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Abstract

To cope with the rising price of drugs, in 2009 the Chinese government launched a large pharmaceutical reform. Its key element is the implementation of a National Essential Medicine List, leading to a reorientation of incentives for health services providers. Health facilities are not anymore allowed to make any profit on drug sales ("zero mark-up policy"), while this used to be their main source of financing. Different compensation schemes have been implemented by the authorities. In a context of refunding of the financing structure of health care facilities, it is crucial to understand how the reform has affected –or not- health care facilities activity and efficiency.

This study relies on a survey data from a sample of 30 Township Hospitals of the rural prefecture of Weifang (Shandong province). Using a two-stage procedure, it aims at assessing the THs' technical efficiency scores and then at identifying the determinants of this efficiency. The first stage is realized with a non-parametric frontier approach, the so-called 'partial frontier' method, order-m to deal with the problem of dimensionality. The identification of the determinants of efficiency requires panel data models, with random individual effects. Results show that the average efficiency remains constant between 2006-09 and 2010-12, around 0.65. The most significant and robust factors of technical efficiency are the share of subsidies in the TH incomes for the first sub-period (negative effect), and the number of covered inhabitants per bed (positive effect). It suggests that drug reform hasn't improve primary health facilities efficiency, certainly because the reform did not tackle with success the issues of the financial barriers to universal access to healthcare -out-of-pocket payments from patients-, and of the perception of quality of public healthcare.

Key words: Chinese health care system, Hospitals, Incentives to health care providers, Pharmaceutical sector reform, Rural health insurance, Soft budget constraint

JEL codes: I11, I13, I18

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1. Introduction

From the 1970's to the 2010's, due to urbanization and the real income growth of a large part of the population, China experienced a major change of lifestyle (better access to rich food, less physical activity, spread of tobacco use for instance), and has faced the ageing of its population. This caused a spectacular demographic and epidemiological transition. The main factors of the burden of disease shifted from infectious, maternal and nutritional diseases to cardiovascular pathologies, cancers, hypertension, and chronic diseases (Wang et al., 2005). The emergence of those diseases increased the cost of healthcare, mainly borne by households, causing a large problem of inequalities in the access to healthcare. The spectacular increase of the insurance coverage rate between 2003 and 2008 (Audibert et al., 2013, You and Kobayashi, 2009) spurred the activity of public health facilities (Wagstaff et al., 2009), but failed to eradicate the phenomenon of catastrophic expenses (Meng et al., 2012). Financial burden of healthcare still represents a cause of impoverishment (Sun et al., 2009; Yip and Hsiao, 2009). Moreover, public policies around prevention (to tackle tobacco use and obesity for instance, (Wang et al., 2005) are still not satisfying. The education gradient observed in terms of diagnosis and treatment of hypertension in urban areas (Lei et al., 2012) underlines the weaknesses of the public healthcare services in terms of information.
Yet the quantity of financial resources injected in the system has kept increasing for more than three decades, largely because of the rise of costs. The issue of the inefficiency of Chinese healthcare facilities (Hu et al., 2008) has thus become crucial. The daily number of patients cared of by the medical staff has been proved to be weaker in China than in many other countries. The reasons were both intern (inappropriate recruitments and incentives) and environmental (collapse of health insurance, problem of access to healthcare). A growing defiance and dissatisfaction from patients due to a mediocre quality of healthcare in public facilities is also a matter of concern[1].

The rural insurance reform of 2003 spurred health facilities' activity but didn't manage to contain the rise of costs and of out-of-pocket payments. Those costs being largely composed of drug expenses (Sun et al., 2008), in 2009 the government implemented a pharmaceutical reform to cut prices by a National Essential Medicine List (NEML) , and a zero mark-up policy on the sales of drugs. By reorienting the incentives for healthcare providers, it aims at a better use of all the resources of the healthcare system.

Relying on survey data, this study aims at estimating the technical efficiency of a sample of township hospitals (TH), - which are part of the primary level health facilities within the Chinese nomenclature - and its determinants. Particularly, it looks at a potential shift in the determinants of technical efficiency between before and after the pharmaceutical reform. It concludes that there was no significant change in the factors that drive technical efficiency.

Section 2 presents the two main reforms of the Chinese health system in the 2000's decade, the rural insurance and the NEML which are closely linked from the perspective of the objective of this study. Section 3 outlines a literature review about the determinants of efficiency. Section 4 presents the main characteristics of our sample and our study area, located in Weifang prefecture in Shandong province. Section 5 focuses on the estimation of the efficiency scores, while Section 6 deals with the identification of the determinants of efficiency. Results are discussed in Section 7, before a conclusion in Section 8.

2. Background

a. The revival of the Chinese Health Insurance system in rural area

In 1975, the Cooperative Medical System (CMS) ensured an almost universal access to basic healthcare to the Chinese rural population through a pre-payment insurance system (Bloom and Xingyuan, 1997; Dong, 2009). With its disentangling in the 1980's and 90's decades, healthcare became a financial burden for many households due to the absence of health insurance and rising prices. In 2003, the implementation of the New Rural Community Medical System (NRCMS) gave a large part of rural households an access to a basic health insurance, managed at the county level. From 2003 to 2013, the enrollment rate rose from less than 10% up to more than 95 % in 2013 (*WB Policy Note 3,* Yip et al., 2012 and official data quoted in China Daily, 2014-06-03).

[1] The wave of violence against doctors recently observed in several provinces, and which is one extreme manifestation of this dissatisfaction, is being taken very seriously by the National Health and Family Planning Commission (2013 merging of Ministry of Health with the Family Planning Commission).

The NRCMS mainly aimed at avoiding catastrophic health expenditures, to prevent households from falling or sinking deeper into poverty. Though, deductibles and copayments rates have remained high, leaving high out-of-pocket payments for most of the medical acts, with, overall, ambiguous effects on catastrophic health expenditures. There are two main reasons. First, the NRCMS is ruled at the county level. The counties manage their benefit package within a policy guideline (You and Kobayashi, 2009), therefore there are some substantial differences between poor and rich areas (Meng et al., 2012). Second, until very recently, the benefit packages have been focusing mainly on inpatient care (Wagstaff et al., 2009 ; our discussion with members of the National Health and Family Planning Commission), despite the epidemiological transition, and the fact that chronic diseases mainly leads to poorly reimbursed outpatient cares.

b. The National Essential Drug Policy

At the same time, on the supply side, the financing modalities of health providers had spurred overpricing and overprescribing for many years. Central government subsidies to public health care facilities fell off during the 80' and 90', and to offset it, hospitals were allowed to take a markup on drug sales and 'new' medical acts such as tests and surgeries. Simultaneously, there was a severe control of the price of 'basic' cares (Blumenthal and Hsiao, 2005), on which health facilities could not make any profit. Those phenomena put together created incentives for health practitioners to overprescribe high-technology tests and expensive drugs rather than cheaper ones, to increase the TH income, through user fees. Drug benefits became the main source of hospitals financing (Yip et al., 2010). Until 2009, health facilities were allowed to take a 15% mark-up on the drug purchasing price, and used to "take an average margin between 30% and 40%" (Wang Dongsheng, vice-director of the Social Development Division of National Development and Reform Commission, 2006). This made the financial burden of health expenditures even heavier for households. On the contrary, basic care services were neglected by health providers, enhancing a problem of quality of primary health in addition.

