The Effect of Privatization on Public Hospitals: Evidence from the Healthcare Reform in China

by

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Honours Thesis in Part Fulfilment for the Honours B. Soc. Sci. Degree

Presented to the Department of Economics,

National University of Singapore 2018/2019

Abstract

In this paper, we investigate the behavior of public hospitals when there is a sudden influx of private hospital entry. During the new round of healthcare reform in 2009, the Chinese government introduced a policy that encouraged the development of private hospitals. Using this policy to implement an instrumental variables approach, we find that the increase in the proportion of private hospitals has led to a change in public hospitals' hiring behavior. In the face of privatization, the public hospitals began to hire more medical professionals and opts for better ones. However, these public hospitals did not choose to increase in medical equipment or hire more non-medical employees after the policy. We show that comparative advantage and profit-seeking attitudes may be the primary mechanisms for the hospital's behavior. We also found evidence that privatization has led to improvements in public hospitals' quality in terms of mortality rates.

KEYWORDS: Privatization, Healthcare Reform, Public Hospital Behavior

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1 Introduction

Governments around the world increasingly rely on private contractors for the provision of goods and services, due to a tighter government budget constraints and the hope of enjoying cost savings from the stronger incentives linked to private ownership and competition. In recent years, privatization has become more prevalent in healthcare markets (particularly in less-developed countries[1]). However, research on hospital ownership has typically considered hospitals in isolation. One key factor for this problem is the fact that there is a lack of empirical setting or dataset for researchers to conduct an empirical analysis across hospital ownership. Given the lack of empirical evidence of competition between private and public (or for-profit and nonprofit) hospitals, the effectiveness of privatizing hospital markets comes into question.

In this paper, we seek to mend this empirical gap in the literature. We estimate the effect of privatization on public hospitals in China, by exploiting a policy introduced during the healthcare reform in 2009 that aims to privatize its hospital market. We have two main measures of outcome, namely hospital behavior and quality. For hospital behavior, we consider the change in the hospital's human capital, in terms of the change in the type of employees they hire (i.e., non-medical employees vs medical employees, experienced employees vs less-experienced employees etc.), and the change in the hospital's medical capital, in terms of the change in high cost medical equipments. For the outcome measure of quality, we consider mortality rates, a performance indicator commonly used in healthcare literature.

Our empirical analysis is performed on a panel of hospitals from an affluent city in China from 2007 to 2015. In 2009, China introduced a policy during the healthcare reform that aimed to privatize its hospital market. After the reform, there is a huge increase in the number of private hospitals annually. The reform gives us a unique opportunity to measure the effect of privatization on public hospitals.

During the healthcare reform, different areas are treated by the policy with different intensity, areas with a lower pre-policy level of privatization are treated with a higher intensity. Our identification strategy makes use of hospital-level variations in policy. Our main empirical strategy

1. Some example of countries privatizing hospital markets in recent years include China, India, and Saudi Arabia (CPC Central Committee and State Council, 2009; Ministry of Health and Family Welfare Government of India, 2017; Oliver Wyman, 2018).

utilizes an instrumented difference-in-differences design (DDIV) framework[2], in which we exploit both the exogenous policy shock from the healthcare reform and the pre-policy variation of the proportion of private hospitals within the incumbent public hospital's vicinity to instrument for the level of privatization.

Using the DDIV framework, we find that in the face of privatization, public hospitals began to hire more medical professionals (i.e., doctors, nurses, pharmacist, medical technicians), and began to hire more experienced doctors (full doctors) while forsaking less experienced ones (assistant doctors). We, however, find that public hospitals did not change their medical capital or hire more service-oriented (non-medical employees) in the face of privatization. Based on both economic theory and the unique context of China's hospital market, we show that comparative advantage and profit-seeking attitudes could be the main reason for the public hospital's behavior. In support of existing theories, we also find that mortality rate decreased (i.e., quality improved) for public hospitals, in the face of privatization.

The remainder of the paper unfolds as follows. Section 2 discusses the theoretical background and prior empirical research. Section 3 describes the institutional background of the hospital market in China and provides an overview of the 2009 Healthcare Reform in China. Section 4 presents our data and reports some descriptive statistics. Section 5 describes our empirical approach. Section 6 presents our main results and discuss various mechanisms for our results and Section 7 briefly concludes.

2 Literature Review

2.1 Theoretical Background

There is a lack of research dedicated to the study of healthcare organizations' behavior in light of private (for-profit) and public (nonprofit)[3] competition, since most theoretical models treat for-profit and nonprofit healthcare organizations as if they each existed in isolation (Hirth, 1999). However, there exist a dominant theory on nonprofit and for-profit competition based on informational asymmetries, which prevent full contracting over the quality of care, pioneered by

2. See Hudson et al. (2017) for more details on this identification strategy.

3. Note that most of the literature on hospital ownership, distinguish hospitals between nonprofit vs. for-profit hospitals, instead of public vs. private hospitals, however since most of the private hospitals in China are forprofit and all of the public hospitals in China are nonprofit, we will consider them as equivalent.

the seminal work of Arrow (1963). Arrow (1963) argues that non-profit healthcare organizations are considered more trustworthy because the concept of profit contradicts the trust relationships required to encourage the provision of high quality. Therefore, for-profits and nonprofits offer different quality services, and firm types price services differently (Hansmann, 1980; Ben-Ner and Van Hoomissen, 1991; Glaeser and Shleifer, 2001). This difference in service provision will serve as the backbone for our empirical predictions for the incumbent public hospital's behavior.

In the literature on theories regarding hospital competition, Gaynor and Town (2011) present a model of a healthcare market where quality increases with competition if prices are fixed, but where the effect is indeterminate if prices are not fixed. Competition may also improve managerial incentives and management practices, and through them, the quality offered by the provider (Bloom et al., 2015). Given that prices are fixed for China's public hospital, in light of Gaynor and Town (2011) model, what we should expect empirically is that more competition from private hospitals[4] would lead to improvements in quality for the incumbent public hospitals, since the prices are fixed for public hospitals in China.

2.2 Prior Empirical Research

Our research contributes to the empirical literature on privatization, hospital ownership, competition and quality in healthcare. Almost all of prior research use US or European dataset.

There is a small body of literature that studies the effects of privatization in the healthcare markets. However, studies on the privatization of healthcare are mostly concentrated on developed countries. In particular, much of this research study the effect of privatization of medical insurance, in the context of Medicare Advantage (in the United States), where private insurers provide coverage side-by-side with the traditional fee-for-service system. Duggan et al. (2018) finds that the MA has led to substantial increases in hospital utilization, but do not find any evidence in the improvement of hospital quality. Baicker et al. (2013) finds that the MA results in lower hospitalization costs and shorter length of stay. Furthermore, there are a few research that study the effect of privatization on nursing homes. Bergman et al. (2016) finds that the pri-

4. Note that Gaynor and Town (2011) model, do not differentiate between private (for-profit) or public (nonprofit) competition, however, we should expect similar effect from the model in our empirical analysis.

vatization of elderly homes has led to an improvement in quality. Grabowski and Stevenson (2008), however, finds that privatization of nursing homes do not improve their performance. However, there is a lack of literature studying the effects of privatization in the hospital markets, and our paper aims to mend this gap.

The effect of competition on hospital performance is still a black box in the economics literature. One of the most prominent research on the effect of competition on hospital's performance is Kessler and McClellan (2000); they find that AMI mortality is substantially and significantly higher for patients in more concentrated markets. In contrast, Gowrisankaran and Town (2003), using similar methods to Kessler and McClellan (2000), finds that mortality is higher for Medicare heart attack and pneumonia patients receiving care in less concentrated markets. On the other hand, Mukamel et al. (2001) find no effect of market concentration on mortality from all causes for Medicare patients.

Many papers also study the effect of entry and exit of hospitals on the hospital's performance. Cutler et al. (2010) examine the impact of entry into the market for heart bypass surgery. They find that entry led to improved quality, but that the welfare gains from increased quality are offset by the fixed costs of entry. Lindrooth et al. (2003) examines the impact of urban closure on hospital markets and find that closure of hospitals led to a decrease in the average cost per admission. Furthermore, a growing body of literature is exploiting healthcare market reforms as exogenous shocks to study the effect of the competition and hospital performance. Cooper et al. (2011) and Gaynor et al. (2013) exploits a pro-competition policy reform in the United Kingdom to study the effects of competition on hospital quality. They find that higher competition led to the heart attack and AMI mortality rates fell respectively. Bloom et al. (2015) exploits the variation in hospital closures that is driven by the political process in the United Kingdom to identify the impact of competition on management quality. They also find that competition led to drop in AMI mortality rates.

There is also a small number of papers which examines healthcare competition in China. Due to the lack of data, the analysis of competition on hospital performance is based on the changes in aggregated data over time or utilise a small sample of survey dataset with a few observations (Eggleston et al., 2008). Pan et al. (2015) analyse the effects of hospital competition on

quality using aggregate level data and survey data, and finds suggestive evidence that competition improves quality of Chinese hospitals in terms of mortality rates, waiting time and costs. However, a critical problem in these analyses is that they do not account for the distance factor, which could bias the results since travel distance is essential in the hospital markets (see Kessler and McClellan, 2000).

Our research is also closely related to the literature on the effect of hospital ownership mix on hospital's behaviour. There are relatively few empirical works done on this, and most of the research done utilizes dataset from the US. Most of the research on this topic study non-profit hospital behaviour in relatively high for-profit mix setting.

Duggan (2000) and Duggan (2002) finds that non-profit hospitals behaviour in relatively high for-profit mix setting are more responsive to profit-making opportunities. Kessler and McClellan (2002) finds that areas with a presence of for-profit hospitals have lower levels of hospital expenditure. Horwitz and Nichols (2009) and Hughes and Luft (1990) also finds that non-profits in relatively high for-profit hospital penetration markets are more likely than other types to provide profitable services.

3 Background Information

3.1 Institutional Background

In China, hospitals are generally classified as non-profit private, for-profit private (with a majority of private hospitals begin for-profit) and public hospitals. Unlike in many developed countries where the private hospitals are more dominant in the healthcare system, providing more extensive and higher-quality services, with the public hospitals are mainly for providing primary medical care to the socio-economically disadvantaged population. Private hospitals in China are designated to be a supplement to public hospitals (Pan et al., 2016).

