On the supply of China's healthcare resources in a decentralized healthcare system

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Abstract
The structure of China's current governance bears prominent features of fiscal decentralization. The supply of healthcare resources in China has clearly witnessed slower growth in the last two decades during which the fiscal decentralization process has taken place. Using China's provincial panel data, we examine the determinants of healthcare resource supply while paying particular attention to the role of fiscal decentralization. We find that the supply of healthcare resources is inversely related to the degree of decentralization, which, using spatial econometrics, is attributed to the presence of strategic substitutes in healthcare spending across city governments. These findings have important implications for policy makers in making fiscal arrangements among different government tiers.

Keywords: Healthcare resources, Strategic substitutes, Decentralization, Spatial econometrics

JEL codes: I10; H7; C21

1. Introduction

The Chinese economy's rapid growth has improved people's living standards dramatically; however, increasing numbers of residents are in poor health due to various internal and external causes, such as work-related stress, environmental pollution, and food safety. A national health and nutrition report revealed that one out of two people on average who received physical examination are confronted with the threat of poor health (Guangdong Society of Nutrition, 2011).[1] The "Triple *H*" (hypertension, hyperglycemia, and hyperlipidemia) phenomenon is becoming increasingly common across almost all levels of ages from the young to the old.[2] Numerous people suffer from obesity, osteoporosis, angiosclerosis, and other angiocardiopathy problems. According to the *National Nutrition and Health Condition Investigation Report* issued by the Ministry of Health of China in 2004, the overweight and obesity rates of Chinese adults are 22.8% and 7.1%, respectively. These two rates increased by 39% and 97%, respectively, in ten years. In addition, approximately 160 million people suffer from dyslipidemia, and more than 160 million people suffer from hypertension. Health conditions are not only important for the human beings themselves but also for economic factors such as economic output, growth, productivity, and FDI (Foreign Direct Investment) at the national or regional level. The importance of health conditions is widely examined in the academic literature (Arora, 2001; Mayer, 2001; Bloom, Canning, & Sevilla, 2004; Alsan, 2006; Cole & Neumayer, 2006; Acemoglu & Johnson, 2007; Weil, 2007; Liu, Dow, Fu, Akin, & Lance, 2008).

Along with health problems, the demand for healthcare services is increasing. Taking two indicators as examples, number of inpatients and times of treatments, Fig. 1 shows that between 1994 and 2008, both indicators greatly increased in China. Specifically, the number of inpatients trends upward from 1994 and increases rapidly from 2000. In addition, the number of inpatients doubled during the 2000-2008 period, with a growth rate of 75%. Turing to another index, the times of treatments in general are relatively stable during 1994-2003 and increase sharply afterward. Since 2003, the treatment times have increased from 1.28 billion to 1.9 billion with a growth rate of approximately 50%.

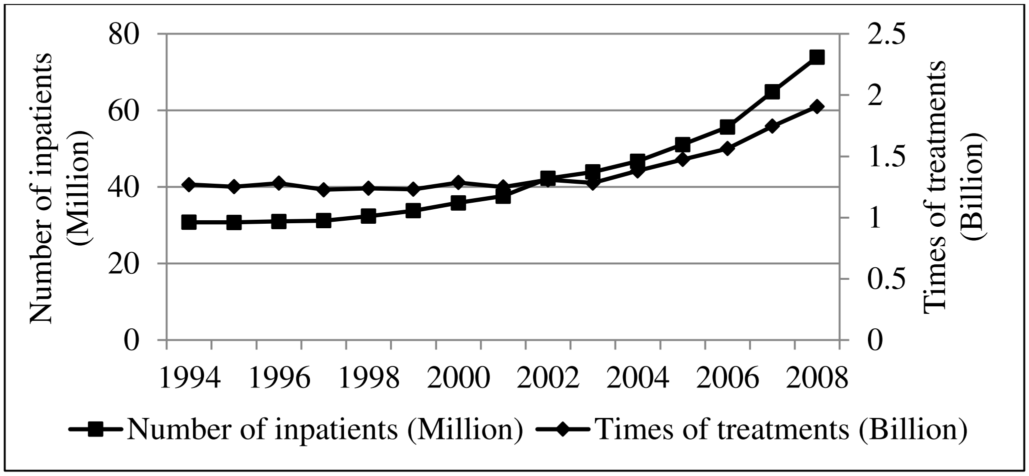

Fig. 1. Healthcare demand trend in China during 1994-2008

Source: China Health Statistical Yearbook (various years)

Despite the obviously increasing demand for healthcare services in the last few decades, the supply of healthcare services has lagged behind. The relative shortage of healthcare supply has caused several problems. There is anecdotal evidence indicating that "seeing a doctor is like fighting a battle, and making an appointment is like going through Spring Festival, China's most important holiday for family reunion, travel season." The number of medical institutions, such as hospitals and clinics, decreased from 67,524 to 59,572 with a decreasing rate of 11% from 1994 to 2008 (Fig. 2).