Drug overpricing was also spurred by the national drug supply chain, due to the excessive number of wholesalers, intermediaries between the drug producers and health facilities, and by the absence of bidding system ((Yu et al., 2010). Indeed, in China the pharmaceutical market was made of thousands of manufactures, selling their production to a 'third-tier' who made the contact to another wholesaler, or to health facilities. Every actor of the supply chain taking a benefit, this structure participated in the very high prices of drugs in China (compared to the international prices).

To contain the excessive drug prices and disconnect hospitals income from drug sales, in 2009 the Chinese government implemented the National Essential Drugs Policy (NEDP). It aimed at improving the drug supply system and ensuring both equity in the access to basic care medicines and safety of drug utilization. A National Essential Medicine List (NEML) was released at the same time, updated in 2012. It includes three medicinal categories: chemical and biological drugs (317 drugs), traditional Chinese patent medicines (203 drugs) and traditional Chinese cut crude herbs (NHFPC, 2013). To meet regional specific needs, local governments were allowed to establish an additional list of essential drugs. In Shandong province, where our study area is located, the additional list (2010 version) consists of 216 drugs. All Primary Healthcare Facilities (PHF) must now prescribe exclusively essential drugs. As for other healthcare facilities, the utilization of essential drugs is compulsory, and the rate of essential drug utilization must reach the threshold defined by health authorities (NHFPC, 2009).

Another core objective of the reform was to strengthen TH (also called Township Health Center) initial missions in the health care pyramid: treatment for non-severe pathologies (and reference of severe cases to county hospitals), management of Village Health Stations (VHS) staff on their coverage area and prevention services. To ensure this preventive mission, the reform included the development of public health activities: vaccinations, health records for children and elder people, with specific subsidies for this purpose.

Since October 2009, the government also gradually implemented a zero-markup policy for the sales of essential drugs (NDRC, 2008). The selling price in PHF was adjusted to the purchasing price, including delivery costs but without any markup for PHF. This policy, completely redefined the structure of PHF financial balance. Indeed, the loss of drug benefits is a huge hole in PHF revenue and could have widely disturbed their daily activity.

To compensate losses due to the zero-markup policy, and ensure the stability of NEDP, different modes of financial compensation were implemented (Yuan and Tang, 2012; Zhuo and Zou, 2012). Each county can either choose one, or mix several modes of compensation among the following: exclusive government compensation, incentive system, multiple compensations, and separation of revenue and expenditure system.

When a financial compensation comes from the county, the performances of PHF are assessed for the attribution of the subsidies. The amounts are generally disbursed in several times such as once at the beginning of the period, once at the end. The first allocation is usually higher, to ensure the daily activity of PHF. In Weifang prefecture, our study area, 80 % of the subsidies are allocated monthly, during the current year. The remaining 20% are disbursed in March of the next year only if the PHF meets the requirements in the assessment organized by the county health authority. However, leaving a TH without any financing because of its poor performances would be unrealistic as it jeopardizes its activity for the following year. Thus, county governments actually handle most of the financial deficits in TH in Weifang, as long as their finances allow them. .

Due to the complexity of the compensation and of the incentives measures, the effects of the reform on THs efficiency are far from predictable and may seem contradictory.

3. Literature review and the potential effects of the zero mark-up policy on township hospitals efficiency

a. Expected effects of the reform

Because of the high cost of care, we can consider that the health care demand at TH level is relatively price elastic, more precisely, elastic to the amount of the residual cost borne by the households. The mandatory use of essential drugs as well as the policy of zero mark-up should lead to a decrease in the unit cost of care and reduce catastrophic costs, all things being equal. For these reasons, an increase in healthcare demand is expected, and was found in various studies (Li et al., 2013; Xiao et al., 2013). This can result from a demand that was previously not satisfied for financial reasons (renunciation to care, self-medication) or from a transfer of demand from Village Health Stations or county hospitals to TH. On the other hand, increase may not be observed if patients, considering the decrease in unit costs, seek more sophisticated care than they would have without cost decrease. This effect was highlighted in Gansu province following the development of NCMS (Wagstaff and Yu, 2007).

Considering that Township Hospitals are far from being saturated, an increase of activity could be joined to an increase of efficiency of health facilities. The mean bed occupancy ratio (BOR) decreased over the 1990's (Liu et al., 1996). Pélissier et al., 2012, on the same area than this study, finds a decreasing BOR from 2000 to 2004 (from 40 to 35%) and then an increasing until 2008 (60% in 2008). In such a context, a take-off of activity does not necessary mean new inputs, but an increase of efficiency is expected as the physical and resources are fully used. In contrast to this hypothesis , Audibert et al., 2013 exhibits a positive and significant impact of the NRCMS on the THs' activity in Weifang, but a negative impact on their efficiency. It is thus essential, in terms of public policy, to distinguish the two analyses.

In the precise context of the pharmaceutical reform, three main scenarios (with variants) can be considered, suggesting that the effect of the reform on the efficiency of TH is unknown a priori:
i) Demand for care increases, all other things being equal: efficiency progress is noted.
ii) Demand for care increases, but its expected positive effect on efficiency is offset by an increase in the number of staff and other inputs. To anticipate and promote increased attendance in TH, the county health authorities (manning staff) or the TH manager (staff out of quota) may decide to increase the number of staff, despite the low staff productivity. If the demand does not increase sufficiently, the effect on the efficiency is potentially negative. It seems likely in Weifang, regarding our discussion with the local authorities.
iii) Demand remains unchanged as does the level of personnel and equipment. A decline or stagnation of efficiency is expected for several reasons:

a) Compensation for loss of income from drugs is partial; demand remains unchanged because THs develop coping strategies, for example by increasing medical activities (lab tests, drug injections) that are not supervised by the reform (Xiao et al., 2013). The unit cost of care borne by households does not decrease.
b) Cost of care decreases. If there is partial compensation, and without THs coping strategies, objective and/or perceived quality of care are likely to decline. The negative effect on demand neutralizes or outweighs the positive one coming from the decrease in the cost of care borne by households.

b. Determinants of efficiency and selection of potential determinants

The literature related to this issue highlights two main types of factors.

The first type of determinants corresponds to the internal ones. Yip et al., 2010 underlines the crucial role of health care providers on hospitals efficiency: behaviors related to provider payments (which can create perverse incentives if not appropriate) and qualification. Here, all the THs implement the same provider payment system so we only study qualification and incentive of staff. Two variables are tested: the wage and bonus expenditure, per employee and the proportion of licensed staff (i.e. proportion of doctors among the medical staff).

