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ORIGINAL PAPER

# A research on relations between governance modes and efficiency in China's urban bus transport service

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**Abstract** With a case of China's urban bus service, this paper combines the methods of data envelopment analysis with Tobit regression to analyze the efficiency differences between market-oriented mode and government-oriented mode. It shows that the mean of market-oriented mode efficiency is higher than the mean of government-oriented mode efficiency, but both of them are low. Furthermore, it shows governance mode actually affect efficiency. Specifically, the increasing market competition and enterprise scale indeed improve the efficiency. While enterprise scale has an "inverted U" shape relationship with the efficiency.

**Keywords** Urban bus service · Governance modes · Efficiency

**Mathematics Subject Classification** 90B30

## 1 Introduction

For the past three decades, a number of public bus transport systems have underwent significant changes on their organizational forms in China's municipalities (Our research objective does not include *Hong Kong*, *Macao* and *Taiwan*. It only

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involves in China's Mainland municipalities), and their governance modes have changed from government-oriented to market-oriented. The market reforms aim at curbing the decline of the sector, restoring economic efficiency and improving the quality of the service in a context of severe public budget constraints. But the reform failed. Many municipalities' bus systems are changing governance mode from market-oriented to government-oriented. For example, *Shiyan* municipality, located in Hubei province, regain its bus service operational right from private franchise in 2008 after citizens' daily lives were severely negatively affected by four strikes in the privatization period. After that in 2009, all the private capitals in *Chongqing* and *Shanghai* municipalities withdraw from the public bus transport market. Other municipalities in China, such as *Guangzhou*, *Changsha*, *Zhuhai* etc. also cleared out the private capitals and made their bus enterprises back to state-owned. These government decision-makers think that governance modes affect bus service performance, and the private capitals couldn't improve service quality and effectiveness. Liang et al. (2007) use a historical dimension to the discussion by describing governance modes in different periods: Before 1980, the form is government monopoly; after 1980, governments are inclined to choose deregulation form; then from 2000 to now, governments are apt to use the form of competitive bidding.

Indeed, the problems in the field of bus service need to be made a further empirical study. It needs to analyze the efficiency of the different governance modes. Our research questions thus can be: which governance mode of public bus transport service has a higher efficiency? Would governance mode really affect on efficiency? And how does governance mode affect on efficiency?

## 2 Literature review

The issue of the efficiency difference between the two modes has motivated a broad empirical study since last two decades and is still largely debated. There is indeed no clear consensus in the theoretical literature as to whether market-oriented mode outperforms government-oriented mode and the empirical literature also remains inconclusive (Megginson and Netter 2001). There are two different viewpoints about the debate. One of them argues that bus transport firms selected by means of market-oriented display higher efficiency than firms operating under government-oriented. Kerstens (1996) provides an early empirical investigation in the field, and he finds that the efficiency of private bus firms is better than public ones in France. More recently, applying the methods of data envelopment analysis (DEA), frontier function model, some other authors use data of France, Italian and other Europe countries to get the same result (Ottoz et al. 2009; Boitani et al. 2013). For instance, Roy and Yurande-Billon (2007) get that private operators outperform public ones in the French urban public transport system. Moreover, Bray and Wallis (2008) provide a positive outcome between the service quantity, quality and the impacts of competitive tendering in Adelaide bus service reform. Karlaftis and Tsamboulas (2012) use the data from 15 European transit systems for a 10 year time period (1990–2000) and find that transit systems regulated with either of market contracts

are more efficient than public systems. Sakai and Takahashi (2013) show that municipal bus operators have a particularly low fare-box ratio compared with their privately owned counterparts in Japan. And other literatures also get the results of competitive tendering are good and efficiency certainly improved (van de Velde et al. 2008; Nash and Wolanski 2010).

While on the other side, some authors believe bus transport firms selected by market-oriented mode do not display significant higher efficiency than firms under government-oriented mode. For instance, Pina and Torres (2001) compare the efficiency of public and private sectors in the provision of urban transportation services in Spain, and the results show that private management of urban transport service isn't more efficient than public management. Leland and Smirnova (2009) also get that private agencies are no longer more efficient or effective than public provider. As for the impact of tendering process, Yvrande-Billon (2006) thinks many studies, more particularly in Transaction Cost Economics, have highlighted prevented from achieving the designated objectives of increased efficiency. It provides theoretical arguments supported by empirical evidence explaining why the compulsory use of competitive tendering in France did not translate into better performance, the main reasons being the lack of transparence and the limited monitoring capabilities of local authorities. Hensher and Stanley (2008) suggest there are high transactions costs of re-tendering through competitive process. Properly structured transparent and performance-based negotiated arrangements can avoid this problem.

In China, there are some publications about the efficiency of urban public transport (Zheng and Wang 2006; Zhu and Zhao 2007). For example, Shen et al. (2008) use the DEA method to evaluate the efficiency of Nanjing city public transportation. Much attention has been paid to how to evaluate the efficiency. There are few studies that attempt to trace the effect of governance mode on efficiency.

To sum up above arguments, this paper focus on addressing two research contents: (1) Lots of literatures have researched the bus service efficiency difference between market-oriented mode and government-oriented mode, and they all conclude that the different governance modes can result in different efficiency, but the question of which governance mode can get a higher efficiency is still debated. In particular, there is little empirical study to identify in China's urban bus service. (2) The main research literatures use two types method, one is a non-parametric approach, such as DEA model, the other is a parametric approach, such as various kinds of production frontier models. However, the parametric approach has some disadvantages. For example, it needs an explicit function. The non-parametric approach, i.e. DEA method, can avoid the problem. While most of the literatures only use one step DEA method, which couldn't explain whether governance mode affects efficiency.