Prices of healthcare delivery in China are generally set by the government, with providers receiving direct budgetary support to cover the difference between costs and revenues earned from these nominal fees (Eggleston et al., 2008), this gives us an excellent institutional setting to measure the effect of competition from private hospitals on the quality (on incumbent public

hospitals) since public hospitals cannot compete in prices.

3.2 China's Healthcare Reform in 2009

In April 2009, the Chinese government launched an ambitious health-care reform, whereby 850 billion Yuan (approx. US$125 billion) was committed by the government for this reform. The overall goal of health care reform is to establish and improve the basic health care system covering urban and rural residents and provide the people with secure, efficient, convenient and affordable health care services. In accordance with the 2009 State Council's health reform roadmap, the reform focused on mainly on five areas. These areas include: (1) universal basic medical insurance coverage, (2) the essential drug system, (3) primary health care service provision, (4) equitable public health services, and (5) public hospital improvements (Yip and Hsiao, 2009; Ministry of Health of China, 2009; Chen, 2009).

While there are a lot of policies introduced during this reform, for the sake of our paper, we will solely focus on the reform that targets public hospital improvement. More specifically the policy that encourages the development of private hospitals[5]. To help alleviate the burden of care from public hospitals, the Chinese government introduced various policies to encourage entry from private hospitals. Some of these changes include lowering various regulatory barriers from private hospitals, making it easier for private hospitals to hire doctors or to become designated medical insurance hospitals. These changes led to the rapid privatization of its hospital markets after 2009 (Pan et al., 2016; CPC Central Committee and State Council, 2009).

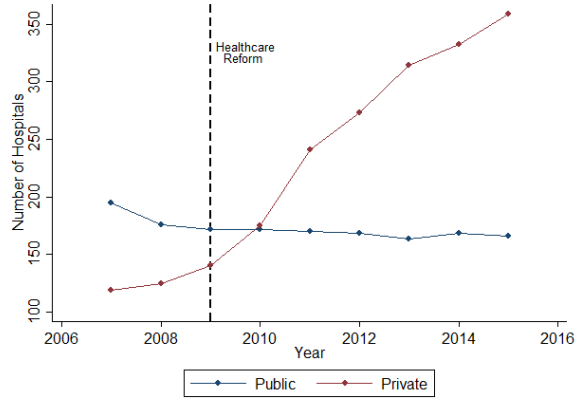
Figure 1, Panel A, shows the yearly trend of the number of hospitals between private and public hospitals using our dataset which includes every hospital in an affluent city in China. Figure 1, Panel B provides the yearly trend of the change in number of hospitals between private and public hospitals using our dataset which includes every hospital in the same affluent city in China. From this figure, we can see that there is generally no change in the number of public hospitals, but there is an exponential increase in private hospitals, especially after 2009.

This reform gives us a unique setting to measure the effects of privatisation on public hospitals, since this reform only encourages the entry of private hospitals and not public hospitals.

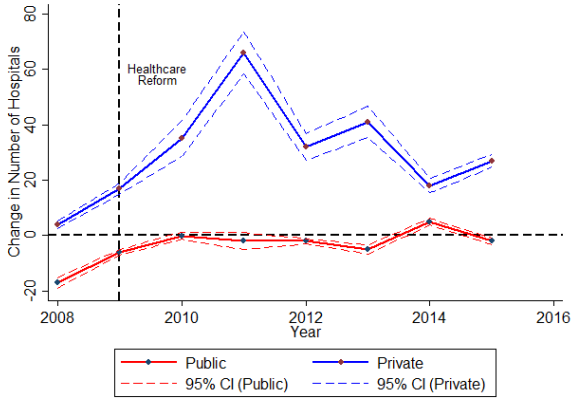
5. For a more detailed summary on the aims and some other key policies introduced during the healthcare reform in China, please refer to Chen (2009).

FIGURE 1: EFFECT OF HEALTHCARE REFORM: PUBLIC VS PRIVATE HOSPITALS

PANEL A: NUMBER OF PUBLIC VS PRIVATE HOSPITALS PER YEAR



PANEL B: CHANGE IN NUMBER OF PUBLIC VS PRIVATE HOSPITALS PER YEAR



Notes: The figure is plotted based on our dataset using hospital-level dataset. The dotted lines (for Panel B) are the confidence intervals at the 95% level and clustered at the hospital level.

With the help of our novel dataset, we can fully exploit this policy to give us key empirical evidence on the effects of privatisation on the hospital markets, something that is lacking in the economics of healthcare literature but is of great importance.

4 Data and Measures

We use a proprietary panel data set of a major city in China. The city consistently ranks within the top 10 cities in China in terms of GDP, government spendings and healthcare development. Using this city for our study is advantageous as it would undoubtedly be exposed to the healthcare reform since it is not only one of the major cities in China, but also one of the key cities targeted by China for the healthcare reform[6].

Our paper is one of the first in the literature on China's healthcare delivery that utilizes micro-level hospital data of a major city (see Eggleston et al., 2008; Wagstaff et al., 2009). We have complete information on every hospital's annual report in the aforementioned city from 2007 to 2015. We also observe every hospital's exact location, which is especially crucial for our empirical analysis. The data is rich in various measures for the hospital's financial operations, such as the hospital's revenue, cost, number of personnel hired, and also various measures for inpatient quality such as mortality rates and diagnostic failure rates[7].

6. Due to disclosure agreements, we are not allowed to state the name of the exact city for our study.
7. Indeed, whilst this dataset is extremely comprehensive relative the other papers studying China's hospital mar-

Our sample selection rule is as follows, we first restrict our sample to only public hospitals. We then, only keep the incumbent public hospitals that are available for throughout the entire sample period from 2007-2015 to ensure that the incumbent public hospital are present during both pre- and post policy[8]. Our final sample contains 135 public hospitals, totalling 1203 hospital-year observations across the 9 years in our sample period[9]. For our analysis of emergency department mortality rates, we further exclude hospitals without emergency department, and also exclude hospitals without emergency department admissions in both pre- and post-policy. This further decreased the hospital-year observations to 1004.

4.1 Measures on Privatisation

We utilise the proportion of private hospital within a 10 km radius of the incumbent private hospital as the baseline measure of privatisation[10] (do note that the 10 km radius is by arbitrary choice since there is no set optimal radius in the China's hospital market literature, given the lack of research utilising hospital level data, we will perform robustness checks with different radius in Section 6.5). The proportion is calculated as the number of private hospitals over the number of public and private hospitals (including the incumbent hospital). Indeed, for this measure to be a valid measure of privatisation, we have to ensure that the variation in proportion is due to the change in private hospitals rather than the change in public hospitals. Figure 1 provide clear evidences that the variation of the proportion of private hospitals are largely due to the change in private hospitals. The yearly trend of public hospitals is generally unchanged whereas the number of private hospitals is increasing significantly every year.

4.2 Measures on the Effects on Public Hospital

In this paper, there are there are three different ways that we will measure the effects on public hospitals. Firstly, we will measure whether the incumbent public hospitals changed its hiring

kets, it is still not comparable to the quality of the US or European datasets.

8. Since the change in number of public hospitals did not change much throughout the sample period, only a minority of the public hospitals are dropped. Out of the 195 public hospitals we have in our dataset, we dropped about 60 public hospitals.

9. Note that the hospital-year observations across the 9 years in our sample period is not 135×9, as there are some hospitals with missing observations for the control variables in between years and these observations are dropped.

10. While utilising the number of private hospitals (similar to Bloom et al., 2015, that used the number of public hospitals) would be very intuitive but it would not be an optimal choice for our institutional setting, due to the large variation of number of private hospitals. Based on our dataset the number of private hospitals within a 10 km radius of the incumbent hospital spans from 0 to 64, with an average of 28.89 and a standard variation of 27.3 during 2007. Using the number of hospitals may not capture the policy effect given this huge pre-policy variation.

behaviour in face of privatisation. This will be our main focus in the paper since our dataset is rich in the employee structure of the hospital. We are not only able to observe the number of employees of the hospitals, we are able to observe the number of medical personnels (i.e number of doctors, nurses, pharmacists, surgeons, medical laboratory and imaging technician), and the number of non-medical personnels (i.e. service staffs, management personnels and non-medical technicians). Furthermore, we are also able to observe some important heterogeneity within the employees, such as the number of full doctors and assistant doctors, within the total number of doctors. These variables would help us to provide a rigorous and robust analysis on the hiring behaviour of hospitals in presence of privatization.

Secondly, we also measure the effect on public hospitals by its medical equipments, whether or not the public hospitals purchased more medical equipments in face of privatisation. Our main measure of this effect by the change of the number of high cost medical equipments (more than 10,000 yuan). Other measures include medical IT dummy variables for whether the public hospitals utilised Medical Information System (MIS), whether they purchased Medical Imaging or whether they utilised Electronic Medical Records (EMR). These two main outcome (hiring behaviour and medical capital) will measure for the change in hospital behavior.

Lastly, we also measure the effect on public hospitals by its change in quality. The key quality measure that we will use are the emergency department (ED)'s mortality rates per 10000 admissions. However, since this measure is subjected to measurement errors since we do not observe the exact cause of death[11], our results can only provide suggestive evidence. We will also use the total emergency mortality rates (per 10000 admissions) for a secondary measure, this includes mortality rates from both ED and emergency observational room (EOR) mortality rates, but this measure may be subjected to higher measurement errors (compared to the ED mortality rates), since less severe patients from ED would be placed in the EOR, patients may not be largely influenced by the quality of care.

11. Since we do not observe the cause of the admission to the ED, we do not observe whether the patient truly require emergency care, especially since the ED is often left to manage patients who require admission or observation but have been deemed undesirable for sub-specialty inpatient services (Pei and Xiao, 2011). This may cause downward bias in our quality analysis (or upward bias for mortality rates). Furthermore, many researches that utilise mortality rates as a quality measure elucidates various other problems if we do not observe the exact cause of death (see Kessler and McClellan, 2000; Gaynor et al., 2013).

4.3 Other Controls

Since many potential control variables are very likely to be endogenous (for example, the level of revenue, number of admissions etc), we use a very limited number of time-varying variables as our controls. In all specifications, we added both time and hospital fixed effects, this will help us to control for both time-invariant differences between hospitals (such as location of hospitals), and hospitals-invariant time differences (such as economic shocks like the financial crisis in 2008).

For the main time-varying controls, we added the hospital's department mix based on severity of illness the department treats based on both outpatient and inpatient flows[12]. We also include the level of government subsidies and also the hospital's tier[13].