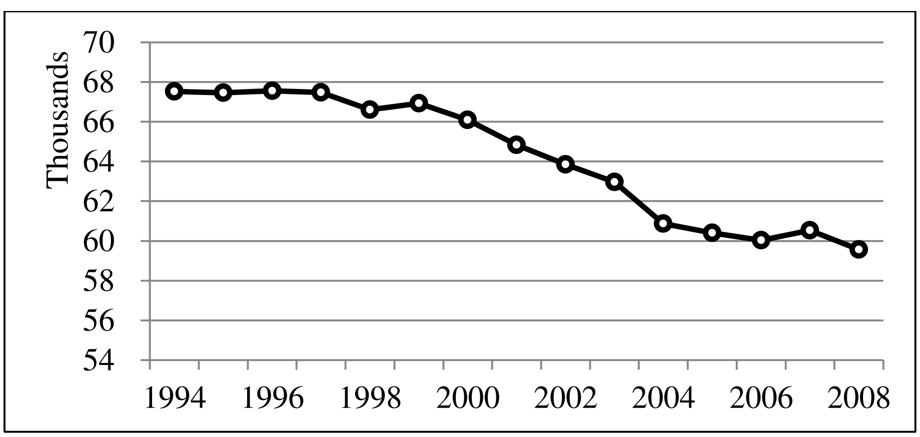

Fig. 2. Number of medical institutions in China during 1994-2008

Source: *China Health Statistical Yearbook* (various years)

The imbalance between demand and healthcare service supply is apparent in Fig. 3, which represents the average growth rates of five indices during 1998-2008. They are the number of inpatients, times of treatments, hospital beds, healthcare professionals, and medical institutions. The first two indices reflect the demand status, whereas the following three indices indicate the supply status of healthcare services. On the demand side, the number of inpatients grows the fastest at the rate of 8.23%; times of treatments grow at 4.19%. On the supply-side, both the number of medical professionals and hospital beds increase at the rates of 1% and 2%, respectively, and the number of medical institutions decreases at a rate of 1.12%. The demand for healthcare services grows much faster than the supply.

During this decade, 1998-2008, China's intergovernmental fiscal relationship is highly decentralized. Since the 1990s, local governments have financed approximately 70% of total fiscal expenditures, an exceptionally high proportion even compared to other countries (OECD, 2006). These basic facts pose an interesting question concerning the role of fiscal decentralization in the context of China, where the provision of healthcare services is mainly shouldered by local governments.

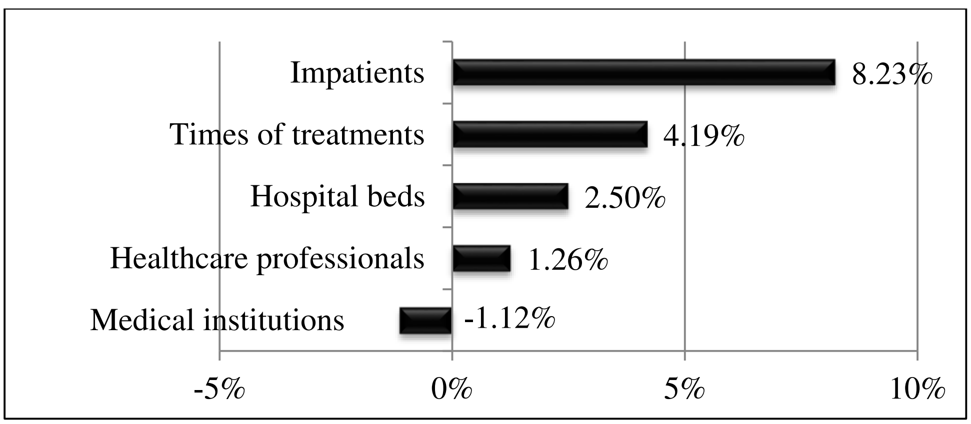

Fig. 3. Growth rate of healthcare demand and supply from 1998-2008

Note: authors' calculation based on *China Statistical Yearbook*.

Research provides inconsistent answers. Collins & Green (1994) and Robalina, Picazo, & Voetberg (2001) posit that decentralization can improve access to healthcare and other social services by enhancing the participation of the community in decision-making and implementation processes and strengthening local authorities who can better tailor staff, resources, and procedures to local circumstances compared to the central government. Frank & Gaynor (1994) use data from the states of Ohio and Texas to examine the impacts of fiscal decentralization on public mental healthcare. They find that fiscal decentralization leads to increased expenditures on healthcare services by local governments. However, some studies find that fiscal decentralization is negatively related to the provision of public goods and services. Singh (2008) examines delivery of public healthcare services in India in the context of decentralization and finds that decentralization aggravated public sector delivery of healthcare. Pan (2010) finds that China's fiscally decentralized system enables local governments to under-provide public healthcare services. Similar results are presented by UNDP (2000), Ping & Bai (2006), and Shen & Fu (2006).

However, the existing literature ignores the possible presence of spatial interactions across local jurisdictions due to fiscal decentralization. It is necessary to take the spatial interaction into consideration because of two effects. First, healthcare service is a sort of public good with low geographical restrictions. If there are abundant healthcare provisions in neighboring regions that are able to meet local demand, local governments have reduced motivation to spend on healthcare, referred to as the substitution effect resulting from the spillover effect. Second, subnational governments in China are organized in a four-level hierarchy: the central government, provincial governments, city-level governments, county-level governments, and township-level governments. Each level of government is supervised and evaluated by its next highest level. The government with better performance receives more support from the higher-level governments, and its officials have better chances at promotion. Thus, on one hand, local governments increase the overall supply of public goods to catch up to the public service level in neighboring areas, the catch-up effect. On the other hand, local governments might increase the productive public goods supply for projects such as highways, railways, and airports to attract capital and high-skilled labor, whereas the supply of public services, such as education and healthcare, are reduced. We call this the competitive effect. Both effects make the spatial interaction an important factor when analyzing the relationship of fiscal decentralization and local healthcare resource provision.