Another crucial issue, especially in the context of the reform, is the financing structure of a hospital income, between subsidies and activity revenues. In a situation of *soft budget constraint* (Kornai, 2009), by a mechanism of moral hazard, the dependence of hospitals to public subsidies has a negative impact on their efficiency. On the contrary, if subsidies are allocated according to performances, then their effect can be positive on efficiency, by an incentive mechanism.

A methodological concern is the potential endogeneity of the effect of subsidies on technical efficiency, through reverse causality. In theory (according to the policy guidelines), the amount allocated to a TH is related to its performance, so the causality would be from efficiency to the amount of subsidy, with a positive sign. It can also be considered, in a situation of soft budget constraint, that if a TH is inefficient, it will be more likely to be bailed out at the end of the year to offset its deficit and reach a financial balance. In this case, the amount of subsidies is still explained by TH performances, but with a negative sign.

To check for the endogeneity of subsidies, we studied the determinants of subsidies in our sample through a panel data model. The results highlighted an absence of reverse causality between subsidies and efficiency scores. Indeed, the amount of subsidies allocated to each TH is largely driven by the population of the township (size effect), by the county GDP per capital (which has a positive effect on the financial capacities of the NCMS bureau), and unobservable factors. Neither the efficiency score, nor its lagged value being significant, the endogeneity of subsidies is thus rejected.

The importance of subsidies is captured through several variables. First, the proportion of subsidies in TH total income is used, as a proxy of TH dependence to public financing. Yet this variable is not fully satisfying, since it depends upon activity income. As an inefficient hospital probably exhibits a weak activity income, so mechanically subsidies will represent an important proportion of its global revenue. To deal with this issue, the proportion of subsidies in TH expenditures is also tested, as it is likely more stable. Other proxies are successively introduced in the model: amount of subsidies in the catchment area, per bed and medical staff.

The second type of determinants of efficiency is the *externa*l one. It gathers all the aspects of the hospitals environment: competition of other healthcare facilities, importance of the potential demand in the catchment area. In the same area, but on a previous period (2000-2008), those variables were found to be the most determinant factors of TH efficiency (Audibert et al., 2013). We use as external determinants the population covered by the NCMS in the township, the density of population, the net income per capita and the number of Village Health Stations under the responsibility of the TH. This last variable can have two opposite effects on TH efficiency: there can be a phenomenon of competition (a negative effect), or stimulation of activity by the referring of patients from VHS to TH (positive effect).

To check whether there was a shift in the determinants of efficiency between the beginning and the end of the period, the potential determinants were interacted with dummies corresponding to sub-periods, as well as variables at square to test non-linear relations.

4. Study area and descriptive statistics

a. Database

This study relies on annual survey data, from the rural part of the Weifang prefecture, in Shandong province, a relatively rich coastal province. The Weifang prefecture includes 12 administrative divisions, each formed of several townships. To each township is associated one Township Hospital. The sample is made of 30 TH randomly selected, belonging to the 8 rural counties of the prefecture. The study period runs from 2006 to 2012. Data was collected by the staff of Weifang Health Bureau, colleagues from Weifang Medical University and the authors. Sources of data include books and registers of TH, Statistical and Finance Offices of townships and counties.

b. Important evolutions of the activity

Every township in the sample is administratively classified rural, and actually exhibits a large majority of rural population (around 90%, stable across the period). The covered populations and density are very unequal between the TH, which can induce major differences in terms of potential demand for healthcare. The average net income per capita is rather homogenous between the 30 townships (and even more for end of the period, as the dispersion decreased), and almost doubled from 2006 to 2012 (Table 1, 5510 annual constant yuan in 2006, 10800 in 2012).

Table 1. Characteristics of the 30 Townships of the sample

	2006			2009			2012		
	Mean	Std dev.	Rel std dev	Mean	Std dev.	Rel std dev.	Mean	Std dev.	Rel std dev
Population of the Township	58599	29615	50.54%	72950	31666	43.41%	71359	33000	46.25%
TH catchment area	46233	17979	38.89%	55143	24453	44.34%	56317	25312	44.95%
Number of VHS under the TH supervision	28	13	48.41%	34	16	48.89%	36	19	50.98%
Density of the covered population *(Inhabitants per km²)*	483	187	38.79%	503	224	44.57%	495	232	46.78%
Density of the township population (*Inhabitants per km²)*	545	408	74.93%	563	451	80.05%	553	482	87.12%
Average net income*	5511	1170	21.23%	7626	992	13.01%	10800	982	9.09%

Source: Data from Township registers. Rel. std dev= Std%mean ;
(*) Nominal values have been deflated by the General Retail Price Index in Shandong province, 2006=100 (from China Data Online)

The broad characteristics of the population remained stable across the period (Table 2). Data from the county statistics show that there is no major demographic evolution between 2006 and 2012 (very slight increase of the proportion of inhabitants above 65 or below 6 years). Yet it can be noticed that infant and juvenile mortality decreased, suggesting that quality of maternal and postnatal care improved. In our context of randomly selected sample, the stability of demographic indicators, associated to the very precise missions of THs (curative treatment of non-severe cases only) justify a homogeneous case-mix across the THs of the sample, and across the period.

Table 2. Global statistics about the 8 counties of the sample

	2006			2009			2012		
	Mean	Std dev	Rel std dev	Mean	Std dev	Rel std dev	Mean	Std dev	Rel std dev
Rate of under 6 pop (%)	7.83	3.83	48.89%	8.00	4.09	51.20%	8.32	4.00	48.06%
Rate of above 65 pop (%)	8.97	1.31	14.61%	9.81	1.37	13.91%	11.23	2.29	20.42%
Rural net income (yuans)	5326	574	10.78%	7507	626	8.34%	11735	824	7.02%
Infant mortality *(per 1000)*	5.19	3.08	59.29%	4.32	1.62	37.57%	3.30	1.13	34.23%
Juvenile mortality *(per 1000)*	5.70	3.21	56.23%	4.87	1.84	37.85%	4.00	1.16	28.91%
Inpatient mortality *(per 1000)*	4.91	2.63	53.61%	4.68	2.74	58.59%	3.74	1.92	51.27%

Source: Data from County registers. Rel. std dev= Std%mean

During the period under review, the level of both resources and activity increased. The activity of TH grew drastically regarding outpatients, inpatients, lab test, medical examinations (radiology, etc.) and preventive activities (Table 3)**.** For instance, the number of outpatients increased by 82% and of inpatients by 126%. Nevertheless, no disruption in the trend is to be noted, the evolution being regular.

The inputs of THs also rose over the period. But the number of available beds (+75%) and the equipment index (+85%) grew faster than the staff (+19%). Indeed, TH managers frequently underlined their difficulties to hire staff in rural areas.

