Economics

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--Manuscript Draft--

Manuscript Number:	ECONJOURNAL-D-24-00171
Full Title:	Can government expenditure impove the efficiency of institutional elderly-care service?-- Take Wuhan as an Example
Article Type:	Research Article
Keywords:	government expenditure; institutional elderly-care service; integrated technical efficiency; pure technical efficiency; scale efficiency
Manuscript Region of Origin:	CHINA
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Manuscript Classifications:	9.2.5: Health and Inequality; 9.2.6: Health and Economic Development; 9.2.8: Other

Can government expenditure impove the efficiency of institutional elderly-care service?*

-- Take Wuhan as an Example

Zhang Rui Zhang Huarong

School of Finance and Public Administration, Guangxi University of Finance and Economics

Guangxi Nanning 530007

Abstract: Whether government expenditure in elderly-care institutions can improve the efficiency of care in elderly-care institutions is not only related to the realisation of "Care for the Elderly", but also one of the concerns of policy makers and implementers. Based on a sample of 50 elderly-care institutions in Wuhan, this essay explores the impact of government expenditure on the efficiency of care in elderly-care institutions using the DEA-Tobit two-stage model. The research finds that government direct investment has no significant effect on the efficiency of care in elderly-care institutions, while fiscal subsidies can effectively improve it. Under the condition of controlling other variables, for every 10,000 yuan increase in fiscal subsidies, the value of comprehensive technical efficiency and pure technical efficiency of elderly-care institutions increase by 0.244 and 0.181 respectively. Therefore, in order to improve the efficiency of care in elderly-care institutions, fiscal subsidies should be chosen more often to purchase care in elderly-care institutions, and through it to guide the social forces to enter the field of nursing services, and to focus on its positive role in improving the efficiency of care in elderly-care institutions.

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Fund projects: Research on the Coordination Mechanism of Atypical Labour Relations in New Businesses (2020XSH011), a project of the National Social Science Fund of China.

Author Resume: Zhang Rui (1973-), Male, Han, Suizhou, Hubei, Associate Professor, Doctor, Research Direction: Labour Relations and Pension Security; Corresponding Author Zhang Huarong (1979-), Female, Han, Suizhou, Hubei, Associate Professor, Doctor, Research Direction: Income Distribution and Social Security.

Contact information: Address: Room 322, College Building, 189 West University Road, Xixiangtang District, Nanning, Guangxi;

Zip Code: 530007;

Mobile phone number: 13476117216;

Email:593404064@qq.com

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* This essay is a phase result of the project of the National Social Science Fund of China 'Research on the Coordination Mechanism of Atypical Labour Relations' (Project No. 2020XSH011).

1 Introduction

At the end of 2023, the national population aged 60 years or older will reach 297 million, accounting for 21.1% of the total; the population aged 65 years or older will reach 217 million, accounting for 15.4% of the total.[①]This means that China has entered a deeply ageing society, which puts higher demands on the supply side of institutional elderly care services.At the end of 2023, there will be 41,000 elderly care institutions nationwide, with 8.201 million beds for elderly care services, and only 27.6 beds for every 1,000 elderly people.[②]Institutionalised elderly services are characterised as quasi-public goods. The government is the public service arranger or provider and can arrange who produces public services, what services are produced, and how oversight of the services is achieved (E. S. Savas, 2002).[③]Since 2006, China has put forward the idea of actively supporting the development of the elderly services industry in a variety of ways, such as public-private construction, privately running under state ownership, government subsidies and the purchase of services[④], as well as guiding and supporting social forces in the development of various kinds of elderly service facilities.[⑤]Since then, the construction of elderly care facilities across China has been diversified into contracting, joint ventures, leasing, etc. In 2013, the State Council called for the launch of a pilot restructuring of publicly-run elderly care facilities, and government-invested elderly care beds have gradually been transformed into privately-run facilities.[⑥]The way and content of government purchasing in institutionalised elderly care services are further clarified in this document (Kang Rui and Lv Xuejing,2016).[⑦]In April 2019, the Opinions on Promoting the Development of Elderly Services, issued by the General Office of the State Council, proposes to give full play to the role of public elderly care institutions and public-private elderly care institutions in underwriting and guaranteeing elderly care, reduce the burden of elderly care taxes and fees, include elderly care in the guiding catalogue of services purchased by the government, and

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① National Bureau of Statistics website . Statistical Bulletin of the National Economic and Social Development of the People's Republic of China for 2023. [EB/OL].(2024-02-29)[2024-04-29] https://www.stats.gov.cn/sj/zxfb/202402/t20240228_1947915.html.