This study contributes to the literature in two aspects. First, it considers different types of public healthcare services that could be affected differently by fiscal decentralization. This study uses China's provincial panel data to investigate the determinants of healthcare resource supply as represented by hospital beds and doctors, while paying particular attention to the role of fiscal decentralization. Hence, unlike empirical studies by Westert & Groenewegen (1999), Papastergiou, Rachiotis, Polyzou, Zilidis, & Hadjichristodoulou (2008), Wang, Zhou, Zheng, Zhang, Wu, & Chen (2009), Chon (2010), and Hsu (2013), among others who focus on examining the possible effects of healthcare resource supply, such as supply of hospital beds or medical staffs on health improvement, mortality, homicide rate, efficiency of government spending on health, economic growth or other indicators, we examine the related issue from a different angle. In other words, we examine the driving forces behind the healthcare resource supply. Second, we examine the mechanisms through which fiscal decentralization affects the public supply of healthcare services by introducing the spatial interactions into the model using a city-level dataset.

The primary finding of this study is that the supply of healthcare resources is inversely related to the degree of decentralization in the first step. To elucidate the mechanisms that result in this negative relationship between fiscal decentralization and healthcare provision, in the second step, we find that the inverse relationship is attributed to the presence of strategic substitutes in healthcare spending across city governments originating from the fiscal decentralization reform.

Section 2 presents the panel model of provincial healthcare resource supply, discusses the database, and describes the methodology. Section 3 reports the empirical results, with particular focus on the role of fiscal decentralization. Section 4 further explores the mechanism through which fiscal decentralization can lead to under-provision of healthcare resources by specifying a spatial model of city government healthcare expenditures. Finally, the last section concludes with some policy implications.

2. Model, variables, and data

The estimated model is,

$$Healthcare_{it} = \beta_0 + \beta_1 Decentralization_{it} + \beta_2 Revenue_{it} + \beta_3 Edu\_province_{it} + \beta_4 Waterwaste_{it} + \beta_5 Age14_{it} + \beta_6 Age65_{it} + \beta_7 Urbanization_{it} + \varepsilon_{it},\ i = 1,..., 31;\ t = 1994,..., 2006 \quad (1)$$

where i denotes the province, and t denotes time. The dependent variable *Healthcare* indicates healthcare resources provided in province i at time t. In the empirical implementation, two variables, the number of hospital beds (*Hospitalbed*) and number of doctors (*Doctor*), are used as proxies. These two variables are taken from *Comprehensive Statistical Materials on 60 Years of the New China (1949-2008),* which was published by the National Bureau of Statistics (NBS). It is worth noting that Chongqing was part of Sichuan until it became a separate province in 1997. The NBS reports Sichuan and Chongqing data separately. We treat Chongqing as a separate province in this study.

Decentralization, which is the major explanatory variable, measures the degree of fiscal decentralization in China and is defined as the share of city governments' own-source revenue within a province in total provincial own-source revenue. Specifically, $Decentralization_{it} = (\sum_{j=1}^{n} own\text{-}source\ revenue_{jt}) / total\ own\text{-}revenue\ of\ province_{it}$, where *j* represents the municipal-level city in province *i*, and *n* is the total number of municipal-level cities in province *i*. A higher ratio of this index indicates a higher degree of fiscal decentralization in the province and vice versa. The source of the city governments' own-source revenue data is *Prefecture- and County-level Public Finance Statistics*, whereas the provincial own-source revenue data are from the *Finance Yearbook of China*. Both statistical yearbooks are published by the Ministry of Finance. In the context of fiscal decentralization under which important expenditure responsibilities have been assigned from national to local governments, we hypothesize that decentralization reform gives local governments more autonomy than before to allocate more expenditures to categories, such as infrastructure, that could produce the most benefits/utility, that is, personal promotion, personal reappointment, or high economic growth; subsequently, the local government would be less motivated to take on improvements in education, social, and pollution programs that generate fewer, if any, benefits to them. Thus, the first hypothesis to be formulated and tested is the following:

Hypothesis 1. A higher degree of fiscal decentralization in a province is expected to lead to a lower supply of healthcare resources.

In addition, the following factors are considered important to explain healthcare supply: *Fiscal variables*: The first fiscal variable is related to a provincial government's own-source revenue (*Revenue*). This variable is defined as the provincial government's own-source revenues divided by the total population of that province. It reflects the provincial government's fiscal capability in allocating its funds to public healthcare services, and it is expected to be positively related to healthcare resource supplies. The source of a provincial government's own-source revenue data is from the *Finance Yearbook of China,* which is published by the Ministry of Finance of China; the population data are from the *China Population Statistical Yearbook*, which is published by the NBS. The second fiscal variable is related to education (*Edu_province*). It is measured as the percentage of total provincial public expenditure allocated to education. Education investments appear to be more attractive than healthcare investments in China as the former tends to be a more relevant index used by the central government to evaluate the provincial governors' performance. It is important to note that, under constant budget constraints, a larger share of education expenditures crowds out other public expenditures, including those for hospital beds and doctors. Hence, the coefficient of *Edu_province* is expected to be negative. In addition, high education expenditure implies a rise in local educational attainment. Hu & Hibel (2013) find that Chinese educational attainment promotes self-rated health by providing better work and economic condition, promoting a higher level of the sense of self-control, encouraging individuals to pay more attention to potential health issues, raising the frequencies of exercise, and increasing the frequencies of moderate drinking. Therefore, with the rise in educational attainment, demands for local healthcare services would drop. As a result, the local healthcare provision may decline. This scenario also explains the negative relationship between *Edu_province* and healthcare expenditure. The NBS is the source of the data on total public expenditures and public education expenditures. Data for the year 1994 are missing for all provinces, and we use an imputation method to replace these missing values.