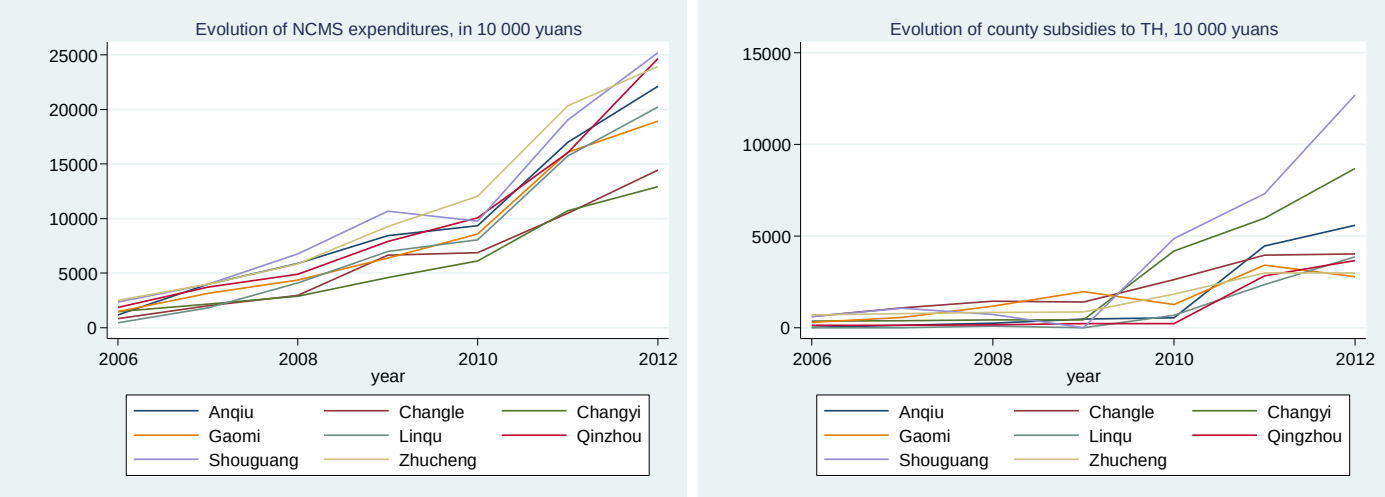
Table 3. Descriptive statistics about TH activity

	Mean			Median			Standard deviation			Relative std deviation		
Variable	**2006**	**Var(%)**	**2012**	**2006**	**Var(%)**	**2012**	**2006**	**Var(%)**	**2012**	**2006**	**Var(%)**	**2012**
Number of outpatients	33087		60290	19612		31982	27566		62230	0.83		1.03
		82.22			63.07			125.75			23.89	
Number of admitted inpatients	1510		3411	1164		2548	1024		2912	0.68		0.85
		125.85			118.90			184.28			25.87	
Number of tests	5417		9494	3320		6815	5629		8914	1.04		0.94
		75.27			105.29			58.35			-9.65	
Number of surgeries	172		217	117		137	185		238	1.08		1.10
		26.16			17.17			28.24			1.65	
Number of vaccinations	11178		16002	11278		14416	7619		20391	0.68		1.27
		43.15			27.83			167.63			86.95	
Number of antenatal visits	1678		1683	1273		965	1545		1561	0.92		0.93
		0.30			-24.19			1.08			0.78	
Number of emergencies	605		1331	157		371	1144		2151	1.89		1.62
		119.95			137.06			88.08			-14.49	
Global Activity Index	21		36	15		25	15		27	0.69		0.75
(see Section 5.a)		69.87			63.98			83.92			8.30	
Number of available beds	44		77	38		61	24		46	0.55		0.59
		74.55			60.53			88.99			8.27	
Staff of the TH	65		77	57		68	36		40	0.55		0.52
		18.46			19.47			11.75			-5.67	
Equipment Index	23		42	21		36	14		25	0.62		0.59
(see Section 5.a)		84.59			68.94			76.28			-4.51	

Source: Authors' calculation from data of Township Hospitals registers; Rel. std dev= Std%mean

At the same time, the expenditures of every NRCMS Bureau in our sample increased, with a strong acceleration starting from 2010, as well as the county subsidies devoted to the THs (Figures 1 and 2), contributing to ensure a quasi-universal coverage for a selected package of outpatients and inpatients care. In Shouguang county, where subsidies to TH increased the most, NRCMS expenditure have been multiplied by 10 in 3 years. There are mainly two complementary explanations to the growth of NRCMS expenditures, the deepening of the benefit package (rise of the reimbursement rate per inpatient case) and an increase of PHF activity. Those elements certainly spurred TH's activity, as the literature generally provides evidence of a positive influence of health insurance on the demand for care.

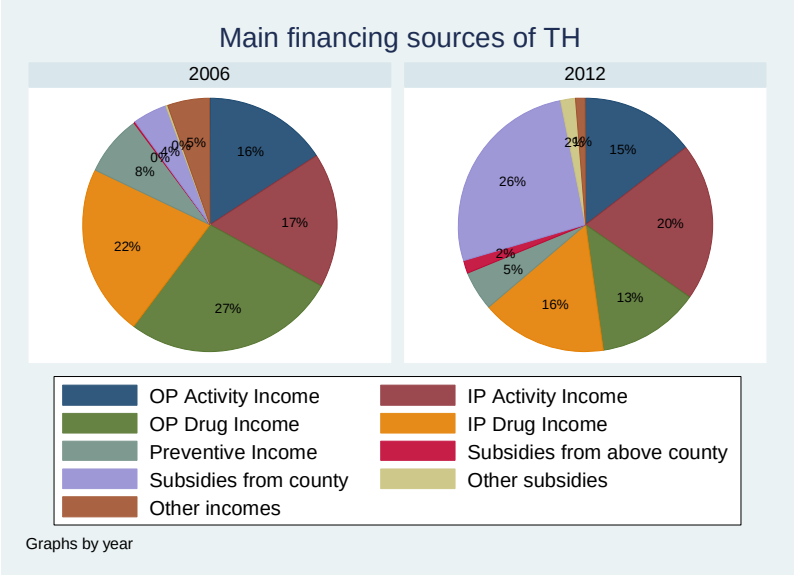
Figures 1 and 2. Evolution of NCMS deflated expenditures, Evolution of deflated county subsidies to TH



Source: Authors database from NCMS and Health Bureau data Nominal values have been deflated by the General Retail Price Index in Shandong province, 2006=100 (from China Data Online)

As stated previously, the NEDP (National Essential Drugs Policy) reform sharply changed the income structure of PHF of the sample. Figure 3 shows the comparison of principal sources of income for all observed TH between 2006 and 2012. In 2006, over 80% of revenues came from hospitals' activities, such as inpatient activity, outpatient activity and drug prescription. Furthermore the drug prescription was the primary source of income, nearly the half of the total income. In contrast, activities rewarded hospitals up to 55% of its revenues in 2012. The huge decrease in drug income originated almost exclusively from the share of drug prescription. This loss of revenues was offset by governmental subsidies, especially subsidies from county level, which represent one third of hospitals' revenues.