② National Bureau of Statistics website . Statistical Bulletin of the National Economic and Social Development of the People's Republic of China for 2023. [EB/OL].(2024-02-29)[2024-04-29] https://www.stats.gov.cn/sj/zxfb/202402/t20240228_1947915.html.

③ E S Savas.Privatisation and Corporate Sector Partnerships [M]. Beijing: Renmin University of China Press. 2002: 19-23.

④ Central Government Portal . Circular of the General Office of the State Council Transmitting the Opinions of the Office of the National Committee on the Elderly and the Development and Reform Commission on Accelerating the Development of the Elderly Service Industry (Guo Ban Fa [2006] No. 6)[EB/OL].(2008-03-28)http://www.gov.cn/zhuanti/2015-06/13/content_2879022.htm.

⑤ Central Government Portal . Circular of the General Office of the State Council on the Issuance of the Plan for the Construction of a Social Service System for the Elderly (2011-2015) (Guo Ban Fa [2011] No. 60)[EB/OL].(2011-12-27) http://www.gov.cn/zwgk/2011-12/27/content_2030503.htm.

⑥ Central Government Portal. Several Opinions of the State Council on Accelerating the Development of the Elderly Service Industry (Guo Fa [2013] No. 35) [EB/OL]. (2013-09-13) http://www.gov.cn/zwgk/2013-09/13/content_2487704.htm.

⑦ Kang Rui, Lv Xuejing. Research on public-private construction of institutional elderly-care service under the perspective of government purchase services[J]. Social Sciences in Guangxi, 2016(2):130-134.

enhance the level of precision in government investment.[①]The Outline of the Fourteenth Five-Year Plan for the National Economic and Social Development of the People's Republic of China and the Vision for 2035, issued in March 2021, calls for the improvement of the elderly care system, the improvement of the management mechanism for public-private construction of private institutions, and the enhancement of policy support for private care institutions for the elderly.[②]In practice, governments at all levels have made substantial investments in government purchases of institutional care services. So, has government expenditure for the elderly (hereinafter referred to as government expenditure) achieved the policy objectives? Has government expenditure improved the efficiency of institutional elderly-care service? To what extent has it done so? What are the areas for improvement? These questions are not only related to the realisation of "old people are supported fully", but are also important concerns for policymakers and implementers, and require urgent research by scholars.

2 Literature Review

Currently, the efficiency of institutional elderly-care service has received little attention and lacks systematic and in-depth research. Despite the large amount of domestic literature on institutionalised elderly care services, most of the research is on the demand for institutionalised elderly care services (Jiang Yuexiang and Swen, 2006; He Wenjiong et al., 2008) and how to increase the supply of institutionalised elderly care services (Gui Shixun, 2001; Liu Lan et al. 2008; Zhang Wei and Zhang Chunlong, 2010; Liu Bo and Xiao Riqui, 2012; Mu Guangzong, 2012; Daniela, 2012; Wang Juan, Zhang Pengfei, 2024). There are fewer researches on the efficiency of institutional elderly-care service, and there is an even greater lack of researches to develop measurement or evaluation of the efficiency of institutional elderly-care service.

In the only literature on the evaluation of efficiency of institutional elderly-care service, Data Envelopment Analysis (DEA) is mostly used.Tran et al. (2019) used Meta-analysis to collate the literature on the evaluation of efficiency of institutional elderly-care service, and found that most of them use the DEA model. Institutional elderly care services have a certain degree of public goods characteristics, which makes it difficult to apply the profit maximisation criterion for evaluation. Inputs and outputs of institutional aged-care services are diversified and difficult to be expressed through explicit mathematical functions. The units of measurement of the various indicators involved are differentiated, making it difficult to make horizontal comparisons and assign weights. The evaluation of service efficiency is subjective and the required data collection is difficult. These factors make the evaluation of efficiency of institutional elderly-care service very difficult (Ren Jie, 2016).