This paper aims at contributing to fill these gaps. With a panel data of China's urban bus service, we apply a two-step DEA model to analyze the efficiency between government-oriented mode and market-oriented mode, and clarify whether governance mode influences efficiency. The main research procedures are as follows. At the beginning, we use the DEA method to measure efficiency of two different governance modes. Subsequently, we apply the Tobit regression method to

investigate the relationship between governance mode and efficiency. Finally, it gets conclusions.

## 3 Theoretical analysis and research hypotheses

China's bus service governance modes swung between government-oriented and market-oriented like a pendulum. China maintained central planned economy before 1980, when public bus service mode was government-oriented. Local governments established state-owned enterprises to supply all the public service. The state-owned enterprises could get government subsidies. From 1980 to 2008, China's governments advocated implementation of market-based reform, which focused on market-driven mechanism. Many private firms were encouraged to supply public bus transport service. In order to balance the interest of multi-participants, governments implemented some regulatory policies to strictly control enterprises' service charges and franchise. The low ticket price made bus enterprises hard to get profit. Then many enterprises applied for adjustment the price. But governments often rejected their applications for citizen benefit's consideration. Under these conditions, bus enterprises were loss which led to a lower quality service. While after 2008, many municipalities were transiting the governance mode back from market-oriented to government-oriented. As mentioned above, government-oriented and market-oriented are two kinds of fundamental bus service governance modes in China. Table 1 presents a classification of governance modes in China's bus transport.

Government-oriented mode is that governments have ownership of bus transport firms. Governments have the legal monopoly of initiative in the sense that autonomous market entry is legally impossible and that all production or market entry is the result of a conscious one-sided to produce or request the production of services (van de Velde 1999). Governments are the providers of public service, and they can directly produce service. They often directly award the operational contract to public ownership companies. The aim of this governance mode is to protect the public interest. During the period of planned economy, bus transport enterprises are all entirely public ownership.

Market-oriented mode is that the bus service is based upon the principle of autonomous market mechanism resulting from a market process with government regulatory responsibility. This mode includes entirely privatization form and public–private partnerships form (PPP), which get franchise contracts by

**Table 1** Comparison with two kinds of governance modes

| | Government-oriented mode | Market-oriented mode |
|---|---|---|
| Theoretical basis | Economies of scale | Market competition |
| Goal | Public interest | Customer-orientation |
| Tool | Government control | Market leading |
| Organizational type | Entirely public ownership firm | All kinds of ownerships firms |
| Selecting operators | Non-tendering process | Competitive tendering process |

competitive tendering process. The entirely privatization means that the enterprises are entirely private. PPP form means private sectors participate with public sectors to develop, maintain and operate public bus transport service (Koppenjan and Enserink 2009). There are many kinds of PPP forms, such as franchise, leasing, joint-stock enterprise and so on. As discussed above, we aim at testing the following hypothesis:

**Hypothesis 1** Public bus transport service selected by market-oriented mode display higher efficiency than operating under government-oriented mode.

Therefore, we make the Hypothesis 1a: governance mode has a significant relationship with efficiency.

Furthermore, we make two dimensions to describe the public bus transport governance mode. One dimension is the market competition environment. There are only entirely public ownership firms in the government-oriented mode, and authorities give contracts to these firms by a non-tendering process. While in the market-oriented mode, there are all kinds of ownerships firms, which get contracts by a competitive tendering process. Those firms could compete with each other to supply the bus service. The other dimension is about the economies of scale. Specifically, the bus firms in the government-oriented mode are public owned. Most of them have large scale though absorbing other medium-sized and small private firms. They devote themselves to realize scale operations. While in the market-oriented mode, there are many firms to share the market so that the scale of firm is not large. These firms believe that small size could make them have the quick corresponsive ability for market change.

According to public choice theory, we know that market monopoly and overstaffing in public organizations make public service low efficiency (Boyne et al. 2003). The neoclassic economics indicates that market monopoly affects enterprise efficiency. Specifically, the competitive market has a positive effect on private enterprises performance. Under a market monopoly environment, the public enterprises have enough fiscal subsidies and haven't motivation to decrease their cost. While private enterprises have motivation to improve their efficiency, or they will be loss. When there is competition for the market, governments could select the most qualified candidates by competitive bidding. Which procedure could select the most qualified supplier is widely debated, at least since Williamson (1976). And recent analyses add further substance to the debate. In particular, Bajari et al. (2009) challenge the common view that competition has higher efficiency, showing that negotiations can indeed display better efficiency than auctions when the object of the contract is complex. Hensher and Stanley (2008) get a similar argument with respect to bus rout contracts. Moreover, they complain that the empirical evidence on the effects of competitive bidding is lacking in the local public transport industry (Boitani et al. 2013). We aim to enrich the literatures, and suggest a hypothesis that tests the influencing factor of public bus transport service efficiency, as follows:

**Hypothesis 2** The enlargement of market competition in public bus transport field improves efficiency.

The research on relations between organization scale and efficiency is a hot point. In the opinion of public choice theorists, the expansion of organization scale generates economies of scale in the initial stage, and then it will make difficult for organization coordination and control. When the organization scale arrives at a critical value, the enlargement of organization scale will erode efficiency. This is the law of descending marginal benefit. The bigger is an organization scale, the greater is the monopoly power. This kind of service will be low quality (Niskanen 1971). However, some other scholars think the efficiency of companies has prominent economies of scale. The advantage of sharing costs in big enterprises could increase efficiency (Chen et al. 2004). For public bus service, its marginal cost is decreasing. But there are few studies on the presence of economies of scale in public transport area (Scheffler et al. 2013). Currently, China's local governments have a preference for scale economy. Therefore, we state another hypothesis that tests the influencing factor of bus service efficiency, as follows:

**Hypothesis 3** The expanding scale of public bus transport firm improves efficiency.

## 4 Research methods and data

### 4.1 Data envelopment analysis (DEA)

The DEA technique is based on the construction of a piece linear production possibility function, known as the efficient frontier. And the original model is CCR (proposed by Charnes et al. 1978, and CCR is the abbreviation of their names), which is non-flexible in the sense that it assumes *Constant Returns to Scale (CRS)* in its production possibility set. The efficiency measure obtained in CRS DEA model is referred to *CRS technical efficiency* (CRSTE). Following the CCR model, Banker et al. (1984) put forward the hypothesis of *Variable Return to Scale (VRS)*, and they extend the CCR model to BCC model (BCC is the abbreviation of their names). The main distinction between the BCC and the CCR model is the introduction of a parameter that relaxes the CRS condition by not restricting hyper planes, defining the envelopment surface to go through the origin (Sánchez 2009). By calculating efficiency using the BCC model, it gets *pure technical efficiency from VRS DEA*, named *VRSTE*. The CRSTE, which is a *comprehensive technical efficiency*, is decomposed into VRSTE and *scale efficiency (SCALE)*. In other words, the nature of *CRS technical inefficiencies* can be due to the inefficient implementation of the production plan in converting inputs to outputs (*pure technical inefficiency*) and/or due to the divergence of the decision making units (DMUs) from the most productive scale size (*scale inefficiency*), and the decomposing CRSTE allows us to gain insight into the main sources of inefficiencies. The difference among the above three efficiency is shown in Table 2.

The DEA method is suitable for assessing comparative efficiency of DMUs. It is a methodology based upon linear programming and has been widely used for the assessment of both public and private organization, including the manufacturing and

**Table 2** The difference of three kinds of efficiency

| | CRSTE | VRSTE | SCALE |
|---|---|---|---|
| Concept | *Comprehensive technical efficiency* value. Technical efficiency from CRS DEA | *Pure technical efficiency* from VRS DEA | *Scale efficiency* |
| Efficient score | 1 | 1 | 1 |
| Inefficient score | <1 | <1 | <1 |
| Relationship | *SCALE = CRSTE/VRSTE* | | |

the services sectors. But there are few appliances in bus service field, especially in China. This method has some advantages. First, bus service efficiency is measured by multiple inputs and outputs. DEA is very suitable to be applied (Borger et al. 2002). Second, DMUs are not affected by any unit of inputs and outputs to measurement. Third, the weights of inputs and outputs in DMUs are elaborated by mathematical programming, there are unnecessary to set beforehand.

We suppose there are N DMUs that use X inputs to obtain Y outputs. Input and output quantities are represented by $X_j$ and $Y_j$, and comparative efficiency (CRSTE) score of DMU is $\theta$. $j$ refers to the $j$th DMU, and $j = 1, 2, \ldots, N$. The efficiency score $\theta$ satisfy the condition $\theta \leq 1$. If $\theta = 1$, it means the DMU is efficient. If $\theta < 1$, it means the DMU is inefficient.

### 4.2 Regression analysis model for relationship between governance mode and efficiency

At the first stage, we use the DEA model to calculate the *comparative technical efficiency* of bus service. At the second stage we estimate a regression analysis where the *comprehensive technical efficiency* is a dependent variable and the governance mode is independent variable. These regression works are done by the statistic software STATA 10.0. The efficiency scores $\theta$ from the DEA range from 0 to 1, there are usually several values at 1, but often none at or close to 0. The Tobit model can deal with this kind of censored data. And it is the most popular way to conduct such analysis.

### 4.3 Variables, selected public bus transport services and data

We select input and output indicators to calculate the efficiency with the DEA method. In fact, every scholar would have different input and output indicators to calculate, which make the forms of indicators be various (see Table 3). As to input indicators, many literatures select the capital, labor, fuel, operational cost and other variables as input indicators (Roy and Yurande-Billon 2007). As to output indicators, some authors argue that the demand-related indicators (e.g. passenger-km or number of passengers) can be used to measure, they argue these indicators are more relevant than pure supply indicators (e.g. vehicle-km or seat-km) because the

**Table 3** Literatures about the sample size, variables

| Author | Country | Sample size | Input | Output |
|---|---|---|---|---|
| Roy and Yurande-Billon (2007) | France | 135 companies; Panel data (yearly) 1995–2002 | Labor; Energy; Vehicles | Vehicle-km |
| Shen et al. (2008) | China, Nanjing city | Panel data (yearly) 2000–2006 | Number of buses; Length of bus lines | Total number of passengers; Urban road area ratio |
| Barnum et al. (2011) | United States | Panel data (yearly) 2002–2006 | Total operating expenses | Estimated seat-hours |
| Karlaftis and Tsamboulas (2012) | European | Panel data (yearly) 1990–2000 | Employees, vehicles, fuel | Annual vehicle-miles |
| Sakai and Takahashi (2013) | Japan | Panel data (yearly) 2002–2009 | Price of labor, price of capital, price of materials | Vehicle-km |
| Holmgren (2013) | Swedish | Panel data (yearly) 1986–2009 | The wages of bus drivers, the price of diesel fuel, the cost of capital | The number of trips |

demand-related indicators take into account the economic motive for providing services (Berechman 1993; Roy and Yurande-Billon 2007). Ignoring demand may lead to consider that the most efficient operators are those whose buses are empty.