TABLE 1: SUMMARY STATISTICS

	Full Sample		Year = 2007		Year = 2011	
	Mean/(S.D.)	N	Mean/(S.D.)	N	Mean/(S.D.)	N
Panel A: Measure for Privatisation						
Proportion of Priv. Hosp. (10km radius)	0.52	1203	0.37	135	0.54	135
	(0.17)		(0.15)		(0.15)	
Panel B: Measures for Hiring Behaviour						
Total No. of Workers	471.21	1202	334.70	135	466.69	135
	(886.52)		(583.95)		(849.66)	
No. of Medical Personnel	373.70	1202	253.66	135	371.10	135
	(658.96)		(404.50)		(634.79)	
No. of Doctors	129.52	1202	92.47	135	129.00	135
	(214.00)		(130.17)		(216.89)	
No. of Registered Nurses	176.82	1202	105.69	135	178.84	135
	(337.81)		(202.87)		(339.24)	
No. of Pharmacist	20.30	1202	17.01	135	19.89	135
	(27.25)		(18.61)		(26.40)	
No of Non-Medical Staff	97.51	1202	81.04	135	95.59	135
	(236.08)		(185.17)		(221.51)	
No of Medical Technicians	47.06	1202	38.49	135	43.36	135
	(94.83)		(61.83)		(61.55)	
Panel C: Measures for Quality						
ED Mortality Rate (per 10000)	12.25	1004	10.52	114	10.97	109
	(41.07)		(29.08)		(33.49)	
Total Emergency Mortality Rate (per 10000)	10.44	1015	8.18	120	9.20	111
	(38.08)		(25.11)		(30.25)	
Panel D: Measures for Medical Capital						
No of High Cost Med. Equipments	352.45	1201	139.35	135	345.36	135
	(988.64)		(230.02)		(964.76)	
Medical Infosys (MIS)	0.54	1203	0.79	135	0.20	135
	(0.50)		(0.41)		(0.40)	
Medical Imaging	0.67	1203	0.36	135	0.77	135
	(0.47)		(0.48)		(0.42)	

Notes: Standard errors are reported in the parentheses (below the mean).
Non-medical staffs includes all non-medical staffs in the hospitals, this includes the management personnels, the service/administrative staffs and the non-medical technicians.
Note that the summary statistics reports results based on the restricted sample as aforementioned in Section 4.

12. This variable can be best described with an example, for example the patients that visited the infectious diseases department are considered to have severe illness, whereas the patients that visited the fitness department are considered not have severe illness. We calculate this variable by the number of severe outpatient/inpatient visits over the total outpatient/inpatient visits.

13. Note that hospitals in China are classified by a 3-tier system, they are classified by the government in terms of the number of beds, level of service provision, size, medical technology and quality etc. (Sun et al., 2017).

Table 1 reports the summary statistics of our dataset. It reports the means and standard deviations of the full sample, during 2007, and during 2011. (Note that the summary statistics only reports the statistics of the incumbent public hospitals.) From Table 1 Panel A, the proportion of private hospitals within a 10 km radius of the increased from an average of 0.37 in 2007 to 0.54 in 2011, this means that it increased by more than 40% from 2007 (pre-policy) to 2011 (post-policy), this gives us clear evidence of the policy effect.

Furthermore, it is clear from Table 1 Panel B, C, D, that the number of employees and medical equipments vastly increased from 2007 to 2011, this is expected since there is a huge government spending to improve quality and access of healthcare during the healthcare reform. Also, by Table 1 Panel B, C, D, some readers might notice the huge variation for our outcome measures, these variations are largely due to the fact that there is a huge differences in the types of public hospitals (for example, different tiered hospitals, rural vs urban hospitals etc.).

5 Empirical Framework

In this section, we will discuss the various empirical methodologies we will employ to test whether the number in private hospitals around incumbent public hospitals has any effects on the public hospital's behaviour and performance (in terms of quality).

5.1 Fixed-effect Model

We first suggest a simple fixed-effect model that controls for the unobserved time and hospital fixed effects. By controlling for these effects, we control various hospital characteristics, such as the size and location of the hospitals, and time effects such as the flu pandemic in 2009.

For the fixed-effect model, we estimate the following equation:

$$y_{it} = \beta_0 + \beta_1 P_{it} + \lambda_t + \mu_i + \xi_{it} \tag{1}$$

, where y_{it} is the dependent variable corresponding to the public incumbent hospital's behavior/performance, P_{it} is the proportion of private hospital within a 10 km radius of the public hospital's vicinity, λ_t is the unobserved time fixed effect, μ_i is the unobserved hospital fixed effect and ξ_{it} is the random noise.

5.2 Instrumental Variables Approach

However, due to the multifaceted nature of the healthcare reform, it is impossible to account for all the time-varying hospital effects that the healthcare reform might bring which may directly impact both the private hospital's entry and the incumbent public hospital's quality. Further, there could be a problem of simultaneity, where the public hospital's performance may cause the private hospital to enter[14]. Also, there could be measurement errors (since the data is procured from a developing country, China), and this could cause regression attenuation, biasing our estimate towards zero.

To study this effect, we exploit both the exogenous policy shock from the healthcare reform and the pre-policy variation of the proportion of private hospitals within the incumbent public hospital's vicinity to instrument for the level of privatization. The reason for this approach is that we conjecture that an area with a smaller proportion of private hospital would have a greater treatment intensity, as the main reason for the introduction of the reform is to help alleviate the burden of care from public hospitals as stated in Section 3.2.

To do this, we estimate the first-stage of the instrumental variables approach by the following equation:

$$P_{it} = \beta_0 + \beta_1 P_{i,2007} \times I(t \geq 2009) + \lambda_t + \mu_i + u_{it} \tag{2}$$

, where P_{it} is the proportion of private hospital within a 10 km radius of the public hospital's vicinity, the instrument $P_{i,2007} \times I(t \geq 2009)$ is the proportion of private hospital within a 10 km radius of the public hospital's vicinity during 2007 interacted with the indicator function for the post-reform period, $I(t \geq 2009)$, which takes the value 1 if the financial year is after 2009 and 0 otherwise , λ_t is the unobserved time fixed effect, μ_i is the unobserved hospital fixed effect and u_{it} is the random noise.

To ensure the validity of our instrumental variables approach, we need to ensure that:

1. The instrument must be exogenous and valid, i.e. we must satisfy exclusion restriction:

14. One plausible reason could be that private hospitals may be encouraged to enter around an under-performing public hospital if they believe that it would be easier to poach patients from them. This would undoubtedly cause an underestimation of the effect of the incumbent public hospital's performance.

$cov(P_{i,2007} \times I(t \geq 2009), \xi_{it}) = 0$.

2. Instrument must be informative or relevant. This means that instrument, $P_{i,2007} \times I(t \geq 2009)$, must have strong correlation with the endogenous regressor, P_{it}, conditional on all exogenous other variables in the model.

3. Furthermore, since we are utilising a difference-in-difference methodology to instrument the endogenous regressor[15], we have to ensure that the potential growth paths of both endogenous regressor, P_{it}, and outcomes, y_{it}, are independent from actual instrument assignment, i.e. the parallel trend assumption must hold[16].

Firstly, the instrument is exogenous and valid (i.e., exclusion restriction should hold) in our context, since the policies encouraging the development of private hospitals during the healthcare reform should only affect the proportion of private hospitals and should not have any other implications towards the incumbent public hospital.

Secondly, it should be expected that the instrument has a strong correlation with our endogenous variable in our context since the policy (i.e., the instrument) aims to increase the proportion of private hospitals in the first place. Results from Table Panel B, which is the first stage results of the IV-2SLS, provides clear evidence of a strong first stage. Public hospitals with a lower proportion of private hospitals around them in 2007 vastly increased in the proportion of private hospitals after the policy in 2009, a public hospital with a 1% lower proportion of private hospitals in 2007 has about a 0.4% higher proportion of private hospital after the policy in 2009. This result is significant at the 1% level. Furthermore, the first stage f-statistics is greater than 20 for all of our main specification[17], and the test for weak identification of the IV model (robust Klebergen-Paap Wald rk statistics) also exceeds 16.38 (Stock-Yogo critical value, allowing for 10% of IV maximum distortion with respect to OLS.) for all of our main specification (Stock and Yogo, 2002).

Lastly, we have to ensure that the potential growth paths of both the endogenous regressor and outcomes have a parallel pre-policy trend. To test this assumption we conduct a Granger test

15. See Duflo (2001) or Field (2007) for canonical examples using this methodology.
16. See Hudson et al. (2017) and De Chaisemartin and D'HaultfŒuille (2017) for the details on this parallel trend requirement.
17. Stock and Yogo (2002) suggests that that the F-statistics should be greater than 10 as a rule of thumb for instrument relevance.

(see Angrist and Pischke, 2008) for our endogenous regressor and our main outcome variables using the specification below:

$$x_{it} = \beta_0 + \sum_{\tau=2008}^{2015} \beta_\tau P_{i,2007} \times I(t \geq \tau) + \lambda_t + \mu_i + v_{it} \tag{3}$$

, where x_{it} denotes both the endogenous regressor P_{it} and outcome variable y_{it}, and $\beta_\tau P_{i,2007} \times I(t \geq \tau)$ is the proportion of private hospital within a 10 km radius of the public hospital's vicinity during 2007 interacted with the indicator function, $I(t \geq \tau)$, which takes the value 1 if the financial year is after τ and 0 otherwise , λ_t is the unobserved time fixed effect, μ_i is the unobserved hospital fixed effect and v_{it} is the random noise.

Results from Equation (3) are reported in Table A3. Column 1-2, conducts the Granger Test for the endogenous variable, the proportion of private hospitals, it provides a clear indication that the common time trend for the endogenous variable hold, the estimates shows no effect a year before the policy (at 2008) and significant effects after the policy (up till 2013). Column 3-6 conducts the Granger Test for the outcome variable, column 3-4 conduct the test for the change in the number of medical personnel, and column 5-6 conducts the test for the change ED, both estimates suggests that the parallel time-trend assumption also holds for the outcome variables.

6 Empirical Results

In this section, we formally test both Equation (1). We first conduct an Ordinary Least Squared (OLS) fixed-effect regression that treats the proportion of private hospitals as exogenous, we analyze by looking at the changes in hospital's hiring behavior, medical capital and quality (measured by mortality rates). We, then, re-examine the results using the instrumental variables framework with (2) as the first stage. Thereafter, we provide an institutional discussion and empirical support for the reasons of the differences in the effect of the hospital hiring behavior and medical equipments.