Figure 3. Main financing sources of TH



Source: Authors database

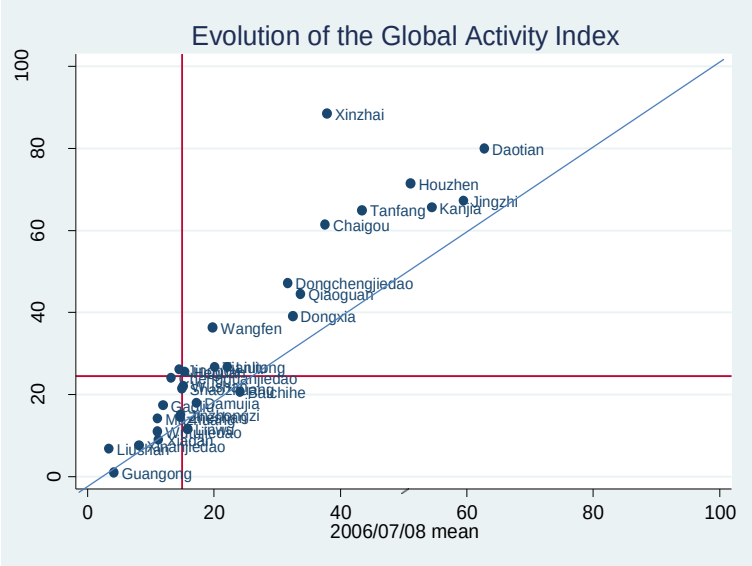
5. Estimating efficiency of Township Hospitals

a. The choice of the production function

The definition of the production function has been made according to observations, and discussion with local actors. First, the multi-output production function of a hospital has to be dealt with. The literature around efficiency in health usually takes only into account the number of inpatients and outpatients (Yang and Zeng, 2014). Here preventive activities (vaccination, antenatal consults) are also at the core of a Primary Healthcare Facility, so a synthetic indicator was computed before the efficiency assessment to get a wider proxy of TH activity. Seven variables were selected as representative of an aspect of the TH's activity: annual number of outpatients, admitted inpatients, emergencies, surgeries, tests, vaccinations and antenatal consultations. A Principal Component Analysis (PCA) was computed in order to get some synthetic factors of the TH activity.

The first factor of the PCA was kept as the output in the production. It is by far the most explanatory axis, and it is positively correlated to each of the introduced variables. This axis, which captures 44% of the total variability, captures a global trend of the activity and is consistent with the characteristics of an output (an increase of any variable will increase the Global Activity Index). It is kept as the Global Activity Index and used as the output of our model.
The evolution of the Global Activity Index confirms the dynamic development activities for almost all TH (cf. Figures), it rose by 70% in mean on the period.

Figure 4. Evolution of the Global Activity Index



Source: Authors database

Three inputs were identified, reflecting the human and physical capital of the TH: the number of available beds, the staff of the TH, and an equipment index. This latter was computed using a Principal Component Analysis (PCA) which included every kind of imaging and test machine found in a TH[2].

b.Measurement of efficiency

There are mainly two ways of assessing health facilities efficiency: a parametric one, the Stochastic Frontier Analysis (SFA), and non-parametric ones such as the Data Envelopment Analysis (DEA). As pointed out by Hollingsworth, 2008, the DEA method has been widely used in assessing health facilities efficiency since its apparition in 1978 (Charnes et al., 1978, Birman et al., 2003; O'Neill et al., 2008). It avoids making any assumptions about the form of the production function, when it is unknown.

Nonparametric efficiency methods can only compare DMUs (Decision Making Units) of the sample. The best performers of the sample will be defined as the efficient units and assessed a score of 1, and will be benchmarks for the other DMUs. The problem of the DEA method relies in its sensitivity to dimensionality, and to outliers in the given sample. If there is an outlier in the sample, the production frontier is distorted, and the scores of all the DMUs compared to those wrongly or artificially efficient units are biased.

Partial frontier methods were developed ((Cazals et al., 2002)(Daouia and Simar, 2007)) to cope with DEA limits. Two close techniques are used, so-called 'order-m' and 'order-α'.

In the order-m frontier, introduced by Cazals et al., to estimate the efficiency of a DMU in an output orientation, many samples of *m* DMUs are simulated, composed of DMUs using at most the same quantities of outputs in the sample (in an input orientation, producing at least the same quantities of outputs). For each simulated sample, an efficiency score is assessed to every firm, relatively to the estimated frontier. The procedure is repeated *n* times, then the mean score of all those simulations becomes the order-m score. This method authorizes DMUs to be above the production frontier, and the scores to be above 1. It is also a way to detect outliers, defined as the DMUs whose score remains largely above 1 even when *m* increases (Simar, 2003). In the 'order-α' technique (Daouia and Simar, 2007), the efficiency scores are computed so that a certain percentage of DMUs in the sample, fixed *a priori*, remains above the frontier. Here, both techniques have been used and gave very similar results. We present and discuss only the order-m results.

[2] The PCA included the number of radiography and computed tomography machines, of echo-graphs, electrocardiogram machines, endoscopes, anesthetic machines and ECG monitoring instruments.

In the efficiency assessment, an output orientation was chosen. THs have limited choice concerning their inputs, the county authorities decide of their size and of the importance of the staff. In this context, their strategy can only have influence on the output level, given the level of their inputs.
The analysis of the evolution of activity exhibits that there is no disruption in the activity trend over the period. As our discussions with local actors suggested that the production function in itself didn't change, and the case-mix remained stable (see Section 4.b), a unique production frontier was estimated.

c. Efficiency scores

Technical efficiency remained quite stable over the period, suggesting that there was no improvement in the performance of THs from 2006 to 2012 (Figures 5 and A1, Table 4). A decrease in efficiency is even observed over the last three years of the period.

Figure 5. Evolution of order-m scores

Table 4. Evolution of efficiency scores

year	mean	min	max	p25	p50	p75	sd
2006	0.662	0.071	1.002	0.434	0.722	0.929	0.300
2007	0.678	0.153	1.010	0.357	0.657	1.000	0.305
2008	0.662	0.154	1.078	0.397	0.712	0.861	0.284
2009	0.660	0.189	1.009	0.411	0.674	0.904	0.280
2010	0.657	0.166	1.034	0.445	0.685	0.925	0.270
2011	0.666	0.241	1.070	0.427	0.653	0.949	0.274
2012	0.649	0.002	1.052	0.400	0.628	0.972	0.300

6. Estimating the determinants of THs efficiency

a. Empirical strategy

The two-stage approach usually uses Tobit model to deal with the bounded nature of the DEA scores, between 0 and 1.
Nevertheless, the fact of this boundary being of a censored nature is a really questioned issue ((Ramalho et al., 2010; Wilson, 2008). Some alternative methods have been proposed (Banker and Natarajan, 2007; Simar and Wilson, 2007). Ramalho (2010) proposes an instrumentalist approach, considering that efficiency scores are *observed managerial performances* regarding a best observed practice, and not an estimate of the *true efficiency* of a score. He proposes a second stage based on fractional regression models (first developed by Wooldridge (2002)) that we use here. As some of our THs exhibits order-m higher than 1, they have been normalized so that they would be bound between 0 and 1.
This method needs to make certain hypothesis. First we have to choose between a one-part or a two-part regression model that would estimates different partial effects for efficient and inefficient firms. Here, as the proportion of efficient firms is small, we considered a one-part model. Then, the link function for the model has to be chosen according to the results obtained by the *p-test*.

b. Results

Results of the second step are presented in Table 5, for normalized scores and a Probit link function, but the conclusions are robust to the use of DEA scores as dependent variable, and to another choice of link function (Tables 6 and 7 in annex).