Demographic variables: This study considers three demographic variables: *Age14*, *Age65*, and *Urbanization*. *Age14* measures the percentages of total provincial population who are aged under 14, whereas *Age65* is the percentages of total provincial population who are aged above 65. Both demographic variables are expected to have positive effects on healthcare expenditure and thus positively related to the healthcare resource provision, as healthcare costs maintain a relatively high level for infants, decline sharply during the first few years of life and then rise, at first gradually, and then more sharply as the population ages (Di Matteo & Di Matteo, 1998). *Urbanization* is defined as the percentage of total provincial population living in urban areas. Two opposing forces may dominate the overall impact of urbanization rate on healthcare resource supplies. A higher urbanization rate may result in a greater demand for hospital beds and/or doctors. However, if agglomeration economies exist that improve the efficiency of healthcare resources and thus increase the return to healthcare resource supplies in urban areas, a higher urbanization rate may result in a lower supply. Thus, the expected sign of such a variable as *Urbanization* is indeterminate.

Environmental variable: One environmental variable is used: *Waterwaste*. This variable indicates per capita waste water emissions, which is an indicator of environmental pollution level.[3] The discharge of water pollutants from medical organizations has long been a crucial concern of all levels of governments. In addition, the domestic waste water resulting from inpatients and their relatives should not be ignored either. Thus, one may expect that higher provision of healthcare resources is associated with a higher pollution level. Table 1 presents the variables used in the empirical model, the summary statistics, and data sources.

Eq. (1) can be estimated using such approaches as the pooled OLS, the fixed effects model

(FEM), and the random effects model (REM). Each approach has advantages and disadvantages. The pooled OLS assumes neither spatial nor temporal effects among the panel data. Both FEM and REM address possible unobservable heterogeneity across provinces, yet one key assumption of the REM model is that unobserved provincial effects are uncorrelated with exogenous variables. The *F test,* Lagrange Multiplier (LM) test, and Hausman test (Hausman, 1978) are used identify the fit of each model.

Table 1 Descriptive statistics of the healthcare resource supply panel model (1994-2006).

	N	Mean	Std. dev.	Min.	Max.
Dependent variable					
Hospitalbed (per 10 thousand population)	403	26.82	11.71	1.42	67.70
Doctor (per 10 thousand population)	403	17.65	8.14	1.06	50.70
Independent variable					
Decentralization (%)	403	44.11	19.29	8.25	98.17
Revenue (per capita million *yuan*)	403	7.94	12.38	0.92	116.98
Edu_province (%)	403	16.78	4.16	6.65	31.73
Age14 (%)	403	20.86	7.07	1.32	37.51
Age65 (%)	403	7.19	3.14	0.36	20.70
Urbanization (%)	403	38.92	17.83	0.32	88.70
Wastewater (per capita thousand tons)	403	202.95	165.52	17.29	1,282.23

Sources: NBS (various years); MOF (various years).

Note: Missing data are imputed using the MI command in Stata 13.

3. Statistical findings

Table 2 reports the fixed effects regression results of the healthcare resource supplies model based on Eq. (1). Both standardized and unstandardized coefficient estimates are presented. The results from all tests indicate that the FEM is preferable to REM and pooled OLS. As seen from Table 2, regardless of the variable proxy for healthcare resource, the *Hospitalbed* or *Doctor,* the coefficient of *Decentralization*, the primary variable of interest, is negative and statistically significant at a 1% level, implying that a higher level of fiscal decentralization is associated with a lower level supply of hospital beds or doctors – hypothesis 1. This result is not only in line with our hypothesis that the fiscal decentralization reform that took place in the early 1990s plays a role in explaining the slowdown of healthcare resource growth but is also consistent with Singh (2008). However, these results contradict Frank & Gaynor (1994) and Costa-Font & Pons-Novell (2007).

The coefficient of *Revenue*, a provincial government's fiscal revenue, is inconsistent when the dependent variable is *Hospitalbed* instead of *Doctor*. The education expenditure share of provincial public expenditure, *Edu_province*, carries unexpected positive signs in both regressions, which could imply that public expenditure on education and healthcare services are complementary, i.e., that a local government would not simply cut back on either category of expenditure to increase another. *Wastewater*, the environmental variable measuring waste water emissions, is statistically significant and carries the expected positive sign in both models. A higher value of *Urbanization*, a higher proportion of the population living in the urban area, is positively related to the healthcare resource supplies. With respect to the other two demographic variables, *Age14* and *Age65*, the results did not meet our expectations. *Age14* appears to have no significant effect on hospital bed provision nor number of doctors per 10,000 persons; the *Age65* variable is inversely related to the number of hospital beds, which differs from our initial expectation.

Since the fiscal decentralization reform in 1994, more fiscal expenditure allocation rights have been held by local governments. This implies that local governments are entitled to more control over healthcare resource supplies. As suggested in the above analysis, fiscal decentralization exhibits a negative instead of positive effect on healthcare resource supplies. What is the mechanism through which fiscal decentralization negatively affects healthcare resource supplies? The following section uncovers the mechanism through further empirical analysis of city governments' fiscal behaviors in terms of healthcare expenditure in China.

Table 2 Fixed effects regression results of healthcare resource supply model.