[①] Central People's Government Portal. Opinions of the General Office of the State Council on Promoting the Development of Elderly Services [EB/OL]. (2019-03-29) https://www.gov.cn/gongbao/content/2019/content_5386616.htm.

[②] Central People's Government Portal. Outline of the Fourteenth Five-Year Plan for the National Economic and Social Development of the People's Republic of China and Vision 2035 [EB/OL]. (2021-03-13) https://www.gov.cn/xinwen/2021-03/13/content_5592681.htm

However, the DEA method can measure the relative effectiveness of decision-making units with multiple inputs and outputs that are homogeneous and comparable (Wei Quanling, 2000). Therefore, it is recognised by many scholars in the efficiency of institutional elderly-care service evaluation. Liu Hongqin (2012) believes that the DEA method has certain advantages in service efficiency evaluation relative to ratio analysis, stochastic frontier analysis, and modified least squares regression analysis based methods.She also elaborated on the idea of applying the DEA method in the evaluation of the efficiency of government-purchased home-based elderly care services, but in the end, the method was not used to further develop empirical research. Dulal (2017) used Bootstrap-DEA method to analyse the efficiency of institutional elderly-care service of 338 institutions in California, USA, and found that the staffing structure was not conducive to the improvement of technical efficiency. Zhou Ying and Chai Zhejun (2015) used the DEA method to research the efficiency of institutional elderly-care service in Ningbo and found that the overall level of scale efficiency was high. Ma Yueru et al. (2017) and Gan Xiaocheng et al. (2022) used the same method to research the efficiency of institutional elderly-care service in China and found that the efficiency of services in the eastern region was significantly higher than that in the western region, but they did not further explore the factors influencing the efficiency of institutional elderly-care service on this basis.

A few scholars have explored the factors influencing the efficiency of institutional elderly-care service on the basis of evaluating their efficiency, but have not focused on the variable of government expenditure. Sexton et al. (1989) used the DEA methodology to derive the values of efficiency of 52 elderly-care institutions in the state of Maine in the United States, and researched the factors influencing the efficiency of institutional elderly-care service using a multiple regression model. Nyman, Bricker (1989), Fizel et al. (1992) and Luasa et al. (2018) successively found that the nature of the elderly care organisation has a significant effect on the efficiency of institutional elderly-care service. Rosko (1995) further found that the differences in the efficiency of elderly care institutions of different natures were due to the influence of managerial and environmental factors. Kooreman (1994) firstly chose the more fitting Tobit model as a tool for exploring the efficiency influencing factors. In China, Wu Min (2011) analysed the efficiency of institutional elderly-care service and its influencing factors in Jinan using DEA method and Tobit model, and found that the efficiency influencing factors were mainly the type of recreational implementation and the number of managers. Ren Jie (2016) used the same method to research the efficiency of institutional elderly-care service in Xiamen and found that factors such as the total value of fixed assets of the institutions and whether or not they were affiliated with hospitals negatively affected the efficiency of institutional elderly-care service. Yang Weiwei, Chang Chao (2019) and Kang Rui, Li Min (2023) explored the effects of factors such as social capital, professional and technical skilled personnel, and the number of beds on the efficiency of elderly care services in the case of Beijing. However, these researches do not consider the impact of government expenditure on the efficiency of institutional elderly-care service when exploring the factors influencing the efficiency of

institutional elderly-care service.