Table 5. One-part fractional regressions with normalized order-m scores

VARIABLES	(1) Order-m score	(2) Order-m score	(3) Order-m score	(4) Order-m score	(5) Order-m score	(6) Order-m score
Covered population	0.0177	0.00984	0.0141	0.0142	0.0173	0.0141
	(0.042)	(0.043)	(0.042)	(0.042)	(0.042)	(0.043)
Proportion of licensed staff	-0.496	-0.532	-0.447	-0.450	-0.468	-0.509
	(0.706)	(0.731)	(0.732)	(0.733)	(0.709)	(0.733)
Number of VHS	-0.007*	-0.006	-0.006*	-0.006*	-0.007*	-0.007*
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Staff expenditures per capita	0.086***	0.079***	0.077***	0.076***	0.085***	0.076***
	(0.022)	(0.025)	(0.023)	(0.023)	(0.021)	(0.023)
Test per OP	-1.150**	-1.237***	-1.211**	-1.207**	-1.170**	-1.186**
	(0.453)	(0.474)	(0.470)	(0.470)	(0.465)	(0.466)
Inhabitants per bed 2006/09	4.009***	4.240***	4.313***	4.308***	3.996***	4.339***
	(0.923)	(1.004)	(1.027)	(1.029)	(0.928)	(1.024)
Inhabitants per bed 2010/12	5.331***	4.755***	4.732***	4.693***	5.184***	5.138***
	(1.233)	(1.276)	(1.277)	(1.279)	(1.224)	(1.295)
Proportion of subsidies in TH income	-0.754***					
	(0.270)					
Subsidies per capita		-0.002				
		(0.002)				
Subsidies per staff			-0.0213*			
			(0.012)			
Subsidies per medical staff				-0.0181		
				(0.012)		
Proportion of subsidies in TH expenditures					-0.705***	
					(0.256)	
Subsidies per available bed						-0.029*
						(0.017)
Constant	0.798*	0.805*	0.766*	0.769*	0.781*	0.795*
	(0.418)	(0.429)	(0.433)	(0.434)	(0.419)	(0.431)
Observations	208	208	208	208	208	208
R2	0.822	0.816	0.816	0.815	0.822	0.816

*Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1*

The environment of a TH is crucial for its performance, but through one aspect only. The population doesn't have any effect, but the number of inhabitants per bed does. This means that where there are few people per bed (where the quantity of inputs is important relatively to the potential demand for healthcare), THs are the most inefficient. The quantity of inputs injected in THs may be excessive regarding the current demand in the catchment area (cf. § Discussion). Considering that staff productivity is very low in the sample – excluding public health activities - (per medical staff and per day, the mean number of outpatients is 1.5 in 2006 and 2.18 in 2012, and of inpatients 0.08 to 0.14), the demand has to grow to spur efficiency. This is a concern for both of the sub-periods, suggesting that the development of the NCMS benefit package across the period, or the implementation of the reform did not allow reaching equilibrium between healthcare demand and supply.

The number of VHS has a very weak impact on efficiency, suggesting that there is no dominant effect between competition and referring. This could mean that the reform succeeded pushing patients to enter the health system at the grassroots' level (VHS) rather than in THs (competition effect). Yet VHS can only deal with basic pathologies, so THs also benefit from this pyramidal system through the reference effect but the global effect is neutral.

As for the managerial factors, all the variables introduced to capture the effect of subsidies on efficiency exhibit a negative sign (with high level of significance and magnitude for the importance of subsidies in TH income and expenditure), giving evidence of the phenomenon of soft budget constraint. Subsidies induce a perverse incentive effect, and fail to spur efficiency. No significant change is noticed between the two sub-periods, so this situation did not change with the pharmaceutical reform and the redefinition of TH financing. One of the main goals of the reform has not been reached. This negative effect of subsidies is also found by (Hu et al., 2012) on coastal township hospitals, confirming the perverse effects of modalities of granting subsidies..

7. Discussion

Results of the first step exhibit no positive trend in TH efficiency between 2006 and 2012, contrary to what was expected of the pharmaceutical reform. A similar trend is found by (Yang and Zeng, 2014) and (Ng, 2011). Our result brings new elements suggesting that for now the Chinese health system hasn't entered into a phase of improvement of its performances despite the efforts and reforms.

From the second step of the analysis, several barriers to efficiency improvement can be identified, as well as levers for action. First, as the demand side is still crucial to explain TH efficiency, affordance of healthcare has to be spurred, mainly by a deepening of the benefit package of the NRCMS. In Weifang, in 2006 outpatients acts were reimbursed up to 30% only and many cases were not reimbursed at all. In 2012, user fees represent at least half the total costs of outpatient care, and from our discussion with local NCMS and Health Bureau, it is likely that there are still financial barriers to healthcare for some households. But in average, the amount of user fees paid by those who got outpatient and inpatient care is low compared to the households average net income (see Figure A2 in Annex). Moreover, from a county to another, the benefit packages are very different, leading to disparate user fees burden for households, while the net income is quite homogenous (see Table 10 in Annex).

The issue of the optimal size of TH is also a matter of concern. Our results suggest that the inputs of the healthcare system are not fully used, since more inhabitants per bed leads to a better performance (no congestion, or saturation effect for instance). Yet from 2012, the number of available beds per TH grew drastically (from 44 to 77 in average on the sample, see Table 3). In a situation of financial constraint, the priority should be in the improvement of healthcare quality and affordance for households, rather than in the enlargement of existing hospitals. Our discussions with local health authorities suggest that, at this stage, there are both too many staff and not enough patients, and very likely – but it is a sensitive topic – too many TH, with a potential for merging some of them. Moreover, as pointed out by Yang and Zeng, 2014, too oversized hospitals may lead to quality concerns.

Another hot issue in the current Chinese health system is the availability of essential drugs, proved to be problematic in many areas despite of the reform, including in the prefecture of Weifang (from our discussions with local actors). Li et al., 2013 points that, because some ceiling prices have been fixed too low by the provincial government, manufacturers are reluctant to produce them, enhancing some shortage risks, that which was confirmed in Weifang where drug shortage was not rare. A decline of quality is also a concern if the price is the crucial criteria to discriminate firms during the bidding process (Xiao et al., 2013). The lack of availability for some essential drugs can be dramatic for TH daily activity and for healthcare costs (since households have to get drugs from other places, at higher prices).

The core of the reform relying in the reshape of TH financing, from drug margins to subsidies, it is crucial that those subsidies are allocated according to a systemic formula, with incentives, linking subsidies and results, following a Result Based Financing (RBF) approach. Results on the determinants of subsidies (Table 6) highlight a black box around those amounts. To avoid the perverse incentives of the *soft budget constraint* and not to jeopardize their daily activity, TH have to know how much they will get, and that they won't just be bailed out at the end of the period.