There are many other arguments about the selection of input and output indicators, and we select two inputs and one output (see Table 4). The inputs are *the number of buses* and *the length of bus lines*. These variables could represent the inputs of public transport. The output indicator is *the total number of passengers transported*. That is a demand-related indicator. After the efficiency calculation, we apply the Tobit model to analyze the regression.

First, we enter a dummy variable, *governance mode*, which assumes value 1 if it is the government-oriented, and assumes value 0 if it is the market-oriented. We expect to discover whether governance mode really impact on the public bus service efficiency.

Then, we use *the number of public bus transport firms in a city* to represent the market competition. If there is only one public bus transport firm in a city, it is entirely monopoly. The enterprise scale indicator often uses mean of enterprise scale in a city (Nie et al. 2008). We divide the number of buses by the number of enterprises and get a *mean of enterprise scale*. We can see that enterprise monopoly and scale are about the firm and market characteristics in a city. In addition, we consider about some control variables, such as *urban population density*, *per capita urban road area ratio* and *the ratio of passenger numbers to urban population. Urban population density* stands for the city characteristics. *Per capita urban road area ratio* stands for the urban traffic conditions, and the *ratio of passenger numbers to urban population* stands for urban resident' habit of the transportation. We expect to discover whether city characteristics, urban traffic conditions and urban resident' habit of the transportation impact on the efficiency.

**Table 4** Descriptive statistics of variables (2007–2011)

| | Number of observation values | Min | Max | Mean | Standard deviation |
|---|---|---|---|---|---|
| Total number of passengers (Output) | 145 | 11,081 | 516,517 | 108,123.68 | 91,996.12 |
| Number of buses (Input) | 145 | 992 | 21,716 | 5,465.45 | 4,381.56 |
| Length of bus lines (Input) | 145 | 306 | 23,131 | 3,944.08 | 5,512.04 |
| Governance mode | 145 | 0 | 1 | 0.4689655 | 0.5007657 |
| Number of bus firms (log) | 145 | 0 | 3.7612 | 0.9406626 | 0.9879881 |
| Mean of enterprise scale (log) | 145 | 6.899723 | 9.985805 | 8.366785 | 0.6738833 |
| Urban population density (Control variable) | 145 | 223.31 | 11,449.3 | 1,727.654 | 1,488.087 |
| Per capita urban road area ratio (Control variable) | 145 | 4.08 | 21.36 | 10.97876 | 3.821038 |
| Ratio of passenger numbers to urban population (Control variable) | 145 | 96.17567 | 523.6699 | 257.2906 | 87.11208 |

We select 29 China's municipalities as our sample, which are 25 China's capital municipalities and 4 municipalities directly under the central government. We know that there are 31 capital municipalities and municipalities directly under the central government in China's mainland. However, the two capital municipalities, *Lhasa* and *Haikou*, do not have enough data. We have to exclude them. So there are 29 municipalities in our research. In our samples, there are not only large municipalities, but also medium-sized. The inhabitants in these municipalities range between 2 and 13 million.

All of our data come from official publications from 2008 to 2012. They are China's City Construction Statistical Yearbook, China's City Statistical Yearbook, and City Statistical Web Site. All these yearbooks are published and these web sites are supervised by National Bureau of Statistics of China. We select the data from 2007 to 2011. China promulgated the "*Municipal Utilities Franchise Management Approach*" law to support the franchise form in 2004, then many municipalities used this competitive tendering process to operate their public bus transport service, but after the reform in 2008, some municipalities' governments changed their governance mode of public bus transport service. So the panel data in our research could display the efficiency change after the reform. And the panel data are a total of 145 observations (29 municipalities $\times$ 5 years). The summary statistics of variables are shown in Table 4.

## 5 Empirical results

### 5.1 The efficiency analysis of public bus transport service modes

On the websites of governments and bus transport firms, we could find out bus service governance modes. In the 29 municipalities, there are 14 municipalities

adopt government-oriented mode before 2008. Their organizational type is state-owned companies, and their operational contracts are directly awarding without tendering. They are *Beijing*(*Bei J*), *Tianjin (Tian J), Shijiazhuang (Shi JZ), Taiyuan (Tai Y), Huhehaote(Hu HHT), Changchun (Chang C), Hangzhou (Hang Z), Nanchang (Nan C), Jinan (Ji N), Wuhan (Wu H), Guiyang (Gui Y), Lanzhou (Lan Z), Xining (Xi N)* and *Yinchuan*(*Yin C)* municipalities. Other 15 municipalities use market-oriented mode before 2008, their organizational types include state-owned enterprise, joint-stock companies and private companies which are public ownership, mix ownership and private ownership respectively. And in market-oriented mode, the franchise process is competitive tendering. These 15 municipalities are *Shenyang (Shen Y), Harbin (Ha RB), Shanghai (Shang H), Nanjing (Nan J), Hefei (He F), Fuzhou (Fu Z), Zhengzhou (Zheng Z), Changsha (Chang S), Guangzhou (Guang Z), Nanning (Nan N), Chongqing (Chong Q), Chengdu (Cheng D), Kunming (Kun M), Xian (Xi A) and Wulumuqi (WL MQ)*. After 2008, two cities changed their governance mode from market-oriented to government-oriented (*Shanghai* and *Chongqing*). And after 2010, *Wulumuqi* city also had the same change. The comparative efficiency scores are estimated using the DEAP 2.1 software. The estimation results are presented in Table 5 below.