These researches provide some support for the evaluation of the efficiency of institutional elderly-care service and the exploration of its influencing factors, but due to the demographic, economic and geographic differences in each region, the indicators chosen are not the same, and the conclusions obtained are different. Moreover, these researches omit the important variable of government expenditure when analysing the influencing factors of efficiency of institutional elderly-care service, which is inconsistent with the current situation of government fiscal support for the development of institutional elderly-care service at all levels in China. In view of this, this essay takes Wuhan as an example to evaluate the efficiency of institutional elderly-care service in Wuhan using the DEA method, adopting the correlation analysis method to determine the independent variables and select the control variables. On this basis, the Tobit model is used to focus on whether government expenditure has an impact on the efficiency of institutional elderly-care service and the degree of its impact, which provides a foundation for optimising the allocation of resources in elderly-care institutions and improving the efficiency of institutional elderly-care service. The structure of the article is as follows. Firstly, theoretical hypotheses are proposed based on public goods theory. Secondly, the efficiency of institutional elderly-care service is evaluated using the DEA method based on the sample data of 50 elderly-care institutions in Wuhan. Then, Tobit regression model is used to examine the effect of government expenditure on the efficiency of institutional elderly-care service and the degree of its influence. Finally, corresponding conclusions and recommendations are put forward.

The innovations of this essay are as follows: (1) DEA-Tobit analysis based on the micro-data obtained from the investigation of institutional elderly services in Wuhan. (2) It focuses on whether the variable of government expenditure, which has been neglected in previous research, can improve the efficiency of institutional elderly-care service. (3) According to the mode of government expenditure, it is divided into government direct investment and government subsidy to observe whether different modes of spending have different effects on the efficiency of institutional elderly-care service and the degree of their effects.

3 Theoretical Hypothesis

Musgrave (1939) and Samuelson (1954) argue that, given the non-exclusive and non-competitive nature of public goods, private provision entails an efficiency or welfare loss and therefore should be supplied by the government. The non-exclusive and non-competitive nature of institutional elderly-care service is incomplete, and it is a quasi-public good with characteristics of both private and public goods. Because institutional elderly-care service have benefit spillovers, one part of the benefits it provides is enjoyed by its owner, is divisible, and its benefits can be priced, having the characteristics of private goods. However, the other part of the benefits is enjoyed by other people, which is indivisible and has the characteristics of public goods. For example, if the elderly residents enjoy institutional elderly-care service to improve the quality of life of the elderly, this part

of the benefits is divisible, but the improvement of the quality can benefit the whole society, which reflects the characteristics of public goods.

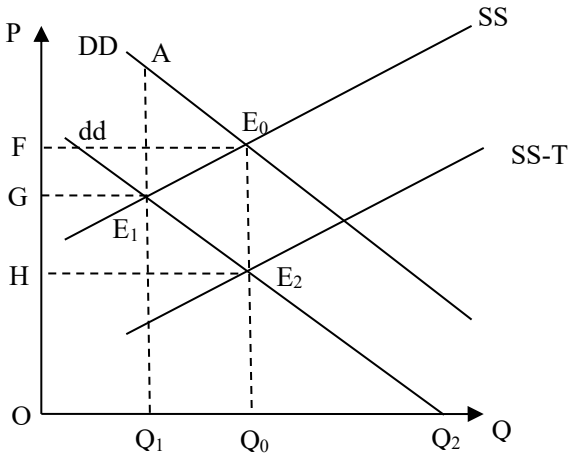

Figure 1 Efficiency of institutional elderly-care service provision

For the efficiency of institutional elderly-care service supply. As in Figure 1, dd is the marginal utility curve (demand curve) of the purchaser of institutional elderly-care service, DD is the marginal utility curve of society, and the vertical distance between them is expressed as the marginal external utility of institutional elderly-care service. The marginal cost curve is SS (supply curve), and the intersection of DD and SS, E_0, corresponds to Q_0, which is the level of output consistent with social efficiency and the Pareto optimum. At that level, the net utility of institutional elderly-care service to society is maximised. If institutional elderly-care service are provided exclusively by market-based private elderly-care institutions, this fully market-based mechanism will result in an efficiency loss due to the quasi-public good attributes of institutional elderly-care service. Under the conditions of the full market mechanism, the elderly residents will determine the amount of service purchased based on the maximum level of benefits they can obtain, and the intersection of dd and SS, E_1, corresponds to Q_1, which is this portion of the purchased amount. It can be seen that although the individual purchaser's benefit is maximised, in terms of society there is a loss in the level of welfare, with AE_1E_0 being the amount lost.