6.1 Fixed-effect (OLS) Results

Equation (1) was initially estimated with OLS, treating the proportion of private hospitals as exogenous, but this specification may be subjected to large bias and should only present descriptive evidence.

TABLE 2: FIXED-EFFECT ESTIMATES OF PRIVATISATION ON HIRING BEHAVIOR

	Log No of Employee		Log No of Med. Pers.		Log No of Doc.	
	(1)	(2)	(3)	(4)	(5)	(6)
Prop. of Priv. Hosp. (10km radius)	0.105	0.141	0.110	0.149	0.111	0.155
	(0.239)	(0.252)	(0.235)	(0.246)	(0.197)	(0.207)
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Hospital Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Hospital Controls	No	Yes	No	Yes	No	Yes
R^2	0.858	0.861	0.865	0.867	0.887	0.889
Observations	1202	1202	1202	1202	1202	1202

Notes: Standard errors are clustered at the hospital level and reported in the parentheses.
$^{+}$ $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Additional controls include department mix based on outpatient and inpatient flows, level of government subsidies and hospital tier fixed effects. For more information please refer to Section 4.3.

Table 2 reports the results of our OLS fixed-effect regression of the changes of various types of employees of the hospitals (these include changes in the total number of employees, medical personnel, number of doctors[18]) on proportion of private hospitals within 10 km radius of the incumbent public hospital. The results from Table 2, Column 1-6 shows that there is a positive but statistically insignificant association between the proportion of private hospitals and the change in the various types of hospital's employee, this suggests that that privatization does not affect the public hospital's hiring behavior.

TABLE 3: FIXED-EFFECT ESTIMATES OF PRIVATISATION ON HIGH COST MEDICAL EQUIPMENTS

	Log No of Med. Equip.		MIS		Med. Imaging	
	(1)	(2)	(3)	(4)	(5)	(6)
Prop. of Priv. Hosp. (10km radius)	-0.427	-0.454	0.183	0.205	0.173	0.185
	(0.451)	(0.468)	(0.177)	(0.175)	(0.207)	(0.211)
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Hospital Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Hospital Controls	No	Yes	No	Yes	No	Yes
R^2	0.809	0.814	0.562	0.566	0.446	0.447
Observations	1201	1201	1203	1203	1203	1203

Notes: Standard errors are clustered at the hospital level and reported in the parentheses.
$^{+}$ $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Additional controls include department mix based on outpatient and inpatient flows, level of government subsidies and hospital tier fixed effects. For more information please refer to Section 4.3.

Table 3 reports the results of our OLS fixed-effect regression of the changes in high-cost medical equipment in the hospitals on the proportion of private hospitals within 10 km radius of

18. We also include the results for the number of nurses, number of pharmacists and medical technicians in Table A1.

the incumbent public hospital. The results from Table 3, Column 1-6 shows that there is a statistically insignificant association between the proportion of private hospitals and the change in the high-cost medical equipment, the sign of the coefficients are not consistent in this case, this suggests that that privatization has no effect on the public hospital's decision to purchase high cost medical equipments.

TABLE 4: FIXED-EFFECT ESTIMATES OF PRIVATISATION ON QUALITY

	ED Mort. Rate		Total Emergency Mort. Rate	
	(1)	(2)	(3)	(4)
Proportion of Priv. Hosp. (10km radius)	-3.981	-3.302	-5.793	-5.058
	(15.811)	(16.270)	(14.926)	(15.282)
Time Fixed Effects	Yes	Yes	Yes	Yes
Hospital Fixed Effects	Yes	Yes	Yes	Yes
Hospital Controls	No	Yes	No	Yes
R^2	0.436	0.437	0.420	0.421
Observations	1002	1002	1013	1013

Notes: Standard errors are clustered at the hospital level and reported in the parentheses.
$^{+}$ $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Mortality Rates are adjusted to per 10000 as noted in Section 4.2.
Total Emergency Mortality Rates includes Mortality Rates from both ED and EOR.
Additional controls include department mix based on outpatient and inpatient flows, level of government subsidies and hospital tier fixed effects. For more information please refer to Section 4.3.

Table 4 reports the results of our OLS fixed-effect regression of mortality rates on the proportion of private hospitals within 10 km radius of the incumbent public hospital. The results from Table 4, Column 1-4 shows that there is a negative but statistically insignificant association between the proportion of private hospitals and the change in the hospital's employee, this suggests that that privatization does not affect the public hospital's decision to purchase high-cost medical equipment.

Overall, the OLS results seem to suggest that privatization has no effect on the incumbent public hospital's behavior and quality, however, as seen in Table 2 and 4, the coefficient of some of the key outcomes (hiring behavior and quality) have similar signs (positive for hiring behavior and negative for mortality rates). This reason for the statistical insignificance could be largely because the omitted variable bias and the issue of simultaneous causality may have caused huge underestimation in our analysis.

6.2 Instrumental Variables (IV) Results

Given the fact that the OLS results suffer from huge underestimation in our analysis, in this section, we present the IV-2SLS estimates utilizing the procedure mentioned in Section 5.2.

Table 5 reports the results of our IV-2SLS analysis of the effect of privatization on the public hospital's hiring behavior. Table 5, Column 1-2, finds that a 1% increase in the proportion of private hospital (within a 10 km radius of the public hospital) increases the total number of employees by 1.20-1.30%. Table 5, Column 3-4, finds that a 1% increase in the proportion of private hospital increases the total number of medical personnel by 1.31-1.41%. Table 5, Column 5-6, finds that a 1% increase in the proportion of private hospital increases the total number of doctors by 1.19-1.30%. These results are significant at the 5% level[19].

TABLE 5: IV ESTIMATES OF PRIVATISATION ON HIRING BEHAVIOUR

	Log No of Employee		Log No of Med. Pers.		Log No of Doc	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: IV-2SLS Second Stage						
Proportion of Priv. Hosp. (10km radius)	1.202**	1.295**	1.310**	1.412**	1.187**	1.298**
	(0.610)	(0.627)	(0.602)	(0.614)	(0.497)	(0.511)
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Hospital Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Hospital Controls	No	Yes	No	Yes	No	Yes
F-stats (first stage)	24.708	24.115	24.708	24.115	24.708	24.115
Panel B: IV-2SLS First Stage						
After 2009 X Prop. of Priv. Hosp. in 2007	-0.433***	-0.430***	-0.433***	-0.430***	-0.433***	-0.430***
	(0.087)	(0.088)	(0.087)	(0.088)	(0.087)	(0.088)
Observations	1202	1202	1202	1202	1202	1202

Notes: Standard errors are clustered at the hospital level and reported in the parentheses. $^{+}$ $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Additional controls include department mix based on outpatient and inpatient flows, level of government subsidies and hospital tier fixed effects. For more information please refer to Section 4.3.

After controlling for the underestimation from the OLS result, we can see that the privatization has caused the public hospital to increase in the number of employees, particularly in terms of the medical personnel. It would also be interesting to look at the effect of privatization on the type of employees (medical vs. non-medical) and on the type of medical personnel (highly qualified vs. less qualified).

19. We also include results for the changes in the number of nurse, pharmacist and medical technicians in Table A2, in Appendix.

TABLE 6: IV ESTIMATES OF PRIVATISATION ON HETEROGENEOUS HIRING BEHAVIOUR

	Log No of Full Doc.		Log No of Asst Doc.		Log No of Non-Med. Staff	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: IV-2SLS Second Stage						
Prop. of Private Hosp. (10km rad)	1.402**	1.515***	-0.793^{+}	-0.839^{+}	0.326	0.366
	(0.552)	(0.571)	(0.528)	(0.537)	(0.561)	(0.591)
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Hospital Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Hospital Controls	No	Yes	No	Yes	No	Yes
F-stats (first stage)	24.708	24.115	24.708	24.115	24.708	24.115
Panel B: IV-2SLS First Stage						
After 2009 X Prop. of Priv. in 2007	-0.433***	-0.430***	-0.433***	-0.430***	-0.433***	-0.430***
	(0.087)	(0.088)	(0.087)	(0.088)	(0.087)	(0.088)
Observations	1202	1202	1202	1202	1202	1202

Notes: Standard errors are clustered at the hospital level and reported in the parentheses. $^{+}$ $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Non-medical staffs includes all non-medical staffs in the hospitals, this includes the management personnels, the service/administrative staffs and the non-medical technicians.
Additional controls include department mix based on outpatient and inpatient flows, level of government subsidies and hospital tier fixed effects. For more information please refer to Section 4.3.

Table 6 provides the heterogeneous effects of privatization on hiring behaviors, particularly for doctors. Table 6, Column 1-2 finds that a 1% increase in the proportion of private hospital (within a 10 km radius of the public hospital) increases the number of full doctors by 1.40-1.52%. This result is significant at the 1% level. Table 6, Column 3-4 finds that a 1% increase in the proportion of private hospital (within a 10 km radius of the public hospital) decreases the number of assistant doctors by 0.79-0.83%. This result is almost significant at the 10% level (11% level). This results suggest that privatization not caused the public hospitals to hire more medical personnel, but also caused the public hospitals to hire better medical personnel (i.e., hiring/promoting more full (more qualified) doctors, and dismissing assistant (less qualified) doctors). Table 6, Column 5-6, finds that there is a positive but insignificant effect of privatization on the public hospital's decision in hiring non-medical staff. This further supports the notion that the increase in employees is largely due to medical personnel and not non-medical staff.

Table 7 reports the results of our IV-2SLS analysis of the effect of privatization on the public hospital's choice in purchasing high-cost medical equipment. Table 7, Column 1-2, finds that a 1% increase in the proportion of private hospital (within a 10 km radius of the public hospital) decreases the number of high-cost medical equipment by 0.70-0.76%. Table 7, Column 3-4, finds that a 1% increase in the proportion of private hospital decreases the probability of the public

TABLE 7: IV ESTIMATES OF PRIVATISATION ON HIGH-COST MEDICAL EQUIPMENTS

	Log No of Med. Eq.		MIS		Med. Img	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: IV-2SLS Second Stage						
Prop. of Private Hosp. (10km rad)	-0.700	-0.756	-0.366	-0.324	-0.809	-0.795
	(1.429)	(1.459)	(0.579)	(0.582)	(0.829)	(0.830)
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Hospital Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Hospital Controls	No	Yes	No	Yes	No	Yes
F-stats (first stage)	24.692	24.097	24.729	24.145	24.729	24.145
Panel B: IV-2SLS First Stage						
After 2009 X Prop. of Priv. in 2007	-0.433***	-0.430***	-0.433***	-0.430***	-0.433***	-0.430***
	(0.087)	(0.088)	(0.087)	(0.087)	(0.087)	(0.087)
Observations	1201	1201	1203	1203	1203	1203

Notes: Standard errors are clustered at the hospital level and reported in the parentheses. $^{+}$ $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Additional controls include department mix based on outpatient and inpatient flows, level of government subsidies and hospital tier fixed effects. For more information please refer to Section 4.3.

hospitals equipping MIS by 0.32-0.37%. Table 7, Column 5-6, finds that a 1% increase in the proportion of private hospital decreases the probability of the public hospitals having medical imaging by 0.80-0.81%. These results are however are not statistically significant at the 10% level.