Finally, to re-orientate incentives, the provider payment has to be tackled in Chinese PHF. In our sample the fee-for-service method is still used, while it has been proved to be linked with higher costs than prospective payment methods (Yip et al., 2010). The introduction of this kind of payment is in discussion in Weifang, and appears to be an essential way to make public healthcare system more efficient, particularly in a situation of multitasking of healthcare (Cheng et al., 2012; Eggleston, 2005; Robyn et al., 2014)

8. Conclusion

Using a two-stage procedure, partial frontier methods to assess technical efficiency, and fractional regression model in the second-stage to explain it, this paper highlights the role of the public subsidies and demand side in the technical efficiency of primary health care facilities in the rural prefecture of Weifang. The technical efficiency remains constant over the first part of the period under review, and decreased on the three last years. A negative effect of the share of subsidies is identified. The soft budget constraint has not been efficiently tackled, showing that the way subsidies are allocated doesn't manage to spur efficiency.

In addition, deeper information has to be collected regarding the real criteria of subsidies allocation, as several elements suggest that in the field, because the local context, the real process may deviate by pragmatism from some of the criteria established in texts. This will be necessary to have a better understanding of how incentives are aligned or not with the health policy objectives.

At the same time, the importance of demand side factors such as the density of covered population per available bed exhibits the fact that working on the managerial aspect is not sufficient to improve provider efficiency. To spur activity in this perspective, it is necessary that outpatient health care become more affordable (what is currently an objective of the National Health and Planning Commission) and that the NCMS enlarges its benefit package towards better reimbursement of outpatient care. Another crucial aspect is the households' perception of quality of care in TH. It's going better in Weifang, but room for improvement remains. Finally, it seems that, at least for some counties, THs may be oversized, regarding their intermediary position between VHS and county hospitals.

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Annex

Table A1. Descriptive statistics about explanatory variables

variable	mean	min	max	p25	p50	p75	sd
staff - manning staff	4.05	-56	79	-11	0	17	24.14
Inhabitant per bed	0.10	0.03	0.70	0.07	0.10	0.11	0.07
NCMS reimbursment per OP (yuans)	20.605	8.328	57.718	12.929	17.675	23.225	10.451
Income from subsidies	140.56	0	1054.57	16.19	59.49	186.36	195.31
Proportion of subsidies in TH income	17.15	0	69.68	4.23	12.16	26.14	16.45
Subsidies per capita (yuans)	25.10	0	125.48	3.88	11.92	41.51	28.18
Proportion of licensed staff	0.39	0.11	0.66	0.33	0.39	0.45	0.10
Density of Village Health Centers	6.32	1.43	16.86	5.38	6.47	7.46	1.83
Density of covered population	0.05	0.02	0.15	0.04	0.05	0.05	0.02

Nominal values have been deflated by the General Retail Price Index in Shandong province, 2006=100 (from China Data Online)

Table A2. Comparison between DEA scores and Order-m scores in each sub-period

	Efficiency scores with order-m, 2006/07/08 /09					
DEA	<0.6	0.6<x<0.8	0.8<x<1	x=1	1<x<1.2	Total
<0.6	46	18	11	4	0	79
0.6<x<0.8	0	5	12	4	5	26
0.8<x<1	0	0	4	2	3	9
x=1	0	0	0	5	1	6
Total	46	23	27	15	9	120

	Efficiency scores with order-m, 2010/11/12					
DEA	<0.6	0.6<x<0.8	0.8<x<1	x=1	1<x<1.2	Total
<0.6	39	11	8	3	1	62
0.6<x<0.8	0	4	6	0	1	11
0.8<x<1	0	0	7	0	6	13
x=1	0	0	0	1	3	4
Total	39	14	21	4	11	90

Figure A1. Evolution of the distribution of efficiency scores

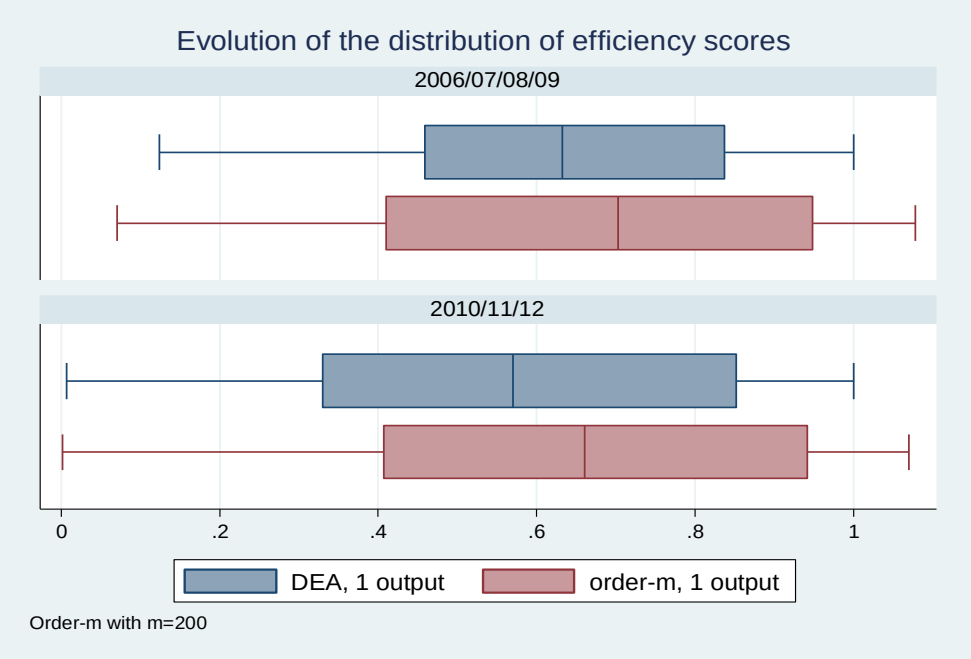


Table A3. Fractional regression with DEA scores as dependent variable

VARIABLES	(1) DEA score	(2) DEA score	(3) DEA score	(4) DEA score	(5) DEA score	(6) DEA score
Covered population	0.095**	0.098**	0.0985**	0.099**	0.094**	0.095**
	-0.045	-0.045	-0.044	-0.044	-0.045	-0.045
Proportion of licensed staff	-0.608	-0.583	-0.655	-0.657	-0.585	-0.598
	-0.723	-0.764	-0.758	-0.757	-0.730	-0.755
Number of VHS	-0.003	-0.004	-0.004	-0.004	-0.003	-0.003
	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003
Staff expenditures per capita	0.081***	0.055**	0.041*	0.040*	0.079***	0.062***
	-0.021	-0.022	-0.022	-0.021	-0.021	-0.020
Test per OP	-0.958**	-0.958**	-0.942**	-0.946**	-0.977**	-0.975**
	-0.460	-0.468	-0.464	-0.464	-0.466	-0.466
Inhabitants per bed 2006/09	1.876***	2.007***	1.941***	1.941***	1.886***	2.006***
	-0.577	-0.629	-0.635	-0.636	-0.584	-0.622
Inhabitants per bed 2010/12	1.711*	0.647	0.273	0.261	1.500	0.839
	-1.006	-0.985	-1.000	-0.998	-0.980	-1.054
Proportion of subsidies in TH income	-0.585*					
	-0.307					
Subsidies per capita		0.001				
		-0.002				
Subsidies per staff			0.025			
			-0.020			
Subsidies per medical staff				0.024		
				-0.019		
Proportion of subsidies in TH expenditures					-0.476*	
					-0.285	
Subsidies per available bed						-0.001
						-0.021
Constant	-0.075	-0.039	0.024	0.028	-0.080	-0.047
	-0.405	-0.416	-0.422	-0.422	-0.409	-0.414
Observations	208	208	208	208	208	208
R2	0.751	0.745	0.747	0.747	0.749	0.745

*Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1*

Table A4 One part fractional regression with normalized order-m sores as dependent variables, and logit as link function

VARIABLES	(1) Order-m score	(2) Order-m score	(3) Order-m score	(4) Order-m score	(5) Order-m score	(6) Order-m score
Covered population	0.001	-0.017	-0.009	-0.009	0.000	-0.009
	-0.070	-0.071	-0.071	-0.071	-0.070	-0.071
Proportion of licensed staff	-0.794	-0.863	-0.713	-0.721	-0.747	-0.815
	-1.181	-1.221	-1.221	-1.225	-1.187	-1.223
Number of VHS	-0.008	-0.006	-0.007	-0.007	-0.008	-0.008
	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006
Staff expenditures per capita	0.148***	0.139***	0.135***	0.133***	0.145***	0.133***
	-0.037	-0.042	-0.039	-0.039	-0.037	-0.039
Test per OP	-2.041***	-2.196***	-2.146***	-2.139***	-2.067**	-2.105**
	-0.784	-0.822	-0.821	-0.821	-0.806	-0.819
Inhabitants per bed 2006/09	7.712***	8.264***	8.433***	8.430***	7.695***	8.495***
	-2.152	-2.367	-2.432	-2.440	-2.168	-2.450
Inhabitants per bed 2010/12	9.821***	9.043***	9.049***	8.978***	9.565***	9.738***
	-2.446	-2.604	-2.648	-2.652	-2.441	-2.673
Proportion of subsidies in TH income	-1.255***					
	-0.461					
Subsidies per capita		-0.004				
		-0.003				
Subsidies per staff			-0.0377*			
			-0.022			
Subsidies per medical staff				-0.032		
				-0.021		
Proportion of subsidies in TH expenditures					-1.169***	
					-0.438	
Subsidies per available bed						-0.0485*
						-0.028
Constant	1.267*	1.260*	1.182	1.188	1.234*	1.232
	-0.737	-0.759	-0.763	-0.764	-0.738	-0.764
Observations	208.000	208.000	208.000	208.000	208.000	208.000
R2	0.826	0.821	0.820	0.820	0.825	0.821

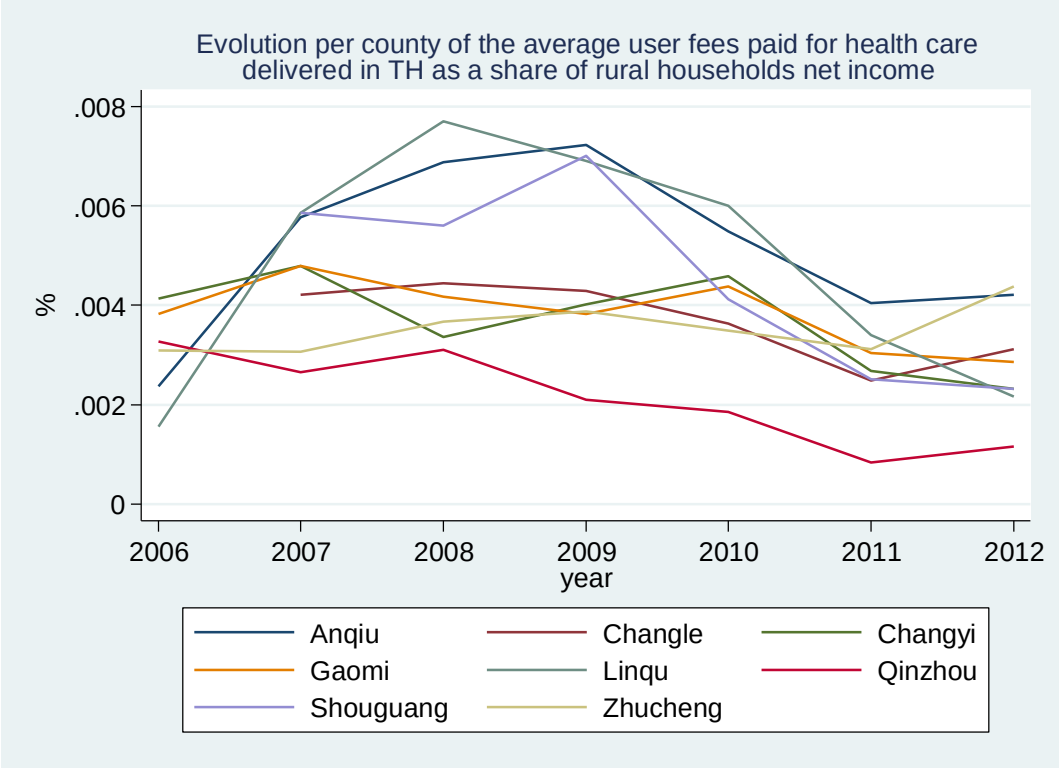
*Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1*

Table A5. Statistics about the cost of healthcare in 2012

	Average burden of TH expenses	Mean user fees for 1 IP case in TH (yuans)	Mean user fees for 1 OP case in TH (yuans)	Mean user fees for 1 OP case in VHS (yuans)	Rural net income (yuans)
Anqiu	0.42%	17.03	28.34	35.99	10773
Changle	0.31%	23.05	13.07	37.24	11576
Changyi	0.23%	21.24	6.28	27.93	11842
Gaomi	0.29%	21.77	11.89	48.05	11774
Linqu	0.22%	8.75	13.94	11.25	10512
Qinzhou	0.12%	6.28	7.41	64.62	11797
Shouguang	0.23%	11.59	18.10	67.39	12805
Zhucheng	0.44%	22.23	33.81	51.57	12804

NB: those figures were reconstructed using actual reimbursements by NCMS bureaus and reimbursement rates to estimate the mean cost of a case, and the user fee that is the difference between the two elements. Nominal values have been deflated by the General Retail Price Index in Shandong province, 2006=100 (from China Data Online)

Figure A2. Evolution per county of the average user fees paid for health care delivered in TH as a share of rural households net income



Nominal values have been deflated by the General Retail Price Index in Shandong province, 2006=100 (from China Data Online)