In view of the attributes of quasi-public goods of institutional elderly-care service, in order to avoid the loss of efficiency entirely under the market mechanism, the government should intervene and take the government purchase of institutional elderly-care service by means of direct investment and subsidy, so as to realise an effective combination of the government and the market. As in Figure 1, without government expenditure, in order to satisfy the demand of buyers of institutional elderly-care service, the product supply is Q_1, the cost is OG, and the value of the efficiency is Q_1/OG. As in Figure 1, without government expenditure, in order to satisfy the demand of buyers of institutional elderly-care service, the product supply is Q1, the cost is OG, and the efficiency value is Q_1/OG. In order to satisfy the demand of social elderly-care service, the product supply is Q_0, the cost is OF,

and the efficiency value is Q_0/OF. The government invests in and subsidises the provision of institutional elderly-care service, and the marginal cost curve falls to SS-T, the level Q_0 at which social benefits can be maximised. OF is the marginal cost of institutional elderly-care service, of which the government bears the FH portion and the institutions themselves bear the OH. In this way, the government's purchase of institutional elderly-care service is an effective Pareto improvement, which is conducive to the maximisation of benefits (Zhang Naiying, Wang Chenyao, 2012). At this point, the cost of elderly-care services provided by the institutions is reduced by GH from OG to OH, and the efficiency value is Q_0/(OG-GH) that is Q_0/OH. Because $Q_0 > Q_1$ and OH < OG, the efficiency value of the elderly institutions after the government investment, Q_0/OH, is greater than the efficiency value Q_1/OG before the investment. For the institutions providing institutional elderly-care service, the cost reduction is accompanied by an increase in the supply of the product, and therefore, the efficiency of institutional elderly-care service increases. However, in the case of institutional elderly-care service for society, is the efficiency of institutional elderly-care service improved after the equilibrium point changes from E_1 to E_0? That is, it is uncertain whether Q_0/OF is greater than Q_1/OG. This depends on the respective growth rates of demand and supply, or on the elasticity of demand and supply. The two main forms of government financial investment in the institutional elderly-care care are direct government investment and fiscal subsidies. In order to examine whether government expenditure can improve the efficiency of institutional elderly-care service and the differences in the impact of the two different types of government direct investment and fiscal subsidies on the efficiency of institutional elderly-care service, the following research hypotheses are proposed:

H1: Government direct investments have a significant positive effect on the efficiency of institutional elderly-care service (can improve the efficiency of institutional elderly-care service).

H2: Government fiscal subsidies have a significant positive effect on the efficiency of institutional elderly-care service (can improve the efficiency of institutional elderly-care service).

4 Research Methodology and Data Sources

4.1 Research methodology: DEA-Tobit two-stage model

Based on Farrell's idea of efficiency measurement and metric theory, American mathematicians Charnes and Cooper et al. (1978) proposed the DEA method. DEA can measure the relative effectiveness of homogeneous and comparable multiple-input, multiple-output Decision Making Units (DMUs) (Wei Quanling, 2000). Compared with methods such as stochastic frontier analysis, the DEA method has the following advantages: it does not require preset functions and artificial weights, and it can research multiple inputs and multiple outputs at the same time (Li Hongyan, 2013). In view of the characteristics of institutional elderly-care service, the DEA method is well adapted to evaluate the efficiency

of institutional elderly-care service. At the same time, it can avoid the problem of subjective assignment of weights, highlighting its objectivity, scientificity and practicality.

There are two classical models for data envelopment analysis (DEA), C^2R and BC^2.The C^2R model, created by Charnes, Cooper and Rhodes (1978), assumes the measurement of the combined technical efficiency of decision units under the condition of Constant Returns to Scale (CRS).Banker et al. (1984) proposed the BC^2 model, which relaxes the use of C^2R, introduces the condition of Variable Returns to Scale (VRS), separates scale efficiency from DEA, and measures pure technical efficiency and scale efficiency.

