically expected. Therefore THs and village health stations activities are complementary, rather than competitors. The increase of the NRCMS coverage influences negatively the efficiency of THs, despite of the increase of activity the insurance scheme

[6] Due to calculation, Table 5 shows the coefficient of factors that explain the technical inefficiency. Many others specifications were tried and results doesn't change. Our results contrast with those of Liu and Mills (2005) in six county hospitals (at the upper level of TH) for the period 1978-98. They find that bonus induced unnecessary care associated with decrease productivity over time. These two elements were factors leading to the current reform including a tighter control of the health bureau on hospitals, both at county and township levels.

generates. The development of the NRCMS may induce a softer budget constraint often associated with less cost control and expenditures.

The lack of other significant traditional variables reflects the fact that efficiency of THs to produce curative activities is driven by unobservable variables such as the dynamism of the director of the hospital, the relations (fair or not) between the director and the staff, and the so called social network ("guanxi"). This last point has been confirmed by our discussion with several Chinese interlocutors. More investigations around the social organization (Meltzer et al. 2010) can be conducted to detect variables that can influence the technical efficiency of THs.

(ii) *Preventive activities.* The efficiency of THs to produce preventive activities is affected by three variables. When the number of households by preventive staff increases, indicating that inputs are used more intensively, the efficiency increases. As for curative activities, the increase of the coverage by NRCMS reform leads to a decrease of efficiency in the production of preventive activities.

Table 5 Double bootstrap **t**runcated estimation for the curative and preventive technical inefficiencies

	B	P(β<0)	CI-5l	CI-5u	CI-10l	CI-10u
MODEL 1: Y= curative technical inefficiency						
Hospital level	-0.3781	0.8355	-1.0473469	0.2595639	-0.8585351	0.1182606
Share of bonus by curative staff	-0.7524*	0.948	-1.4255112	0.0081935	-1.2239672	-0.1304908
Share of subsidies	1.7514	0.229	-1.7217663	4.6844902	-0.9422274	3.9738142
Number of VHS by HH	-0.6425**	0.9815	-1.1180055	-0.1576235	-0.9723370	-0.2629907
Share of covered population by NRCMS	0.0079**	0.0365	0.0006285	0.0147601	0.0020598	0.0130058
TE scores of input-oriented preventive DEA model	-0.1410	0.573	-1.0415021	0.8049170	-0.8275377	0.6020329
Constant	2.885**	0.0035	1.4819319	4.1343677	1.8101407	3.8758158
MODEL 2: Y= Ln (1/preventive technical inefficiency)						
Hospital level	0.0222	0.852	-0.0298296	0.0074686	-0.0254661	0.0031041
Number of Household by preventive staff	-0.0001**	1	-0.0001797	-0.0001519	-0.0001765	-0.0001550
Share of subsidies	-0.4471	0.0025	0.1002584	0.4283085	0.1342931	0.3929799
Number of VHS by HH	0.0088	0.3775	-0.0043042	0.0071360	-0.0031974	0.0055560
Share of covered population by NRCMS	0.0019**	0	0.0018792	0.0026576	0.0019572	0.0025741
TE scores of output-oriented curative DEA model	0.0805*	0.938	-0.0793193	0.0029840	-0.0706834	-0.0074817
Constant	0.7914**	0	0.8260676	0.9446124	0.8406755	0.9334797

Note: Double bootstrap truncated estimations with 2000 replications (Simar and Wilson 2003, 2007) are estimated. Due to the construction of the right hand variable, a positive sign denotes a positive sign on inefficiency and thus a negative influence of the variable on efficiency. By contrast, a negative sign means a positive effect on efficiency. The probability is computed following Badin and Simar (2003). ** indicates significance at 5% and * at 10%. CI indicates confidence interval, at 5% and 10% and m for the lower bound, u for the upper one.