In the Table 5, we clearly know that the biggest CRSTE scores are 1 during the period from 2007 to 2011. The smallest CRSTE score is 0.345 (*Yin C* in 2007), the mean of CRSTE scores are 0.629 in 2007, 0.637 in 2008, 0.630 in 2009, 0.738 in 2010, and 0.726 in 2011. On the one hand, the results show that these urban bus services differ greatly in their efficiency scores, and the mean of CRSTE scores are all not high in different years. On the other hand, after the reform in 2008, the efficiency was increased.

In 2011, it presents that only four municipalities, which are *Chang S*, *Xi A*, *Gui Y* and *Lan Z*, have efficient scores. They only occupy 13.8 % of overall municipalities. Their CRSTE, VRSTE and SCALE scores are 1. These 4 municipalities are named as the efficient frontier. The other 25 municipalities' CRSTE score is <1. They are inefficient. These cities occupy overall 86.2 %. Furthermore, we divide the 25 municipalities into two groups in terms of their different efficiency scores. One group includes *Bei J, Hu HHT, Xi N, Yin C* and *WL MQ*. Their VRSTE scores are 1, but their CRSTE and SCALE scores are less than 1, which mean that the reason of their inefficiency lies in the inefficient scale. From the Table 2, we know that CRSTE = SCALE × VRSTE, so it is the scale inefficiency. These results indicate that their outputs have got the biggest under certain inputs in these five cities (converting inputs to outputs), but they still have not realized large-scale operation (the most productive scale size). The second group includes other 20 municipalities. Both of their VRSTE and SCALE scores are all <1. They are all inefficient both on VRSTE and SCALE. It indicates these municipalities should increase their outputs in certain inputs on one hand and try to achieve economies of scale on the other hand.

Meanwhile, the return to scale (RTS) results told us that the municipalities of *Bei J*, *Shang H*, *Shen Y*, *Ha RB* and other nine municipalities belongs to DRS, which means their proportional growth of outputs maybe smaller than inputs increasing proportion. And other 12 municipalities are all IRS. In the same way, we can

**Table 5** Public bus transport service efficiency scores (2007–2011)

| DMUs | Governance mode | 2011 | | | |
|---|---|---|---|---|---|
| | | CRSTE | VRSTE | SCALE | |
| 1. Shen Y | Market-oriented | 0.793 | 0.830 | 0.956 | DRS |
| 2. Ha RB | | 0.724 | 0.752 | 0.963 | DRS |
| 3. Nan J | | 0.558 | 0.590 | 0.945 | DRS |
| 4. He F | | 0.663 | 0.666 | 0.995 | IRS |
| 5. Fu Z | | 0.729 | 0.846 | 0.862 | IRS |
| 6. Zheng Z | | 0.599 | 0.614 | 0.976 | DRS |
| 7. Chang S | | 1 | 1 | 1 | – |
| 8. Guang Z | | 0.740 | 0.876 | 0.845 | DRS |
| 9. Nan N | | 0.770 | 0.793 | 0.970 | IRS |
| 10. Cheng D | | 0.611 | 0.671 | 0.910 | DRS |
| 11. Kun M | | 0.646 | 0.670 | 0.964 | DRS |
| 12. Xi A | | 1 | 1 | 1 | – |
| 13. Bei J | Government-oriented | 0.800 | 1 | 0.800 | DRS |
| 14. Tian J | | 0.582 | 0.616 | 0.945 | DRS |
| 15. Shi JZ | | 0.578 | 0.601 | 0.962 | IRS |
| 16. Tai Y | | 0.826 | 0.836 | 0.988 | IRS |
| 17. Hu HHT | | 0.774 | 1 | 0.774 | IRS |
| 18. Shang H | | 0.583 | 0.697 | 0.836 | DRS |
| 19. Chang C | | 0.517 | 0.522 | 0.989 | IRS |
| 20. Hang Z | | 0.575 | 0.605 | 0.951 | DRS |
| 21. Nan C | | 0.654 | 0.670 | 0.976 | IRS |
| 22. Ji N | | 0.657 | 0.660 | 0.996 | IRS |
| 23. Wu H | | 0.691 | 0.760 | 0.909 | DRS |
| 24. Chong Q | | 0.769 | 0.865 | 0.889 | DRS |
| 25. Gui Y | | 1 | 1 | 1 | – |
| 26. Lan Z | | 1 | 1 | 1 | – |
| 27. Xi N | | 0.803 | 1 | 0.803 | IRS |
| 28. Yin C | | 0.498 | 1 | 0.498 | IRS |
| 29. WL MQ | | 0.926 | 1 | 0.926 | IRS |
| Mean | | 0.726 | 0.798 | 0.918 | |