The DEA method can measure the efficiency of institutional elderly-care service, but it is difficult to find out its influencing factors. Therefore, other models need to be used for further research on this. Sexton et al. used a multiple regression model and Ozcan used a logistic regression model. Based on the problem of restrictive distribution of DEA efficiency values (e.g., the upper limit of the efficiency value is 1), the use of regression models based on the OLS method would be biased. In order to solve this problem, Kooreman chose the more fitting dependent variable restricted Tobit model as a tool to explore the factors affecting efficiency[38]. It is recognised and used by many scholars, and the method has been proven to be more applicable in practice. The model is as follows:

$$\begin{cases} y_i^* = \beta_i x_i + \mu_i \\ y = \max(0, y^*) \end{cases} \quad (1)$$

y^* is the potential dependent variable. x_i is the vector of independent variables. β_i is the regression coefficients. The error terms μ_i is independent and follow a normal distribution: $\mu_i \sim N(0, \sigma^2)$. When 0< y^* <1, $y = y^*$; When y^* =0, y =0; When y^* =1, y =1.

The Tobit regression model was applied to analyse the factors influencing the efficiency of institutional elderly-care service, and the integrated technical efficiency value, pure technical efficiency value and scale efficiency value obtained by the DEA method are used as the dependent variables respectively to examine the influence of the independent variable of government expenditure on the efficiency of institutional elderly-care service.

4.2 Data sources

The data in this essay comes from the survey data of institutional elderly-care service status in June 2019 by Hubei Provincial Association of Nursing Institutions. The content of the survey includes: (1) basic information of the elderly-care institutions: the nature of the institution, the nature of the real estate, the area, the building area, the time of registration and the number of beds approved by the civil affairs department, etc.; (2) the service capacity: the neighbouring traffic conditions, the functional facilities of the institution, the elderly-care construction projects, the management system and standards, three major competitive advantages and the three most serious problems faced, etc.; (3) the basic information of the staff: job structure, academic structure, training, holding professional

qualification certificates, etc.; (4) basic information on elderly residents: number of residents, self-care ability, etc.; (5) operation status: obtaining government subsidies and special projects, charging standards, service content, number of services, etc.; (6) Combination of medical care and nursing care. The Association of Nursing Institutions used a sample survey to investigate 151 nursing institutions in Wuhan. According to the degree of perfection and reliability of the survey data, this essay includes 50 elderly-care service institutions as research samples.

5 Evaluation of Efficiency of institutional elderly-care service

5.1 Selection of indicators for evaluating the efficiency of institutional elderly-care service

Ozcan (1998) believes that the more indicators for input and output of DEA method is not the better, and should be strictly controlled. Wang Zengwen (2012) summarised six principles for selecting indicators and constructing an indicator system when using the DEA method for efficiency measurement: purposefulness, independence, streamlining, objectivity, relevance, diversity. Golany and Roll (1989) argue that the decision-making units (DMUs) in a the DEA method must be homogeneous, in the same market environment, and use the same efficiency measures, and the relationship between the size of the DMUs and the validity of the method has to be dealt with. A general rule of thumb is that the number of DMUs $\geqslant$ 2 x the sum of the number of input-output indicators.

In terms of input indicators selection, early research on the efficiency of elderly services (Sexton et al. 1989; Nyman and Bricker 1989; Fizel 1992) use the working hours of all types of staff, while later scholars (Rosko 1995; Björkgren 2001; Shimshak 2009; Ren Jie, 2016; Yang Weiwei and Chang Chao, 2019; Kang Rui and Li Min, 2023) mostly use the number of staff in each category. In terms of the selection of output indicators, the literature is basically consistent, adopting the number of elderly people staying in each category as output indicators. On the basis of previous scholars' research, combined with the data we collected, this essay extracts four items as input indicators, including the number of elderly care workers, the number of administrative managers, the number of cooks, and the number of other staff members (cleaners, security guards, etc.). On the one hand, it is because the elderly-care care service industry is labour-intensive and capital is difficult to replace. On the other hand, compared with material costs, manpower costs are the main variable costs of elderly-care care service institutions and are within the adjustable range of policymakers. Therefore, these four human cost inputs are chosen as input indicators. In addition, in contrast to previous research, this study use the number of cooks, rather than the number of doctors, as one of the input indicators. Although the more doctors an institution has the more likely it is to be conducive to the integration of healthcare and the quality of institutional elderly-care service, cooks play a crucial role in the safety of diet, quality of life and satisfaction with services. The survey finds that all elderly-care care service institutions have cooks as a human cost input, while very few have doctors. Cooks are more essential