	Hospital bed		Doctor	
	Unstd. coef.	Std. coef.	Unstd. coef.	Std. coef.
Intercept	22.460*** (1.380)		16.980*** (0.991)	
Fiscal variables				
Decentralization	−0.562*** (0.127)	−0.926	−2.476*** (0.836)	−5.868
Revenue	11.420*** (3.291)	12.073	−8.424** (3.992)	−12.812
Edu_province	14.930***(3.36)	5.304	5.406** (2.41)	2.763
Demographic variables				
Age14	7.429 (5.159)	4.485	13.290 (8.630)	11.543

Age65	−13.660**(5.965)	−3.663	−31.150** (12.510)	−12.016
Urbanization	2.532* (1.353)	3.855	1.996** (0.970)	4.372
Environmental variable				
Wastewater	0.024* (0.014)	0.339	0.09* (0.047)	1.830
Time fixed effects	No		No	
N	403		403	
No. of provinces	31		31	
F test for fixed effects	263.91 [0.0000]		247.67 [0.0000]	
LM test for random effects	1,794.88 [0.0000]		1,252.83 [0.0000]	
Hausman test	165.23 [0.0000]		39.50 [0.0002]	
Likelihood ratio test for time fixed effects	15.37 [0.2217]		12.23 [0.4275]	

Source: Author's calculations.

Note: "Unstd. (Std.) coef." refers to "Unstandardized (Standardized) coefficient". Standard errors are reported in parentheses. *p* values are reported in brackets. * $p < .1$. ** $p < .05$. *** $p < .01$.

4. Further analysis

The second hypothesis is:

Hypothesis 2. City governments do not act alone in allocating their public expenditure categories.

Given the fact that healthcare supply has a spillover or free-riding effect, city governments consider their neighbors' healthcare spending decisions in their own decision-making process. To capture the potential interactions across city decision-makers, we follow Hoel (1991) by introducing a simple model with spatial spillovers concerning a public healthcare spending game. Specifically, there are two cities, $i = 1, 2$, in this noncooperative game. Each city's public healthcare spending is X_i ($i = 1, 2$). The payoff function to each city is specified as,

$$\pi_i = B_i(X_1 + X_2) - C_i(X_i) \tag{2}$$

where B_i is the benefit function which depends on total healthcare spending, and C_i is the cost function which depends on the healthcare spending of city *i*. Assuming that $B_i' > 0$, $B_i'' < 0$, $C_i' > 0$, and $C_i'' > 0$, we total differentiate Eq. (2) with respect to X_1 and get the following first order condition to maximize the payoff,

$$d\pi_1/dX_1 = B_1'(X_1 + X_2) - C_1'(X_1) = 0, \text{ or } B_1'(X_1 + X_2) = C_1'(X_1) \quad (3)$$

This defines X_1 as a function of X_2, which is called the response function of city 1, and denoted by $R_1(X_2)$. From Eq. (3) we have,

$$R_1'(X_2) = -B_1''/(B_1'' - C_1'') < 0 \quad (4)$$

Similarly, city 2's optimal response to city 1's choice of X_1 is given by,

$$B_2'(X_1 + X_2) = C_2'(X_2) \quad (5)$$

which yields city 2's response function as,

$$R_2'(X_1) = -B_2''/(B_2'' - C_2'') < 0 \quad (6)$$

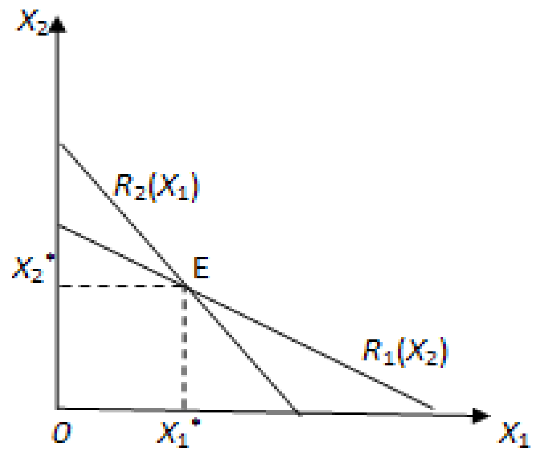

Fig. 4. Nash Equilibrium of public healthcare spending

Fig. 4 illustrates these two response functions. Their intersection at point E is the Nash equilibrium where the set of strategies (X_1^*, X_2^*) satisfies Eqs. (3) and (5), i.e., $X_1^* = R_1(X_2^*)$ and $X_2^* = R_2(X_1^*)$. Following Eqs. (4) and (6) we conclude that the decision-makings of these two cities are strategic substitutes. In other words, if one city increases its public spending expenditure, the neighboring city may cut its own spending as a response. This suggests that positive spillovers exist in cities' healthcare public expenditures.

Thus, we hypothesize that, in a decentralized healthcare system, city governments would not act alone but behave strategically in regards to education, social, and pollution programs. In other words, intergovernmental fiscal interactions could cause a lower level of public healthcare resource supply. The hypothesis is tested empirically in the following section using a spatial econometric technique.

4.1 Spatial model

The empirical model of municipal-level public healthcare expenditure without accounting for spatial effect can be specified as follows:

$$Expense\_city_i = \alpha\iota_n + X_i\beta + \varepsilon_i,\ \varepsilon \sim N(0, \sigma^2 I_n),\ i = 1,\dots, 245 \qquad (7)$$

where *Expense_city* is a $n \times 1$ vector of dependent variables denoting per capita government spending on healthcare in city *i*. The source for government spending on healthcare is from the *Prefecture- and County-level Public Finance Statistics (2007)* from the Ministry of Finance of China, whereas the population data are from *China City Statistical Yearbook (2007)* published by NBS. ι_n is a $n \times 1$ vector of ones associated with the constant term parameter α. ε is the error term, and β is the parameter to be estimated. X is a set of explanatory variables that are identified to affect deviations of a city government's healthcare expenditures. They are classified as follows:

Fiscal variables: There are two-fold spatial effects of municipal-level healthcare expenditure: first, the vertical spatial effect, which includes the interaction of healthcare expenditure between the provincial and city governments and between the city and county governments and second, the horizontal spatial effect, which results from the interaction of healthcare expenditure between the city governments. Thus, it is necessary to include the variables of *Expense_province* and *Expense_county*, which measure per capita healthcare expenditure spent by the provincial and county governments, respectively, in the municipal-level healthcare expenditure model to identify the true horizontal spatial effects of public healthcare spending across city governments. The effects of these two variables on municipal-level public healthcare spending are hypothesized to be theoretically negative as a higher level of healthcare expenditure in vertical governments would place less burden on the city's government because of the nonexclusive characteristic of healthcare resources, the so-called substitution effect. Thus, there are reasons to believe that a city government may decrease its healthcare expenditures as a response to the increase of its higher- and lower-level governments' healthcare expenditures. The third fiscal variable is related to education (*Education_city*), which is defined as the percentage of city public expenditures on education programs. Similar to the arguments in Section 2, the coefficient sign on *Education_city* is ambiguous. The fiscal data are taken from the *Prefecture- and County-level Public Finance Statistics (2007)*.

Supply-side variables: This study includes two supply-side variables: *Hospitalbed_city* and *Doctor_city*. They indicate, respectively, the number of per capita hospital beds and doctors in the city. They are expected to be positively related to the dependent variable. The source for these two supply variables is the *China City Statistical Yearbook* (2007).

Economic/Demographic variables: Two variables are used. *GDP_city* is per capita city-level GDP, which is used to reflect the spending capacity of that city. The source for these two supply variables is the *China City Statistical Yearbook* (2007). We expect a positive relationship between *GDP_city* and the dependent variable, whereas, *Urbanization_city* captures the urbanization ratio of the city, which is defined as the percentage of total city population living in urban areas. Similar to the arguments in Section 2, the coefficient sign on *Urbanization_city* is ambiguous.

Environmental variables: We consider three environmental indicators in this study. *Waterwaste_city*, SO_2*_city*, and *Pollution_city*, which are three environment-related variables, are defined as waste water emissions per square meter, industrial sulfur dioxide emissions per square meter, and per capita environmental pollution investment at the municipal level, respectively. The source for these environmental variables is also the *China City Statistical Yearbook* (2007) as well. Both *Waterwaste_city* and SO_2*_city* are expected to be positively related to healthcare expenditure because of the reasons presented in Section 2, whereas the variable *Pollution_city* may be endogenously determined and can be positively or negatively related to the healthcare spending. More investments in pollution may reduce the possibility of people getting sick and going to the hospital, which implies that less spending on healthcare is required. However, a high level of pollution investment in a city indicates that the city has already had a severe environmental pollution issue and thus might maintain a higher level of healthcare expenditures. *Mining_city* is the ratio of total employees in the mining sector, which reflects the city's industrial structure. The coefficient on this variable is supposed to be positive as a larger value of the ratio implies that the city is heavily dependent on secondary industries and has more environmental problems, and hence a higher level of healthcare spending is required than other cities with relatively smaller ratios.

The summary statistics of the variables used in this part of analysis are presented in Table 3. The data for these economic, demographic, and environmental variables are taken from the *China City Statistical Yearbook*, whereas the fiscal variables are from the *Prefecture- and County-level Public Finance Statistics*. We obtained a total number of 245 Chinese prefecture-level cities in 2006 after combing data from these two data sources.

The OLS approach may be properly applied to describe the relationship among Chinese cities' public healthcare spending in disregard of the spatial effect. However, the spatial effect undoubtedly exists in terms of public healthcare spending among cities because of two opposite forces. On one hand, city governments compete with each other as the provincial government evaluates the performance of local governors periodically, and the healthcare condition is one of numerous criteria applied. Therefore, a higher share of healthcare spending in the neighboring cities would, *ceteris paribus*, encourage a city's government to spend more on healthcare resources because of the catch up effect. On the other hand, similar to the substitution effect, a city's public healthcare resources are actually a type of shared resource among cities, which do not prevent residents of other cities from taking advantage of them. If a city offers good healthcare services, which indicates a relatively higher share of healthcare spending, residents of nearby cities will be attracted, and the demand for healthcare resources in those neighboring cities will drop, resulting in reduced local healthcare expenditures. In addition, the healthcare service is a relatively less-productive public service; due to the aforementioned competitive effect, the city government's spending on local healthcare resources, *ceteris paribus*, will diminish if the local government obtains more fiscal controls.

Table 3

Summary statistics of public healthcare expenditure model (245 cities in year 2006).

	Mean	Std. dev.	Min.	Max.
Dependent variable				
*Expense*_city (*yuan*/person)	28.45	46.74	1.83	616.25
Independent variable				
*Expense*_county (*yuan*/person)	52.11	27.28	9.74	217.05
*Expense*_province (*yuan*/person)	260.19	227.54	41.13	1.70e+0.3
*Education*_city (%)	8.47	4.11	0.84	24.23
*Hospitalbed*_city (no.)	208.88	159.10	7.00	1.38e+03
*Doctor*_city (no.)	5.92e+03	4.34e+03	377.00	2.73e+04
*GDP*_city (*yuan*)	1.81e+04	1.44e+04	2.77e+03	9.60e+04
*Urbanization*_city (%)	12.13	14.72	1.05	95.06
*Waterwaste*_city (10,000 ton/km^2)	0.93	1.47	0.00	11.23
*SO_2*_city (ton/km^2)	7.91	9.90	0.06	67.96
*Pollution*_city (*yuan*/person)	210.94	351.28	0.74	3,882.15
*Mining*_city (%)	6.34	10.32	0.00	55.20

Sources: MOF (2007) for all fiscal variables (*Expense*_city, *Expense*_county, *Expense*_province, *Education*_city); NBS (2007) for the rest variables.