**Table 5** continued

| DMUs | Governance mode | 2010 | | | | 2009 | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | CRSTE | VRSTE | SCALE | | CRSTE | VRSTE | SCALE | |
| 1. Shen Y | Market-oriented | 0.836 | 0.876 | 0.954 | DRS | 0.652 | 0.655 | 0.955 | IRS |
| 2. Ha RB | | 0.736 | 0.755 | 0.976 | DRS | 0.612 | 0.619 | 0.989 | IRS |
| 3. Nan J | | 0.585 | 0.594 | 0.984 | DRS | 0.488 | 0.494 | 0.986 | IRS |
| 4. He F | | 0.767 | 0.767 | 1 | IRS | 0.639 | 0.707 | 0.904 | IRS |
| 5. Fu Z | | 0.772 | 0.930 | 0.830 | IRS | 0.678 | 0.808 | 0.838 | IRS |
| 6. Zheng Z | | 0.736 | 0.796 | 0.924 | IRS | 0.505 | 0.536 | 0.941 | IRS |
| 7. Chang S | | 1 | 1 | 1 | – | 1 | 1 | 1 | – |
| 8. Guang Z | | 0.759 | 0.886 | 0.857 | DRS | 0.645 | 0.841 | 0.768 | DRS |
| 9. Nan N | | 0.854 | 0.854 | 1 | IRS | 0.636 | 0.684 | 0.930 | IRS |
| 10. Cheng D | | 0.599 | 0.623 | 0.962 | DRS | 0.453 | 0.454 | 0.997 | IRS |
| 11. Kun M | | 0.584 | 0.587 | 0.994 | DRS | 0.479 | 0.493 | 0.973 | IRS |
| 12. Xi A | | 1 | 1 | 1 | – | 1 | 1 | 1 | – |
| 13. WL MQ | | 0.878 | 1 | 0.878 | IRS | 0.792 | 0.830 | 0.954 | IRS |
| 14. Bei J | Government-oriented | 0.818 | 1 | 0.818 | DRS | 0.679 | 1 | 0.679 | DRS |
| 15. Tian J | | 0.479 | 0.491 | 0.976 | DRS | 0.421 | 0.423 | 0.995 | IRS |
| 16. Shi JZ | | 0.591 | 0.622 | 0.949 | IRS | 0.445 | 0.607 | 0.732 | IRS |
| 17. Tai Y | | 0.696 | 0.730 | 0.954 | IRS | 0.516 | 0.795 | 0.649 | IRS |
| 18. Hu HHT | | 0.973 | 1 | 0.973 | IRS | 0.662 | 0.904 | 0.773 | IRS |
| 19. Shang H | | 0.562 | 0.662 | 0.849 | DRS | 0.475 | 0.634 | 0.748 | DRS |
| 20. Chang C | | 0.592 | 0.596 | 0.993 | IRS | 0.503 | 0.537 | 0.938 | IRS |
| 21. Hang Z | | 0.614 | 0.652 | 0.942 | DRS | 0.399 | 0.402 | 0.993 | IRS |
| 22. Nan C | | 0.756 | 0.766 | 0.987 | IRS | 0.576 | 0.647 | 0.890 | IRS |
| 23. Ji N | | 0.602 | 0.605 | 0.996 | DRS | 0.525 | 0.545 | 0.963 | IRS |
| 24. Wu H | | 0.859 | 0.926 | 0.928 | DRS | 0.884 | 0.982 | 0.901 | DRS |
| 25. Chong Q | | 0.749 | 0.829 | 0.903 | DRS | 0.530 | 0.587 | 0.904 | DRS |
| 26. Gui Y | | 0.839 | 0.989 | 0.848 | IRS | 0.971 | 1 | 0.971 | IRS |
| 27. Lan Z | | 1 | 1 | 1 | – | 0.793 | 0.855 | 0.928 | IRS |
| 28. Xi N | | 0.701 | 0.812 | 0.863 | IRS | 0.920 | 1 | 0.920 | IRS |
| 29. Yin C | | 0.455 | 1 | 0.455 | IRS | 0.376 | 1 | 0.376 | IRS |
| Mean | | 0.738 | 0.805 | 0.924 | | 0.630 | 0.725 | 0.883 | |

**Table 5** continued

| DMUs | Governance mode | 2008 | | | | 2007 | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | CRSTE | VRSTE | SCALE | | CRSTE | VRSTE | SCALE | |
| 1. Shen Y | Market-oriented | 0.630 | 0.673 | 0.936 | DRS | 0.620 | 0.843 | 0.736 | DRS |
| 2. Ha RB | | 0.643 | 0.672 | 0.957 | DRS | 0.750 | 0.854 | 0.879 | DRS |
| 3. Shang H | | 0.473 | 0.647 | 0.731 | DRS | 0.483 | 1 | 0.483 | DRS |
| 4. Nan J | | 0.574 | 0.617 | 0.929 | DRS | 0.543 | 0.656 | 0.828 | DRS |
| 5. He F | | 0.689 | 0.690 | 0.999 | DRS | 0.715 | 0.716 | 0.998 | IRS |
| 6. Fu Z | | 0.603 | 0.677 | 0.891 | IRS | 0.666 | 0.853 | 0.781 | IRS |
| 7. Zheng Z | | 0.503 | 0.513 | 0.981 | DRS | 0.566 | 0.599 | 0.944 | DRS |
| 8. Chang S | | 0.957 | 1 | 0.957 | DRS | 0.667 | 0.767 | 0.869 | DRS |
| 9. Guang Z | | 0.750 | 1 | 0.750 | DRS | 0.781 | 1 | 0.781 | DRS |
| 10. Nan N | | 0.614 | 0.642 | 0.956 | IRS | 0.631 | 0.673 | 0.937 | IRS |
| 11. Chong Q | | 0.528 | 0.739 | 0.714 | DRS | 0.538 | 0.777 | 0.692 | DRS |
| 12. Cheng D | | 0.468 | 0.494 | 0.946 | DRS | 0.592 | 0.768 | 0.771 | DRS |
| 13. Kun M | | 0.675 | 0.688 | 0.98 | DRS | 0.433 | 0.469 | 0.924 | DRS |
| 14. Xi A | | 1 | 1 | 1 | – | 0.867 | 1 | 0.867 | DRS |
| 15. WL MQ | | 0.960 | 0.990 | 0.970 | IRS | 0.715 | 0.920 | 0.777 | IRS |
| 16. Bei J | Government-oriented | 0.645 | 1 | 0.645 | DRS | 0.672 | 1 | 0.672 | DRS |
| 17. Tian J | | 0.419 | 0.450 | 0.931 | DRS | 0.422 | 0.493 | 0.856 | DRS |
| 18. Shi JZ | | 0.422 | 0.580 | 0.727 | IRS | 0.508 | 0.668 | 0.760 | IRS |
| 19. Tai Y | | 0.556 | 0.724 | 0.768 | IRS | 0.548 | 0.712 | 0.770 | IRS |
| 20. Hu HHT | | 0.502 | 0.825 | 0.609 | IRS | 0.54 | 0.884 | 0.611 | IRS |
| 21. Chang C | | 0.489 | 0.496 | 0.985 | DRS | 0.439 | 0.461 | 0.952 | IRS |
| 22. Hang Z | | 0.478 | 0.518 | 0.924 | DRS | 0.555 | 0.733 | 0.757 | DRS |
| 23. Nan C | | 0.612 | 0.647 | 0.946 | IRS | 0.644 | 0.670 | 0.961 | IRS |
| 24. Ji N | | 0.514 | 0.525 | 0.987 | DRS | 0.525 | 0.587 | 0.894 | DRS |
| 25. Wu H | | 0.800 | 0.895 | 0.894 | DRS | 0.806 | 1 | 0.806 | DRS |
| 26. Gui Y | | 0.776 | 0.801 | 0.968 | IRS | 1 | 1 | 1 | – |
| 27. Lan Z | | 0.755 | 0.785 | 0.962 | IRS | 0.691 | 0.747 | 0.925 | IRS |
| 28. Xi N | | 1 | 1 | 1 | – | 1 | 1 | 1 | – |
| 29. Yin C | | 0.431 | 1 | 0.431 | IRS | 0.345 | 1 | 0.345 | IRS |