The suggestion that curative and preventive activities are in implicit competition is supported by the results. The coefficient of TE scores for curative DEA model is significant and positive, indicating that higher the curative model efficiency score, the lower the preventive model efficiency score.

3.3 The evolution of the productivity

The Malmquist index is computed for both DEA models. Fig.2 shows the result in the curative configuration while Fig.3 is related to the preventive model.

3.3.1 Curative activities

Five main results are mainly highlighted (Fig.2): (i) first, the evolution of the total factor productivity is largely supported by that of the technical efficiency; (ii) from 2001 to 2005, the Malmquist index is quite stable around one, suggesting that productivity of THs remains unchanged; (iii) E and T seem to compensate themselves, resulting in an unchanged overall productivity; (iv) afterward, global productivity of THs is enhanced since 2006, largely due to technological progress;(v) concerning efficiency changes, THs experienced efficiency losses since 2003 (except in 2006). To conclude, the heterogeneity of the three indexes increases over the time as shown by Fig.2 (b). However, it suggests less important divergences in terms of technological changes between THs rather than in terms of efficiency changes or total factor productivity.

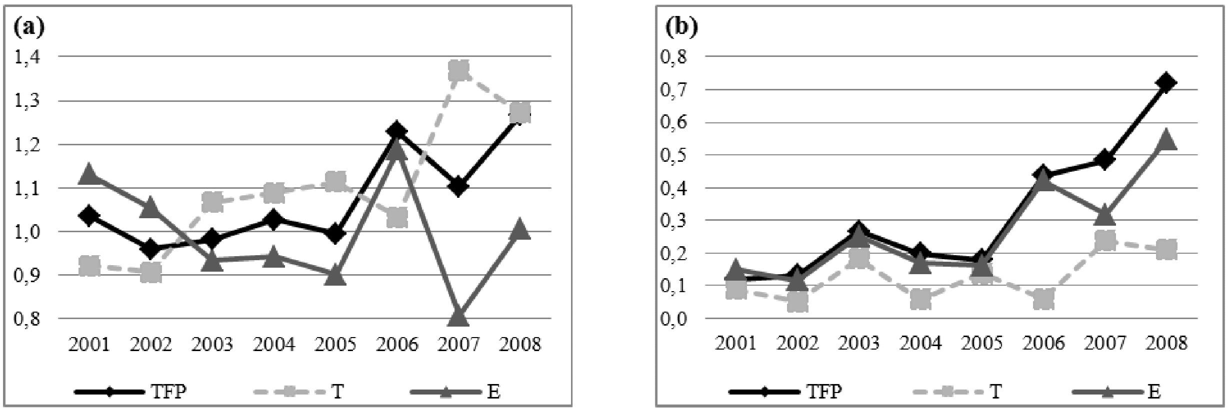

Fig.2 Evolution of mean (a) and of the standard deviation (b) of the Malmquist index and its components for the Curative DEA Model

3.3.2 Preventive activities

Fig.3 comes to light that the total factor productivity follows the same evolution as the technological component until 2005 and, as the technical efficiency component after. The productivity of THs for preventive activities is always higher than 1. Thus productivity increases over the period, albeit at an unstable rate. Two periods characterized the technological change: one of technological decline (2000-2004) and one of technological progress (2005-2008). By contrast, THs experiences efficiency gains until 2006 and efficiency losses after. Finally, the heterogeneity of the three indexes increases over time as shown by the Fig.3 (b).