In the presence of the spatial effect of healthcare spending among cities, the OLS estimation will not yield consistent estimates (Anselin, 1988), so other estimation approaches are required.

Conventionally, there are two types of spatial dependence. One type assumes that the spatial correlation is reflected in the dependent variable and the spatial lag/autoregressive model (SAR) is used to find out this correlation. The other type specifies that the spatial correlation exists in the disturbance term, and the spatial error model (SEM) helps capture this correlation. These two types of spatial correlation are commonly observed in the spatial econometric literature.

To specify the SAR model, the classical linear regression model in Eq. (7) is rebuilt as

$$Expense\_city = \alpha\iota_n + \lambda W^{*}Expense\_city + X\beta + \epsilon,\ \epsilon \sim N(0, \sigma^2 I_n),\ n = 1, \ldots, 245 \qquad (8)$$

where W is the nonstochastic $n \times n$ spatial weight matrix in which the element m_{ij} is posited as being inverse functions of the distance between cities i and j ($i \neq j$) (Anselin, 1988; Moscone, 2007; Baltagi, Blien, & Wolf, 2012; Yu, Zhang, Li, & Zheng, 2012).[3] Let d_{ij} denote the great-circle distance between cities i and j, then m_{ij} can be derived from the following expression:[4] $m_{ij} = 1/d_{ij}$, ($i \neq j$). β, σ^2, and λ are the parameters to be estimated. β and σ^2 are the usual regression parameters, and λ is the additional spatial lag parameter, which captures the magnitude of spatial dependence across cities. This spatial lag parameter is the most important coefficient in that it allows us to test the spatial interaction hypothesis. Anselin (1998) suggests that in the case of spatially lagged dependence, the estimates from traditional OLS are biased and inconsistent as the autoregressive component of the model is correlated with residuals. Thus, the maximum likelihood estimation (MLE) method should be applied instead.

To specify the SEM model, Eq. (7) is reformed as

$$Expense\_city = \alpha\iota_n + X\beta + \mu,\ \mu = \rho W^{*}\mu + v,\ v \sim N(0, \sigma^2 I_n),\ n = 1, \ldots, 245. \qquad (9)$$

Compared with Eq. (8), the spatial weight matrix W is put in the error term here. Although OLS estimation yields unbiased estimates in the presence of spatial correlation among model disturbances, estimates of the standard errors are inconsistent. Thus, the MLE method is still preferred when spatially correlated disturbances are considered. In the empirical implementation session, we will conduct several tests to determine if the SAR or SEM model is preferable.

4.2 Spatial results

The regression results are presented in the Table 4. Columns 2 and 3 show, respectively, the estimating results for the unstandardized and standardized coefficients. Some pretesting results are also reported from the OLS model. First, the result from the Jarque-Bera (1981) test is found to be insignificant at a 5% level of significance, revealing that the OLS errors are considered to be normally distributed, which paves the way for a spatial dependence test based on the assumption of normal distribution. Second, Moran's (1950) *I* test on the residuals derived from the OLS model indicates significant spatial dependence in the data. However, further information is required to judge if the spatial correlation should be considered in the dependent variable or in the error term or in both. To guide the specification search, two different sets of Lagrange Multiplier tests can be used, which are the LM-Error and LM-Lag tests and their robust versions.[5] Although the LM-Error test gives an insignificant result, the robust LM-error test is significant at a 1% level of significance. Both LM-Lag and robust LM-Lag tests are significant as well. Thus, both spatial lag and spatial error effects are presented simultaneously in the classical regression model. As a result, it is reasonable to adopt a spatial mixed model, namely the SAC model, which combines the features of both the SAR and SEM models.

The results of the spatial mixed model are reported in the columns 4 and 5 of Table 4.[6] The autoregressive lag parameter, λ, is most interesting as it captures the magnitude of spatial dependence across cities. The spatial lag parameter is negative and significant at a 1% level of significance. This result suggests that, in a decentralized healthcare system, a city government appears to cut its own spending on healthcare by 1.186 units (standard deviations) as a response to a one unit of standard deviation increase in the healthcare expenditures of its neighboring cities. This empirical finding indeed supports hypothesis 2, city governments engage in strategic interaction in spending-decisions on healthcare programs; moreover, the substitution effect and competitive effect take priority over the catch-up effect.

Turning to other explanatory variables, *Expense_province*, the vertical variable, is significantly and negatively related to the dependent variable as expected, whereas *Expense_county*, the other vertical variable, has a significant and positive relationship with public expenditures on healthcare by the city-level governments, which was unexpected. *GDP_city* is positively associated with public healthcare expenditure. Specifically, as city-level GDP increases by one standard deviation or 14.4 thousand yuan, *ceteris paribus*, city government's healthcare spending increases by 3,900 standard deviations, or 0.18 million yuan. The coefficient for the pollution investment variable is also positive, yet the coefficient size may be overestimated because of the above-mentioned possible endogeneity problem. Urbanization rate is significantly and positively related to the public healthcare spending of city government. In addition, the education ratio carries the expected negative sign. There is no significant evidence of the effects of the two supply-side variables, *Hospitalbed_city* and *Doctor_city*, on the dependent variable. In relation to the two environment-related variables that are expected to affect the public healthcare expenditures, waste water emissions have no significant effect, whereas sulfur dioxide emissions are significantly related to the dependent variable but carry the unexpected negative sign.

Table 4 Regression results of public healthcare spending in Chinese cities, 2006.