**Table 5** continued

| DMUs | Governance mode | 2008 | | | 2007 | | |
|---|---|---|---|---|---|---|---|
| | | CRSTE | VRSTE | SCALE | CRSTE | VRSTE | SCALE |
| Mean | | 0.637 | 0.734 | 0.878 | 0.629 | 0.783 | 0.818 |

DRS is scale inefficient, it is decreasing return to scale. IRS is scale inefficient, it is increasing return to scale

**Table 6** Efficiency comparison between different governance modes (2007–2011)

| | Mean of CRSTE | Mean of VRSTE | Mean of SCALE |
|---|---|---|---|
| Market-oriented mode | 0.693 | 0.768 | 0.911 |
| Government-oriented mode | 0.653 | 0.774 | 0.859 |

analyze the results in 2010, in 2009 and other years, and can get similar results. In these cases, we know that the three cities- *Shang H*, *Chong Q* and *WL MQ* transferred from market-oriented to government-oriented mode. Although their efficiency improved gradually, they still are inefficient.

At last, Table 6 presents the CRSTE mean scores of the two kinds of governance modes in the 5 years are 0.693 and 0.653 respectively. The mean score of market-oriented mode is higher, but their mean of CRSTE, mean of VRSTE and mean of SCALE scores are all low. So, both of the two kinds of governance modes need to improve efficiency.

As expected, market-oriented mode has a higher average efficiency than government-oriented mode, and the above results provide empirical support to our research Hypothesis 1. So our first conclusion is as follows:

Conclusion 1 The bus service average efficiency of market-oriented mode is higher than government-oriented mode. But both of them are low.

## 5.2 Regression analysis for governance mode influencing efficiency

The relationship between market competition and efficiency may be not a simple linear, so does the relationship between enterprise scale and efficiency. We make quadratic forms of market competition and enterprise scale as independent variables. The nonlinear relationship analysis helps to better understand the relationship between governance mode and efficiency. A concrete relationship between the *comprehensive technical efficiency* and *governance mode* for a panel of data is written as:

$$EFF = \beta_0 + \beta_1 GM + \beta_2 COM + \beta_3 COM \times COM + \beta_4 SCA + \beta_5 SCA \times SCA + \sum \beta_m x_m + \varepsilon$$

Where EFF stands for the CRSTE scores. GM stands for *governance mode*. COM and COM × COM stand for the linear and quadratic forms of market competition respectively. SCA and SCA × SCA stand for the linear and quadratic forms of enterprise scale respectively. $x_m$ stands for the potential exogenous factors, which include *urban population density*, *per capita urban road area ratio* and *ratio of passenger numbers to urban population*. $\beta$ is the set of parameters to be estimated and $\varepsilon$ is the error term. The Tobit regressions are estimated using the STATA10 software. The panel data regression results are presented in Table 7 below. In model 1, the dependent variables are GM, COM, COM × COM, SCA and SCA × SCA. In model 2, we add the control variable of *urban population density*. In model 3, we