At this stage, readers might be interested in the mechanisms as to why the incumbent public hospitals have such seeming erratic behavior (i.e., to hiring better quality medical personnel yet forsaking medical equipment and non-medical personnel). Section 6.3 provides plausible explanations for this behavior.

Table 8 reports the results of our IV-2SLS analysis of the effect of privatization on the public hospital's choice in quality, measured by death rates. Table 8, Column 1-2, finds that a 1% increase in the proportion of private hospital (within a 10 km radius of the public hospital) decreases the mortality rate from ED by 1.53-1.55 per 10000. Table 8, Column 3-4, finds that a 1% increase in the proportion of private hospital decreases total emergency mortality rate (from both ED and EOR) by 1.49-1.50 per 10000. The results are significant at the 10% level. The results are very similar in with many of the UK literature where competition improved quality (Cooper et al., 2011; Gaynor et al., 2013; Bloom et al., 2015); this could be largely due to the fact that like the UK, public hospitals cannot compete with prices in China, and can only compete by quality.

TABLE 8: IV ESTIMATES OF PRIVATISATION ON QUALITY

	ED Mort. Rate		Total Emergency Mort. Rate	
	(1)	(2)	(3)	(4)
Panel A: IV-2SLS Second Stage				
Proportion of Priv. Hosp. (10km radius)	-153.173*	-155.197*	-148.686*	-150.233*
	(88.923)	(90.455)	(85.021)	(86.261)
Time Fixed Effects	Yes	Yes	Yes	Yes
Hospital Fixed Effects	Yes	Yes	Yes	Yes
Hospital Controls	No	Yes	No	Yes
F-stats (first stage)	21.597	20.509	21.573	20.621
Panel B: IV-2SLS First Stage				
After 2009 X Prop. of Priv. Hosp. in 2007	-0.441***	-0.434***	-0.441***	-0.434***
	(0.095)	(0.096)	(0.095)	(0.096)
Observations	1004	1004	1015	1015

Notes: Standard errors are clustered at the hospital level and reported in the parentheses. $^{+}$ $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Mortality Rates are adjusted to per 10000 as noted in Section 4.2.
Total Emergency Mortality Rates includes Mortality Rates from both ED and EOR.
Additional controls include department mix based on outpatient and inpatient flows, level of government subsidies and hospital tier fixed effects. For more information please refer to Section 4.3.

6.3 Mechanisms

As aforementioned in Section 6.2, the behavior of the public hospitals look seemingly erratic. In this subsection we provide some plausible mechanisms for this behavior.

One possible mechanism for this behavior is that the public hospitals are comparatively advantaged in recruiting quality medical personnel over procuring better medical equipment or hiring better (or more) non-medical employees[20]. The idea of using comparative advantage to explain the behavior of healthcare organizations is not uncommon, in the seminal works of Arrow (1963) theorize that non-profit organizations thrive in the healthcare market with complex personal services (i.e., nursing homes) as they enjoy comparative advantage of trustworthiness over their for-profit counterparts[21]. Further theoretical research improves on Arrow (1963) work and argues that in light of information asymmetries for-profits and nonprofits offer different quality services, and firm types price services differently (Hansmann, 1980; Ben-Ner and Van Hoomissen, 1991; Glaeser and Shleifer, 2001). We conjecture that this is main reason for our findings in terms of hospital behavior.

20. We have to note that in China, while we posit that the public hospitals have comparative advantage in the having quality medical personnel over having better medical equipment, public hospitals generally have absolute advantage over private hospitals in term of quality of medical personnel, better medical equipment, public's and employee's trust, etc (Eggleston et al., 2010; Yip and Hsiao, 2014).

21. See Hirth (1999), Chou (2002) for empirical evidences of this theory in the context of nursing homes.

The main reason for the conjecture of public hospitals having a comparative advantage over private hospitals is that public hospitals have a relatively lower marginal cost of hiring medical personnel as opposed to private hospitals, compared to medical equipment or non-medical employees. Despite the removal of various governmental restrictions for private firms in terms of the hiring of medical personnel, there is still a lack of medical employees' trust towards private hospitals (in terms of their medical methods and quality) and coupled with various cultural reasons[22] (Cheng, 2013; Harney and Jourdan, 2014), these private hospitals would take a lot more to attract good doctors as opposed to public hospitals. Furthermore, public hospitals have created many barriers to dissuade their doctors from leaving[23] or to moonlight in a private hospital[24].

Coupled with the fact that the short term medical personnel's labor supply is inelastic (especially in China) (Qin et al., 2013), the barriers of attaining medical equipment and non-medical staff is significantly lesser than medical personnel for private hospitals. Thus, we see evidence of public hospitals focusing on getting good medical personnel whereas the private hospitals are focusing on a more service-oriented (non-medical) care, and focusing on getting better medical equipment (Deloitte, 2015). We will formally test this hypothesis using our data. To test this we utilize a simple difference-in-difference approach utilizing our entire dataset (including both private and public hospitals). Our estimation strategy follows the specification below:

$$r_{it} = \beta_0 + \beta_1 Priv_{it} \times I(t \geq 2009) + \lambda_t + \mu_i + e_{it} \tag{4}$$

, where r_{it} is both the proportion of non-medical employees (to medical personnel) and the log of the average cost per medical equipment, $Priv_{it} \times I(t \geq 2009)$ is an indicator which takes the value 1 if the hospital is private and 0 otherwise, interacted with the indicator function for the post-reform period, $I(t \geq 2009)$, which takes the value 1 if the financial year is after 2009 and 0 otherwise , λ_t is the unobserved time fixed effect, μ_i is the unobserved hospital fixed effect and e_{it} is the random noise.

Table 9 reports the results from Equation (4). The results in Table 9, Column 1-2 suggest that

22. The main cultural factor is the fact that working in a public hospital is largely considered more prestigious than working in a private hospital in China.

23. Some barriers include financial improvements to the doctors and improving research and development and connections with medical schools (He, 2017; Li, 2017).

24. Note that while moonlighting in a private hospitals is heavily supported by the Chinese government, there are still many doctors that are unwilling to do so in fear of the repercussions from their hiring public hospitals (Glucksman and Lipson, 2010; Hancock, 2017).

TABLE 9: COMPARATIVE ADVANTAGE OF PRIVATE VS PUBLIC AFTER REFORM

	Prop. of Non-Med. Employee		Log. Avg. Value per Med. Equip.	
	(1)	(2)	(3)	(4)
Private × After 2009	0.029***	0.027***	0.191**	0.153*
	(0.010)	(0.010)	(0.084)	(0.083)
Time Fixed Effects	Yes	Yes	Yes	Yes
Hospital Fixed Effects	Yes	Yes	Yes	Yes
Hospital Controls	No	Yes	No	Yes
R^2	0.720	0.720	0.674	0.676
Observations	3376	3376	3256	3256

Notes: Standard errors are clustered at the hospital level and reported in the parentheses.
$^{+}$ $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Sample includes both private and public hospitals unlike the rest of the tables.
Additional controls include department mix based on outpatient and inpatient flows, level of government subsidies and hospital tier fixed effects.
For more information please refer to Section 4.3.

private hospitals after the reform has 2.7-2.9% higher in the proportion of non-medical employees to medical personnel. The results are significant at the 1% level. Table 9, Column 3-4 suggest that the average cost per medical equipment for private hospitals after the reform increased by 15.3-19.1%. The results are significant at the 10% level. These results support the aforementioned hypothesis of comparative advantage that public hospitals are focusing on getting good medical personnel, and private hospitals are focusing on more service-oriented care with better quality medical equipment.

One question some might ask is, how were the public hospitals able to afford better doctors in light of additional competition from the private hospitals? Duggan (2002) and Horwitz and Nichols (2009) suggests that non-profit hospitals in areas with high for-profit mix could behave in a more profit-seeking way by providing more profitable services. Since, in China, most private hospitals are for-profit, and all public hospitals are non-profit, we conjecture that this might plausibly be the reason for the fact that the public hospitals able to afford better doctors.

We formally test this hypothesis with our data using our IV-2SLS method specified in Section 5.2, using different outcome measures to test the hypothesis of profit-making behavior. One of our outcome variables is the profitable admission ratio. It is the proportion of the number of profitable admissions to the non-profitable admissions, we follow Horwitz and Nichols (2009) closely in terms of defining the "profitability" of a service[25]. Furthermore, we will look that the

25. Table 2 of Horwitz and Nichols (2009) provides a list of relatively profitable service and relatively unprofitable services, we closely follow their results, while excluding services that are not included in their table (such as

change in the average inpatient and outpatient expenditure per patient, since most profitable services are more costly to the patient (as opposed to unprofitable services). If the proportion of profitable services increased, we should expect an increase in expenditure per patient.

TABLE 10: IV ESTIMATES OF PRIVATISATION ON PROFIT-SEEKING BEHAVIOUR

	Profitable Ratio		Log Inp. Expenditure		Log Outp. Expenditure	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: IV-2SLS Second Stage						
Prop. of Private Hosp. (10km rad)	0.517*	0.543*	0.566^{+}	0.652*	-0.077	-0.071
	(0.275)	(0.287)	(0.360)	(0.365)	(0.063)	(0.064)
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Hospital Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Hospital Controls	No	Yes	No	Yes	No	Yes
F-stats (first stage)	15.986	15.647	23.360	22.605	23.624	22.840
Panel B: IV-2SLS First Stage						
After 2009 X Prop. of Priv. in 2007	-0.375***	-0.371***	-0.455***	-0.450***	-0.455***	-0.451***
	(0.094)	(0.094)	(0.094)	(0.095)	(0.094)	(0.094)
Observations	1007	1007	1124	1124	1157	1157

Notes: Standard errors are clustered at the hospital level and reported in the parentheses. $^{+}$ $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Note that Column 3-4 reports the log of inpatient expenditure per inpatient admission, and Column 5-6 reports the log of outpatient expenditure per outpatient visit.
Additional controls include department mix based on outpatient and inpatient flows, level of government subsidies and hospital tier fixed effects. For more information please refer to Section 4.3.