	OLS model		Spatial mixed model	
	Unstd. coef.	Std. coef.	Unstd. coef.	Std. coef.
Intercept	−5.419 (4.66)		24.499^{***} (9.61)	
Fiscal variables				
Expense_county	0.178^{***} (0.06)	0.104	0.224^{***} (0.06)	0.131
Expense_province	−0.013 (0.01)	−0.063	-0.015^{**} (0.01)	−0.073
Education_city	−0.385 (0.30)	−0.034	-0.242^{**} (0.29)	−0.021
Supply-side variables				
Hospitalbed_city	2.950e-04 (0.00)	8.03e-05	0.249 (0.15)	0.068
Doctor_city	−0.278 (0.21)	−0.045	−0.473 (0.29)	−0.076
Economic/Demog. variables				
GDP_city	9.460^{***} (1.67)	3.6e+03	9.050^{***} (1.55)	3.9e+03
Urbanization_city	0.746^{***} (0.07)	0.505	0.725^{***} (0.07)	0.490
Environmental variables				
Waterwaste_city	-2.269^{*} (1.29)	−0.066	−1.511 (1.28)	−0.044
SO_2*_city*	-0.518^{***} (0.17)	−0.103	-0.548^{***} (0.16)	−0.109
Pollution_city	0.022^{***} (0.00)	0.197	0.024^{***} (0.00)	0.215
Mining_city	0.094 (0.13)	0.021	0.029 (0.12)	0.006
λ (spatial lag parameter)			-1.186^{***} (0.31)	−1.186
ϱ (spatial error parameter)			0.631^{***} (0.24)	0.631
R-squared	0.85			
N	245		245	
Jarque-Bera normality test	4.85 [0.0885]			
Diagnostics Test				
Moran's *I*	2.878 [0.004]			
LM-Error	2.147 [0.143]			
Robust LM-Error	10.655 [0.001]			
LM_Lag	4.275 [0.039]			
Robust LM_Lag	12.783 [0.000]			

Source: Author's calculations.

Note: "Unstd. (Std.) coef." refers to "Unstandardized (Standardized) coefficient". Standard errors are reported in parentheses. *p* values are reported in brackets. * $p < .1$. ** $p < .05$. *** $p < .01$.

5. Discussion and conclusion

This study performs two major tasks. First, a longitudinal dataset of 31 Chinese provinces covering 1994-2006 explores the impact of fiscal decentralization on healthcare resources whose outlays are mainly shouldered by local governments. During the period of interest, despite the ever-growing demand for healthcare resources, the supply of healthcare resources have lagged behind. Such a supply shortage partially explains the reason why seeing a doctor is so difficult in China. The results of the fixed effects model indicate that a higher degree of fiscal decentralization is associated with lower healthcare supply when other covariates are controlled for, hypothesis 1.

Next, to elucidate the mechanisms through which fiscal decentralization leads to lower public supply of healthcare resources, the determinants of city government's expenditure on healthcare resources are examined using a spatial econometric technique. The main finding is that city-level governments appear to interact as strategic substitutes in healthcare spending as a result of the fiscal decentralization, hypothesis 2. In particular, a city government appears to reduce its own spending as a response to the increase in healthcare expenditure of its neighboring cities. Such a result implies that in a decentralized health system where more public spending powers are returned to local governments, local healthcare provision is reduced because of the competitive effect and substitution effect.

The reasons for healthcare resource shortages are too complicated to be fully understood, but this paper sheds some light. Although the local government may better know the healthcare demands of the jurisdiction under its control and thus be able to better allocate the resources, this study indicates that fiscal decentralization is not good for stimulating the provision of less productive public goods such as healthcare services.

To better develop the advantages of fiscal decentralization and weaken its negative effects on healthcare provision, we suggest that, first, the local governments assign a fixed percentage of their fiscal budgets to renew healthcare resources, and the central government should effectively supervise the implementation of this policy. The percentage should be determined by both central and local governments, depending on local demand for healthcare services as well as other factors, such as local economy, population, age structure, and so on.

Second, in addition to the local government's expenditure on healthcare services, the central government should also allocate a fund for local healthcare resource supply that is only for compensating for local government shortages. Third, the official promotion system and performance evaluation system should be transformed. In addition to the economic growth rate, the evaluation criteria should also include the improvement of residents' welfare, happiness, and health condition, among other factors.

Notes

1 Under the direction of the Public Nutrition and Development Center of National Development and Reform Commission, By-HEALTH, a leader and benchmark enterprise in the Chinese dietary supplement market and the first in the Chinese healthcare industry to earn an AAA credit rating, and the Guangdong Society for Nutrition, the BY-HEALTH National Health Report was jointly issued in 2011. For more information on BY-HEALTH, please refer to http://www.by-health.com.cn/en/about.aspx and http://health.people.com.cn/mediafile/201112/14/P201112141332141781023641.pdf.

2 Existing literature uses other indexes to reflect pollution level. For instance, Karatzas (2000) uses per capita emissions of industrial waste gas, whereas Or (2002) uses per capita NO_x emissions as a proxy for pollution severity.

3 Another commonly used weight matrix specification is the contiguity-based binary matrix in which each element m_{ij} of the matrix W is set to one if cities i and j ($i \neq j$) share a common border, and zero otherwise (Anselin, 1988; Moscone, 2007; Baltagi, 2012).

4 The great-circle distance is the shortest distance between two points on the surface of a sphere measured along the surface of the sphere. http://en.wikipedia.org/wiki/ Great-circle_distance.

5. Detailed mathematical derivations of the LM test statistics can be found in Anselin (1988) and Anselin & Florax (1995).

6 The analysis of the spatial mixed model in this empirical study is performed using LeSage (1999) MATLAB spatial econometrics toolbox, which is available at http://www.spatial-econometrics.com.

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