**Table 7** Estimation results for the Tobit regression (2007–2011)

| independent variables | Dependent variable (EFF) | | | | |
|---|---|---|---|---|---|
| | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 |
| Constant | −4.887904** (2.74785) | −4.901467** (2.756628) | −4.438918 (2.793071) | −4.710964** (2.123625) | −5.089478* (2.119662) |
| GM | −0.1036389** (0.0482407) | −0.1036505** (0.0482395) | −0.1015005** (.0482012) | −0.143068*** (0.0408184) | −0.1437704*** (0.0406136) |
| COM(log) | 0.1175318** (0.0664156) | 0.1170782** (0.0668354) | 0.1163945* (0.0675174) | 0.1260055** (0.0525298) | 0.1262846* (0.0518617) |
| COM × COM(log) | −0.0167034 (0.0205161) | −0.0165973 (0.0205879) | −0.0157626 (0.0208313) | −0.0155677 (0.0164064) | −0.0164529 (0.0161218) |
| SCA(log) | 1.357653** (0.6571098) | 1.360958** (0.6592822) | 1.237635* (0.6749435) | 1.291912** (0.5077476) | 1.388557** (0.5081542) |
| SCA × SCA(log) | −0.0827585** (0.0391262) | −0.0829396** (0.0392334) | −0.0757206* (0.0402243) | −0.08164** (0.0302407) | −0.0872679** (0.0302103) |
| Urban population density | | −6.37e-07 (0.0000107) | | | −7.64e-08 (0.00000888) |
| Per capita urban road area ratio | | | 0.0052509 (0.0050071) | | 0.0034658 (0.0040468) |
| Ratio of passenger numbers to urban population | | | | 0.0011765*** (0.0001508) | 0.0012618*** (0.0001536) |
| Sigma_u | 0.1361443*** (0.0201226) | 0.1360747*** (0.0201473) | 0.1430697*** (0.0220704) | 0.0980127*** (0.0150242) | 0.0925036*** (0.0155478) |
| Sigma_e | 0.0914881*** (0.0060525) | 0.0914973*** (0.0060556) | 0.0900425*** (0.0060411) | 0.0798866*** (0.0052809) | 0.0806326*** (0.0054348) |

Standardize "beta" coefficients are reported. Standard errors are in parentheses. * Significant at 10 %; ** significant at 5 %; *** significant at 1 %

replace the *urban population density* variable by *per capita urban road area ratio*. In model 4, we replace it by *ratio of passenger numbers to urban population*. And in model 5, we add the three control variables together.

From the results of model 1 and model 5, we clearly know four points. Firstly, it shows that the relationship between governance mode and efficiency is negatively significant. It means market-oriented governance mode has a higher efficiency than government-oriented mode. Secondly, the linear form of market competition has a positive correlation with efficiency. And it is significant. While the quadratic form of market competition is insignificant. This result shows that competition could improve efficiency. In addition, both the linear and quadratic forms of enterprise scale are significant. Meanwhile, the coefficient of the linear form is positively correlated with the efficiency, and the coefficient of the quadratic form is negative which indicates the relationship between efficiency and enterprise scale is an "inverted U" shape. This shows that the enlargement of enterprise scale could improve efficiency. But after the efficiency reaches a maximum, the enlargement of scale could reduce efficiency.

In the model 2, we add a control variable for the city characteristics, which is *urban population density*. Although it has negative effect to efficiency, it is not significant. In the model 3, we replace the *urban population density* variable by *per capita urban road area ratio* variable, it can be seen that *per capita urban road area ratio* does not affect efficiency. In the model 4, we use the *ratio of passenger numbers to urban population* as the control variable. It shows that it affects efficiency significantly. And it means more passengers taking public transport make the efficiency higher. Then, we add the three control variable in model 5 and find that the result is the same with the model 2, model 3 and model 4. These means the city characteristics and urban traffic conditions do not have a significant relationship with efficiency. But the urban resident' habit of taking public transportation affects efficiency.

So we can get some conclusions as follows:

Conclusion 1a Governance mode can affect efficiency significantly.

Conclusion 2 The enlargement of market competition in bus transport field can positively affect efficiency.

Conclusion 3 The expanding enterprise scale of bus service can significantly affect efficiency. But the relationship between efficiency and enterprise scale is an "inverted U" shape.

## 6 Conclusion

In this paper we use the DEA method to investigate two governance modes of public bus transport service in China's main municipalities, namely government-oriented mode and market-oriented mode, and apply the Tobit regression method to discuss the relation between efficiency and governance mode. It has addressed the questions of which governance mode has a higher efficiency, and whether governance mode

affects their efficiency. Much case study research has indicated that the answers are on debate, and there is little large data research on these questions in China. Based on a review of the available literature, we provide a new insight into the public bus transport service mode, which has two dimensions (market competition environment and economies of scale). We test three hypotheses through China's case and get several interesting results, some of which differ from previous research. These results can be summarized as follows.

First of all, most of firms selected through market-oriented mode present higher levels of efficiency, but means of efficiency of the above two modes are both low. It is also discovered that some municipalities' efficiency in market-oriented mode are lower than some municipalities in government-oriented. The regulatory capacity and the degree of expertise of authority may be the important reasons (Amaral et al. 2009; Nash and Wolanski 2010). Furthermore, we test the relationship between governance mode and efficiency, and show that governance mode affects efficiency significantly.

Second, we realize that market competition affects the efficiency. The increase of competition degree improves the efficiency significantly. The entirely privatization and the free market have a higher efficiency. Thus, the competitive tendering may be an effective way to improve efficiency in China. Unfortunately, none of China's regulations strongly demand policy makers to employ the competitive tendering strategy by now. One of reasons may that many Chinese local governments have not the capacity to ensure competition and information flow in the market (Jing and Chen 2012). And they have not sufficient preparation for it. In addition, we find that enterprise scale affects the efficiency. But it has an "inverted U" shape relationship with the efficiency. Those indicate the scale has a maximum value. Or it would have the risk of monopoly. At last, we find that city characteristics do not affect efficiency significantly. This finding supports the conclusion by Boitani et al. (2013) that city characteristics do not affect the level of efficiency. Based on these results, we find that urban traffic conditions do not have a significant relationship with efficiency, while the urban resident' habit of taking public transportation affects efficiency.

However, these conclusions must be considered with care for a number of reasons. This study has focused on China's public bus transport service and the research samples are 29 municipalities from 2007 to 2011. Maybe different municipality scale and the number of municipality have different results. And our research results only present the relationship between efficiency and governance mode. We should be aware that efficiency is not the sole objective of policy makers. In particular, we should also research service effectiveness and public satisfaction that are probably relevant and respectable goals of governments. These are matters for further research.

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