Table 10 provides the results of our test for the public hospital's for-profit behavior. Table 10, Column 1-2 suggest that a 1% increase in the proportion of private hospitals (around a 10 km radius of the incumbent public hospital), there is a 0.517-0.543% increase in the proportions of profitable admissions. The result is significant at the 10% level. This suggests at a higher private hospital mix led to the hospital providing more profitable services as opposed to non-profitable services, which supports our hypothesis that the incumbent public hospital behaves in a more profit-seeking way in the face of an influx in private hospitals. Table 10, Column 3-4 suggest that a 1% increase in the proportion of private hospitals increase the inpatient expenditure per admission by 0.566-0.652%. The results are significant at the 10% level (15% level if we do not include controls). Column 5-6 suggest that a 1% increase in the proportion of private hospitals decrease the outpatient expenditure per visit by 0.071-0.077%. The results are, however, insignificant at the 10% level. These result supports our profit-making hypothesis; since most of the profitable services offered by public hospital require inpatient admission (such as

Traditional Chinese Medicine (TCM)).

open-heart surgery, birthing/labour delivery etc.), we should expect an increase in inpatient expenditure per admission. Whereas most services that only require an outpatient visit offered by public hospital are those that are those that are relatively unprofitable (for example, general practitioner or specialist consultations etc.[26]), we should expect a minimal change in outpatient expenditure per patient.

TABLE 11: IV ESTIMATES OF PRIVATISATION ON MEDICAL PERSONNEL INTENSIVE PROFITABLE ADMISSION

	Medical Personnel Intensity Ratio	
	(1)	(2)
Panel A: IV-2SLS Second Stage		
Prop. of Private Hosp. (10km rad)	0.374***	0.402***
	(0.144)	(0.148)
Time Fixed Effects	Yes	Yes
Hospital Fixed Effects	Yes	Yes
Hospital Controls	No	Yes
F-stats (first stage)	21.277	20.671
Panel B: IV-2SLS First Stage		
After 2009 X Prop. of Priv. in 2007	-0.433***	-0.427***
	(0.094)	(0.094)
Observations	895	895

Notes: Standard errors are clustered at the hospital level and reported in the parentheses.
$^{+}$ $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Additional controls include department mix based on outpatient and inpatient flows, level of government subsidies and hospital tier fixed effects.
For more information please refer to Section 4.3.

In light of the two mechanisms above, some may question whether they are interdependent. So a key question one might ask is whether the public hospitals the increase in profitable admissions are spurred by services that require better medical personnel (such as birthing/labor delivery) as opposed to services that require better service or medical equipment (such as fitness center). We test this hypothesis using the same IV-2SLS method specified in Section 5.2, but with the outcome variable being the proportion of admissions that require better medical personnel as opposed to better service (non-medical) personnel and equipment within profitable admissions.

Table 11 reports the estimates of the test for the hypothesis above. As seen in Table 11 Column 1-2, an increase in the proportion of private hospitals (within a 10 km radius of the incumbent

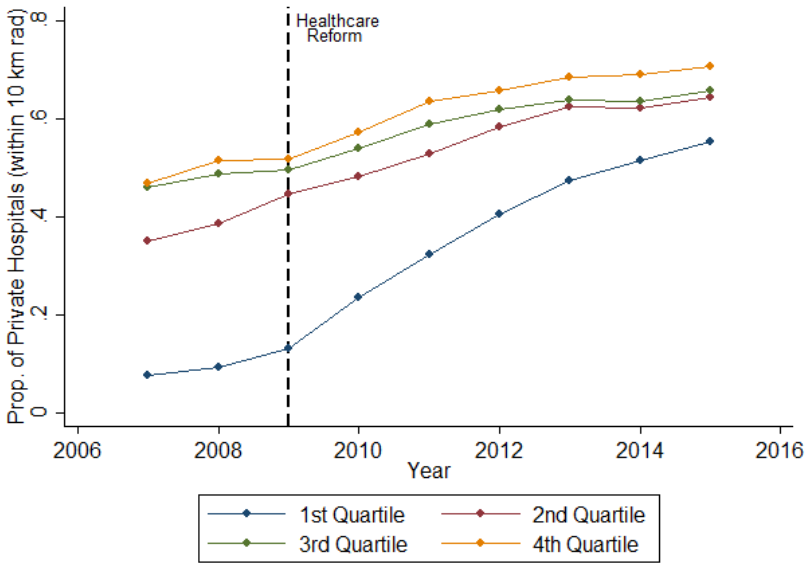
26. Indeed, some of the most profitable services only require outpatient visits, for example plastic surgery or dermatology, however these services are mostly offered by private hospitals instead of public hospitals.

public hospital) by 1% increases the proportion of profitable admissions that require better medical personnel by 0.37-0.40%. These results are significant at the 1% level. The results from Table 11 supports the hypothesis that the increase in profitable admissions are spurred by services that require better medical personnel as opposed to service that requires better service or medical equipment, supporting the fact that the two above mechanism are largely interdependent.

6.4 Placebo Test

In this subsection, we conduct a placebo test to test for the validity of our empirical framework. Given the nature and goals of the policies introduced during the healthcare reform to attract private hospital entry as mentioned in Section 3.2, what we should expect is that the effect of these policies should be concentrated within hospitals in area that have lower pre-policy level of privatization (i.e., lower pre-policy proportion of private hospitals). Hence, we conduct a placebo test by conducting our main empirical analysis by restricting our hospital-year observations between hospitals in areas with lower pre-policy levels of privatization (below mean) and higher pre-policy levels of privatization (above mean). What we should expect is that the hospital behavioral and quality change found in Section 6.2 should mostly stem from hospitals within areas with lower pre-policy levels of privatization.

FIGURE 2: HETEROGENEOUS TREATMENT INTENSITY OF HEALTHCARE REFORM ON PUBLIC HOSPITALS



Notes: Figure 2 only include public hospitals that is in our main analysis, (i.e. the 135 public hospitals restricted based on our sample selection criterion as mentioned in Section 4.)

Figure 2 plots the proportion of private hospitals within 10 km radius of the incumbent private hospital per year across quartiles segregated based on the pre-policy (2007) proportion of private hospitals. From Figure 2, it is clear that hospitals in the 1st quartile are treated with a higher intensity by the healthcare reform, given the fact that there is a distinct increase in the level of privatization after the policy in the 1st quartile compared to the rest of the quartiles. Figure 2 supports our hypothesis that hospitals at areas with a low pre-policy level of privatization are treated at a higher intensity than that of hospitals at areas with a high pre-policy level of privatization.

TABLE 12: IV ESTIMATES OF PRIVATISATION BY LEVEL OF PRE-POLICY PRIVATISATION

	Log No of Full Doc.		Log No of Med Eq.		ED Mort. Rate	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: IV-2SLS Results for Below Average Pre-Policy Level of Privatisation						
Prop. of Private Hosp. (10km rad)	1.333**	1.484**	-3.060	-3.935*	-236.490^{+}	-248.965^{+}
	(0.583)	(0.625)	(2.180)	(2.388)	(156.112)	(172.648)
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Hospital Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Hospital Controls	No	Yes	No	Yes	No	Yes
Observations	615	615	615	615	533	533
Panel B: IV-2SLS Results for Above Average Pre-Policy Level of Privatisation						
Prop. of Private Hosp. (10km rad)	-0.261	-0.173	-1.760	-1.752	-12.679	-14.105
	(1.406)	(1.407)	(1.848)	(1.991)	(65.700)	(66.406)
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Hospital Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Hospital Controls	No	Yes	No	Yes	No	Yes
Observations	587	587	586	586	471	471

Notes: Standard errors are clustered at the hospital level and reported in the parentheses. $^{+}$ $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Additional controls include department mix based on outpatient and inpatient flows, level of government subsidies and hospital tier fixed effects. For more information please refer to Section 4.3.

Table 12 provides the heterogeneous effect of the main outcome variables by pre-policy level of privatization[27]. Table 12, Panel A, provides IV-2SLS second stage results for key outcome variables when we restrict the hospital-year observations to public hospitals with below average proportion of private hospitals (within 10 km radius) in 2007. Table 12, Panel B, provides IV-2SLS second stage results for key outcome variables when we restrict the hospital-year observations to public hospitals with above average proportion of private hospitals (within 10 km radius) in 2007. Table 12 Panel A, reports that within hospitals with below average pre-policy level of

27. Due to space limitations we can only provide 3 out of all the main outcome variables, however similar analysis have been done across other outcome variables (and the results supports of hypothesis), readers can request the results for the other outcome variables from me if interested.

privatization, a 1% increase in proportion of private hospital increases in number of full doctors by 1.33-1.48% (Column 1-2, results are significant at the 5% level), decrease in number of high cost medical equipments by 3.06% to 3.93% (Column 3-4, results are insignificant at the 10%[28]), and decrease ED mortality rate by 2.36-2.49 per 10000 person (Column 5-6 results are almost significant at the 10% (significant at 15% level)).

Table 12 Panel B, reports that within hospitals with above average pre-policy level of privatization, a 1% increase in proportion of private hospital decrease in number of full doctors by 0.17-0.26% (Column 1-2), decrease in number of high cost medical equipments by 1.75% to 1.76% (Column 3-4), and decrease ED mortality rate by 0.13-0.14 per 10000 person (Column 5-6). These results (from Panel B) are insignificant at the 10% level.

The results from Table 12 supports the notion above that the hospital behavioral and quality changes should be concentrated in areas with a below average pre-policy level of privatization. This finding supports our placebo test since hospitals in areas that are already privatized pre-policy (Panel B) is largely unaffected in terms of hospital behavioural and quality changes, whereas hospitals in areas that are not (or minimally) privatized pre-policy (Panel A) are the main hospitals that are affected by the healthcare reform and changed in terms of hospital behavioral and quality.