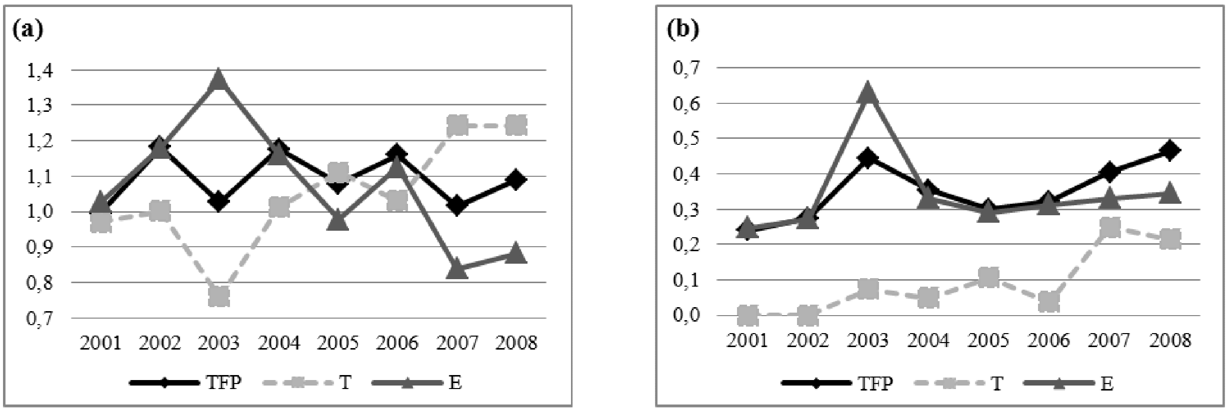

Fig.3 Evolution of mean (a) and of the standard deviation (b) of the Malmquist index and its components for the Preventive DEA Model

4 Discussion and conclusion

During the last ten years, China undertook important health reforms that concern supply and demand sides of health care, as insurance in rural area. Health insurance reform has been ongoing into several waves. The reform of the insurance (NCMS) displays at least two objectives. The first is to increase healthcare access for rural population; the second to improve the performance of health system, more specifically, of township hospitals. We focused on the second goal and studied the efficiency and productivity changes and its determinants among 24 China township hospitals using a two-stage analysis, including DEA, Malmquist index and double bootstrap truncated regressions.

Results show that the technical efficiency to produce preventive activities is stable over the whole studied period, but very low (less than 0.4). By contrast, the technical efficiency to produce curative activities is higher (above 0.7), and non-stable. TE increased between 2000 and 2003, but declined after this date corresponding to the introduction of the insurance reform. But starting from 2005, total productivity of factors increased (Malmquist index). This improvement is the outcome of positive technical change outweighing instability of change in efficiency. Similar findings have been reported by other studies (Burgess and Wilson 1995; McCallion et al. 2000) for hospitals in developed countries.

These results regarding efficiency may suggest that increasing the insurance coverage created a softer budget constraint that negatively influences TH efficiency. For example, Shu and Eggleston (2009) found in their study that hospitals facing softer budget constraints were less aggressive cost control. Puenpatom and Rosenman (2008) also found that if more financial reserve could help stabilize the hospital's financial status, it contributes to decrease efficiency. Double bootstrap truncated analysis confirms that result: efficiency decreased with the improvement of insurance coverage. But, as suggested by Eggleston et al. in their study on a sample of hospitals in Guangdong province in China (2009), a SBC can have positive effects on other dimensions of performance, as quality. This study also shows that hospitals operating in a context of SBC have a lower probability of shutting down safety net services. Other studies have shown (for example for Brazil: La Forgia and Couttolenc 2008) that high efficiency does not necessary impair quality as they found no significant difference between totally efficient hospitals and their inefficient peers.

However, the reform of insurance had a positive effect on the referral system and hence, indirectly on the overall health system performance. Our results showed that village health stations and THs activities are complementary, as VHS patients may be more referred after the reform. The link between referrals and efficiency was also found by Puenpatom and Rosenman (2008) in the sense that more patients entering into the system at the bottom and more referrals improve efficiency.

Finally, our results suggest that staff's bonus may improve hospital efficiency as expected from the standard theoretical literature and confirmed by several empirical evidences. Some can be found in Eichler and Levine (2009). In China, Yip et al. (2010) report that the changes in payment incentives at health facilities and staff levels, when global budget is combined with pay-for-performance or salary bonus linked to some performance indicators, provide measurable improvements in efficiency, quality, and access.

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