6.5 Robustness Checks

Firstly, regression adjustments for observable differences between incumbent public hospitals with different proportion of private hospitals may not be adequate in the presence of non-linearities or interaction effects, even if there is no unobserved selection. If incumbent public hospitals with a lower proportion of private hospitals treat observably less severe patients or observably have more medical personnel, the lack of common support may bias estimates of the effect of privatization even in the absence of unobserved selection (Heckman et al., 1997; Moscelli et al., 2018). To adjust for this potential problem, we use Coarsened Exact Matching (CEM) (Blackwell et al., 2009; Iacus et al., 2012) as a robustness check for our main empirical

28. After controlling for hospital controls, the estimates became significant at the 10% level, as seen in Column 4. Furthermore, whilst insignificant at the 10% level (before controlling for hospital controls), the estimate in Column 3 is still large and negative. This provides suggestive evidence that the policy may have led to public hospitals decreasing the number of medical equipments. While this may be slightly contradictory to the results from Table 7, it still fully supports the comparative advantage mechanism posited in Section 6.3, and have no detrimental effect to the main results and aims of our paper.

results. We match each hospital with a lower proportion of hospitals (below mean) with one or more hospital with a high proportion of hospitals (above mean) who have the similar level of inpatient admissions, outpatient visits and patient-severity mix in 2007 (i.e., pre-policy). We, then, estimate the IV-2SLS model using the weights provided by the CEM algorithm.

Table A4, in the Appendix, reports the results after using the weights provided by the CEM algorithm, the results from Table A4 is very similar to that of our main results, in both statistical significance, sign and magnitude, this suggest that the posited issue of non-linearities or interaction effects is minimal[29].

Secondly, as mentioned in Section 4.1, the 10 km radius is by arbitrary choice since there is no set optimal radius in China's hospital market literature. We conduct robustness checks using different radius specification, using 5 km and 15 km, to estimate the result of our IV-2SLS model.

Table A5, in the Appendix, reports the results using different radius specifications, the sign and magnitude of the results is very similar to the main table, with the natural log of full doctors having positive sign and large magnitude (Column 1-2), the natural log of medical equipments having differing signs and statistical insignificance between different radius specifications (Column 3-4) and the ED mortality rates having negative sign and large magnitude (Column 5-6), supporting the results from our main results (using 10 km radius specification)[30].

7 Conclusion

The question of the effectiveness of privatization of healthcare is still a debatable one, especially in hospital markets. This debate mostly revolves around whether privatization can improve the welfare of patients. However, the effect is still a black box, due to the lack of empirical research. Our paper serves to mend this empirical can and provide a dimension for policymakers to consider.

This paper investigates the effect of privatization on the behavior and quality on public hos-

29. Note that Table A4 only reports robustness check for 3 (out of all) the outcome variable, namely the natural log of number of full doctors, the natural log of the number of high-cost medical equipment and ED mortality rates, due space constraints.

30. Similar to Table A4, we conduct robustness checks only using 3 outcome variables in Table A5 due to space constraints, readers can request robustness checks for all outcome variables from me if interested.

pitals in China. We find that privatization changed the behavior and improved the quality of public hospitals in China. Using the notion of comparative advantage and profit-seeking attitudes, we find that the behavior was largely a reactionary effect from the influx private hospital.

One of the greatest limitations of our dataset is the lack of a good indicator to measure the level of quality of public hospitals. Out of all the outcomes various, quality is arguably the most important outcome measure (out of all our measures we have), when studying healthcare competition, since the improvement in quality is key outcome policymakers around the world aim for when choosing to privatize a market. Furthermore, our findings of hospital behavior, based on our mechanism of comparative advantage, is unique to the hospital market in China. This severely undermines the exclusion restriction of these findings our paper.

Despite the limitations above, the results of this paper are novel and provide evidence that public hospitals do react in the face of privatization. While the change in incumbent public hospital's behavior may differ in different empirical setting, this paper provides another dimension for policymakers to consider when attempting to privatize healthcare. The effectiveness of privatization may be largely affected by how public hospitals behave in the face of privatization; this success can be speculated by considering structural factors (such as cultural factor or healthcare market structure) of the country.

Future research with better data on quality measures in China can be done to improve upon the findings of our paper. Furthermore, with the increasing number of countries privatizing their hospital markets, empirical findings on the effect of privatization can be more explicit in countries where the privatization policy is more clear-cut (unlike the complex nature of the healthcare reform in China). Future research can also compare (or model) hospital behavior across different empirical settings, to measure the type of healthcare market structure or cultural setting, privatization can be most effective.

Reference

Angrist, Joshua D and Jörn-Steffen Pischke, *Mostly harmless econometrics: An empiricist's companion*, Princeton University Press, 2008.

Arrow, Kenneth, "Uncertainty and the welfare economics of medical care," *American Economic Review*, 1963, *53* (5), 941–973.

Baicker, Katherine, Michael E Chernew, and Jacob A Robbins, "The spillover effects of Medicare managed care: Medicare Advantage and hospital utilization," *Journal of Health Economics*, 2013, *32* (6), 1289–1300.

Ben-Ner, Avner and Theresa Van Hoomissen, "Nonprofit organizations in the mixed economy," *Annals of Public and Cooperative Economics*, 1991, *62* (4), 519–550.

Bergman, Mats A, Per Johansson, Sofia Lundberg, and Giancarlo Spagnolo, "Privatization and quality: Evidence from elderly care in Sweden," *Journal of Health Economics*, 2016, *49*, 109–119.

Blackwell, Matthew, Stefano Iacus, Gary King, and Giuseppe Porro, "cem: Coarsened exact matching in Stata," *The Stata Journal*, 2009, *9* (4), 524–546.

Bloom, Nicholas, Carol Propper, Stephan Seiler, and John Van Reenen, "The impact of competition on management quality: evidence from public hospitals," *The Review of Economic Studies*, 2015, *82* (2), 457–489.

Chaisemartin, Clément De and Xavier D'HaultfŒuille, "Fuzzy differences-in-differences," *The Review of Economic Studies*, 2017, *85* (2), 999–1028.

Chen, Zhu, "Launch of the health-care reform plan in China," *The Lancet*, 2009, *373* (9672), 1322–1324.

Cheng, Tsung-Mei, "Explaining Shanghai's health care reforms, successes, and challenges," *Health Affairs*, 2013, *32* (12), 2199–2204.

Chou, Shin-Yi, "Asymmetric information, ownership and quality of care: an empirical analysis of nursing homes," *Journal of Health Economics*, 2002, *21* (2), 293–311.

Cooper, Zack, Stephen Gibbons, Simon Jones, and Alistair McGuire, "Does hospital competition save lives? Evidence from the English NHS patient choice reforms," *The Economic Journal*, 2011, *121* (554), F228–F260.

CPC Central Committee and State Council, *The Principles of the Health Care Reform, CPC Council File No. 6*, CPC Central Committee and State Council, 2009.

Cutler, David, Robert Huckman, and Jonathan Kolstad, "Input constraints and the efficiency of entry: Lessons from cardiac surgery," *American Economic Journal: Economic Policy*, 2010, *2* (1), 51–76.

Deloitte, *China's healthcare provider market: Riding the waves of reform*, Deloitte, 2015.

Duflo, Esther, "Schooling and labor market consequences of school construction in Indonesia: Evidence from an unusual policy experiment," *American Economic Review*, 2001, *91* (4), 795–813.

Duggan, Mark, "Hospital ownership and public medical spending," *The Quarterly Journal of Economics*, 2000, *115* (4), 1343–1373.

_ , "Hospital market structure and the behavior of not-for-profit hospitals," *RAND Journal of Economics*, 2002, pp. 433–446.

_ **, Jonathan Gruber, and Boris Vabson**, "The consequences of health care privatization: Evidence from Medicare Advantage exits," *American Economic Journal: Economic Policy*, 2018, *10* (1), 153–86.

Eggleston, Karen, Li Ling, Meng Qingyue, Magnus Lindelow, and Adam Wagstaff, "Health service delivery in China: a literature review," *Health Economics*, 2008, *17* (2), 149–165.

_ **, Mingshan Lu, Congdong Li, Jian Wang, Zhe Yang, Jing Zhang, and Hude Quan**, "Comparing public and private hospitals in China: evidence from Guangdong," *BMC Health Services Research*, 2010, *10* (1), 76.

Field, Erica, "Entitled to work: Urban property rights and labor supply in Peru," *The Quarterly Journal of Economics*, 2007, *122* (4), 1561–1602.

Gaynor, Martin and Robert J Town, "Competition in health care markets," *Handbook of health economics*, 2011, *2*, 499–637.

_ **, Rodrigo Moreno-Serra, and Carol Propper**, "Death by market power: reform, competition, and patient outcomes in the National Health Service," *American Economic Journal: Economic Policy*, 2013, *5* (4), 134–66.

Glaeser, Edward L and Andrei Shleifer, "Not-for-profit entrepreneurs," *Journal of Public Economics*, 2001, *81* (1), 99–115.

Glucksman, James and Roberta Lipson, "Private Healthcare: A Tough Market to Crack," *China Business Review*, Jan 2010.

Gowrisankaran, Gautam and Robert J Town, "Competition, payers, and hospital quality 1," *Health Services Research*, 2003, *38* (6p1), 1403–1422.

Grabowski, David C and David G Stevenson, "Ownership conversions and nursing home performance," *Health Services Research*, 2008, *43* (4), 1184–1203.

Hancock, Tom, "Chinese doctor's dash underlines private healthcare challenges," *The Financial Times*, Feb 2017.

Hansmann, Henry, "The role of nonprofit enterprise," *Yale Law Journal*, 1980, *89* (5), 835–891.

Harney, Alexandra and Adam Jourdan, "Dearth of doctors drags on China private healthcare drive," *Reuters*, Oct 2014.

He, Laura, "China's dire need to reform health care sector seen as opportunity for private hospitals," *South China Morning Post*, Mar 2017.

Heckman, James J, Hidehiko Ichimura, and Petra E Todd, "Matching as an econometric evaluation estimator: Evidence from evaluating a job training programme," *The Review of Economic Studies*, 1997, *64* (4), 605–654.

Hirth, Richard A, "Consumer information and competition between nonprofit and for-profit nursing homes," *Journal of Health Economics*, 1999, *18* (2), 219–240.

Horwitz, Jill R and Austin Nichols, "Hospital ownership and medical services: Market mix, spillover effects, and nonprofit objectives," *Journal of Health Economics*, 2009, *28* (5), 924–937.

Hudson, Sally, Peter Hull, and Jack Liebersohn, "Interpreting instrumented difference-in-differences," 2017.

Hughes, Robert G and Harold S Luft, "Keeping up with the Joneses: the influence of public and proprietary neighbours on voluntary hospitals," *Health Services Management Research*, 1990, *3* (3), 173–181.

Iacus, Stefano M, Gary King, and Giuseppe Porro, "Causal inference without balance checking: Coarsened exact matching," *Political Analysis*, 2012, *20* (1), 1–24.

Kessler, Daniel and Mark McClellan, "Is hospital competition socially wasteful?," *The Quarterly Journal of Economics*, 2000, *115* (2), 577–615.

Kessler, Daniel P and Mark B McClellan, "The effects of hospital ownership on medical productivity," *RAND Journal of Economics*, 2002, pp. 488–506.

Li, Jane, "China's private hospitals struggle to attract top physicians," *South China Morning Post*, Mar 2017.

Lindrooth, Richard, Anthony Lo Sasso, and Gloria Bazzoli, "The effect of urban hospital closure on markets," *Journal of Health Economics*, 2003, *22* (5), 691–712.

Ministry of Health and Family Welfare Government of India, *National Health Policy 2017*, Ministry of Health and Family Welfare Government of India, 2017.

Ministry of Health of China, *The standing conference of State Council of China adopted Guidelines for Furthering the Reform of Health-care System in Principle*, Ministry of Health of China, 2009.

Moscelli, Giuseppe, Hugh Gravelle, Luigi Siciliani, and Nils Gutacker, "The effect of hospital ownership on quality of care: Evidence from England," *Journal of Economic Behavior & Organization*, 2018, *153*, 322–344.

Mukamel, Dana, Jack Zwanziger, and Kenneth Tomaszewski, "HMO penetration, competition, and risk-adjusted hospital mortality.," *Health Services Research*, 2001, *36* (6 Pt 1), 1019.

Oliver Wyman, *Creating a Sustainable Privatization Program: Realizing Saudi Arabia's Vision for the Future*, Oliver Wyman, 2018.

Pan, Jay, Hanqing Zhao, Xiuli Wang, and Xun Shi, "Assessing spatial access to public and private hospitals in Sichuan, China: The influence of the private sector on the healthcare geography in China," *Social Science & Medicine*, 2016, *170*, 35–45.

_ , Xuezheng Qin, Qian Li, Joseph P Messina, and Paul L Delamater, "Does hospital competition improve health care delivery in China?," *China Economic Review*, 2015, *33*, 179–199.

Pei, Y Veronica and Feng Xiao, "Emergency medicine in China: present and future," *World Journal of Emergency Medicine*, 2011, *2* (4), 245.

Qin, Xuezheng, Lixing Li, and Chee-Ruey Hsieh, "Too few doctors or too low wages? Labor supply of health care professionals in China," *China Economic Review*, 2013, *24*, 150–164.

Stock, James H and Motohiro Yogo, "Testing for weak instruments in linear IV regression," 2002.

Sun, Yuelian, Hans Gregersen, and Wei Yuan, "Chinese health care system and clinical epidemiology," *Clinical Epidemiology*, 2017, *9*, 167.

Wagstaff, Adam, Winnie Yip, Magnus Lindelow, and William C Hsiao, "China's health system and its reform: a review of recent studies," *Health Economics*, 2009, *18* (S2), S7–S23.

Yip, Winnie and William Hsiao, "China's health care reform: A tentative assessment," *China Economic Review*, 2009, *20* (4), 613–619.

_ and _ , "Harnessing the privatisation of China's fragmented health-care delivery," *The Lancet*, 2014, *384* (9945), 805–818.

8 Appendix

TABLE A1: FIXED-EFFECT ESTIMATES OF PRIVATISATION ON HIRING BEHAVIOUR

	Log Total No of Nurse		Log No of Pharmacist		Log No of Med Techs	
	(1)	(2)	(3)	(4)	(5)	(6)
Prop. of Priv. Hosp. (10km radius)	0.194	0.230	0.078	0.109	-0.013	0.013
	(0.219)	(0.227)	(0.156)	(0.160)	(0.205)	(0.208)
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Hospital Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Hospital Controls	No	Yes	No	Yes	No	Yes
R^2	0.904	0.907	0.902	0.904	0.878	0.879
Observations	1202	1202	1202	1202	1202	1202

Notes: Standard errors are clustered at the hospital level and reported in the parentheses.

$^{+}$ $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Total Emergency Mortality Rates includes Mortality Rates from both ED and EOR.

Additional controls include department mix based on outpatient and inpatient flows, level of government subsidies and hospital tier fixed effects. For more information please refer to Section 4.3.

TABLE A2: IV ESTIMATES OF PRIVATISATION ON HIRING BEHAVIOUR

	Log No of Nurse		Log No of Pharmacist		Log No of Med Techs	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: IV-2SLS Second Stage						
Prop. of Private Hosp. (10km rad)	1.213**	1.304**	0.731*	0.807*	0.595	0.659
	(0.602)	(0.608)	(0.442)	(0.447)	(0.574)	(0.568)
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Hospital Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Hospital Controls	No	Yes	No	Yes	Yes	Yes
F-stats (first stage)	24.708	24.115	24.708	24.115	24.708	24.115
Panel B: IV-2SLS First Stage						
After 2009 X Prop. of Priv. in 2007	-0.433***	-0.430***	-0.433***	-0.430***	-0.433***	-0.430***
	(0.087)	(0.088)	(0.087)	(0.088)	(0.087)	(0.088)
Observations	1202	1202	1202	1202	1202	1202

Notes: Standard errors are clustered at the hospital level and reported in the parentheses. $^{+}$ $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Additional controls include department mix based on outpatient and inpatient flows, level of government subsidies and hospital tier fixed effects. For more information please refer to Section 4.3.

TABLE A3: COMMON PRE-TREND TEST

	Prop. of Priv. Hosp.		Log No of Med. Personnel		ED Mortality Rate	
	(1)	(2)	(3)	(4)	(5)	(6)
After 2008 X Prop of Private Hosp in 2007	0.044	0.045	-0.046	-0.039	-39.635	-39.369
	(0.115)	(0.115)	(0.101)	(0.100)	(38.925)	(38.546)
After 2009 X Prop. of Priv. in 2007	-0.102*	-0.101*	-0.286**	-0.314**	73.041**	73.120**
	(0.052)	(0.053)	(0.133)	(0.147)	(36.372)	(36.410)
After 2010 X Prop of Private Hosp in 2007	-0.140*	-0.140*	-0.295*	-0.296*	-69.343	-69.248
	(0.078)	(0.078)	(0.165)	(0.165)	(74.421)	(74.310)
After 2011 X Prop of Private Hosp in 2007	-0.210*	-0.211*	-0.379^{+}	-0.370^{+}	51.415	51.294
	(0.108)	(0.108)	(0.233)	(0.234)	(45.764)	(45.729)
After 2012 X Prop of Private Hosp in 2007	-0.142*	-0.141*	0.299*	0.230	38.675	39.153
	(0.081)	(0.081)	(0.175)	(0.180)	(39.698)	(39.733)
After 2013 X Prop of Private Hosp in 2007	-0.127***	-0.127***	-0.133	-0.108	16.803	17.010
	(0.045)	(0.044)	(0.096)	(0.099)	(17.311)	(17.065)
After 2014 X Prop of Private Hosp in 2007	-0.053^{+}	-0.055^{+}	-0.065	-0.045	-1.822	-2.410
	(0.035)	(0.035)	(0.145)	(0.150)	(13.284)	(12.680)
After 2015 X Prop of Private Hosp in 2007	0.006	0.009	0.296*	0.249^{+}	-13.345	-12.655
	(0.064)	(0.064)	(0.176)	(0.170)	(17.386)	(17.348)
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Hospital Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Hospital Controls	No	Yes	No	Yes	No	Yes
R^2	0.879	0.879	0.891	0.893	0.466	0.467
Observations	1203	1203	1202	1202	1002	1002

Notes: Standard errors are clustered at the hospital level and reported in the parentheses.

$^{+}$ $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Additional controls include department mix based on outpatient and inpatient flows, level of government subsidies and hospital tier fixed effects. For more information please refer to Section 4.3.

TABLE A4: ROBUSTNESS CHECK: COARSENED EXACT MATCHING

	Log No of Full Doc.		Log No of Med Eq.		ED Mort. Rate	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: IV-2SLS Second Stage						
Prop. of Private Hosp. (10km rad)	1.256***	1.324***	-1.162	-1.347	-171.306*	-171.570*
	(0.485)	(0.491)	(1.495)	(1.526)	(96.546)	(97.527)
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Hospital Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Hospital Controls	No	Yes	No	Yes	No	Yes
F-stats (first stage)	23.853	23.448	23.837	23.431	20.798	19.885
Panel B: IV-2SLS First Stage						
After 2009 X Prop. of Priv. in 2007	-0.432***	-0.429***	-0.432***	-0.429***	-0.440***	-0.435***
	(0.089)	(0.089)	(0.089)	(0.089)	(0.096)	(0.097)
Observations	1095	1095	1094	1094	901	901

Notes: Standard errors are clustered at the hospital level and reported in the parentheses. $^{+}$ $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Additional controls include department mix based on outpatient and inpatient flows, level of government subsidies and hospital tier fixed effects. For more information please refer to Section 4.3.

TABLE A5: ROBUSTNESS CHECK: ADJUSTING RADIUS SPECIFICATION

	Log No of Full Doc.		Log No of Med Eq.		ED Mort. Rate	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: IV-2SLS Second Stage						
Prop. of Priv. Hosp. (5km rad)	1.236**		0.594		-158.389*	
	(0.561)		(1.759)		(89.654)	
Prop. of Priv. Hosp. (15km rad)		1.209*		-0.917		-100.691
		(0.694)		(1.685)		(97.050)
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Hospital Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Hospital Controls	Yes	Yes	Yes	Yes	Yes	Yes
F-stats (first stage)	18.206	22.827	18.137	22.797	18.808	18.926
Panel B: IV-2SLS First Stage						
After 2009 X Prop. of Priv. (5km) in 2007	-0.339***		-0.339***		-0.380***	
	(0.080)		(0.080)		(0.088)	
After 2009 X Prop. of Priv. (15km) in 2007		-0.443***		-0.442***		-0.428***
		(0.093)		(0.093)		(0.098)
Observations	1189	1189	1188	1188	993	993

Notes: Standard errors are clustered at the hospital level and reported in the parentheses. $^{+}$ $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Additional controls include department mix based on outpatient and inpatient flows, level of government subsidies and hospital tier fixed effects. For more information please refer to Section 4.3.