than doctors relative to basic elderly-care services, and are therefore more generalisable in measuring the efficiency of institutional elderly-care service. The selection of output indicators is consistent with previous research, with the number of self-care elderly, the number of semi-care elderly, and the number of completely self-care elderly selected as output indicators. The total number of input and output indicators is 7, and the number of decision-making units is 50, which is in line with the rule of thumb that the number of decision-making units is greater than twice the number of indicators. The basic description of the inputs and outputs is shown in table 1.

Table 1 Basic description of inputs and outputs (n=50)

	Indicator	Mean value	Standard deviation	Minimum value	Maximum value
Input	Number of elderly care workers	23.2	29.91	4	168
	Number of cooks	3.22	4.22	1	24
	Number of administrative managers	4.02	4.38	1	23
	Number of other staff members	10.1	20.11	0	123
Output	Number of self-care elderly	34.02	42.14	0	180
	Number of semi-care elderly	41.08	53.60	0	234
	Number of non-self-care elderly	45.58	67.21	0	338

5.2 Results of the evaluation of efficiency of institutional elderly-care service

Using the C^2R model and BC^2 model of input perspective DEA, based on the sample of 50 selected elderly-care care service institutions, the integrated technical efficiency[①], pure technical efficiency and scale efficiency of institutional elderly-care service in Wuhan are analysed.

As can be seen from Table 2, among the 50 decision-making units, 22 decision-making units have a integrated technical efficiency value of 1, which is regarded as DEA-effective, that is, the inputs and outputs of these 22 elderly care institutions have reached the relative optimum, accounting for 44 % of the total number of selected samples. Among the 50 decision units, 12 of them are in weak DEA, that is, only one of the two values of technical efficiency and scale efficiency is 1, accounting for 24% of the total number of decision units. The remaining 16 decision units are non-DEA effective, accounting for 32%. As can be seen from Table 3, the mean value of the integrated technical efficiency of the 50 decision-making units is 0.829, with the lowest value being 0.146 (DMU49).Of the three efficiency values, the pure technical efficiency value is the highest, 0.928, and the pure technical efficiency value has the smallest variance from each other (standard deviation is 0.074).

In terms of the returns to scale, there are 22 institutions with constant returns to scale, accounting for 44%. The scale efficiency of these institutions is optimal, with inputs and

① Integrated Technical Efficiency includes Pure Technical Efficiency and Scale Efficiency.

outputs increasing in the same proportion.16 institutions, accounting for 32%, have increasing returns to scale. It means that the proportion of increase in output is higher than the proportion of increase in inputs in these institutions, and they can increase their current size. There are 12 institutions with diminishing returns to scale, accounting for 24%, indicating that the proportion of increase in inputs is greater than the proportion of increase in outputs, and that inputs should be appropriately controlled.

Table 2 DEA Efficiency Values of 50 elderly-care Service Institutions under C^2R and BC^2 Models

Decision Making Units (DMU)	Integrated Technical Efficiency (TE)	Pure Technical Efficiency (PTE)	Scale Efficiency (SE)	Returns to Scale (RTS)
01	0.654	0.783	0.834	Drs
02	1	1	1	—
03	1	1	1	—
04	0.518	0.694	0.745	Irs
05	0.503	1	0.503	Irs
06	0.510	0.667	0.765	Irs
07	1	1	1	—
08	1	1	1	—
09	0.574	0.877	0.654	Irs
10	1	1	1	—
11	0.908	1	0.908	Drs
12	0.553	1	0.553	Irs
13	1	1	1	—
14	1	1	1	—
15	0.935	1	0.935	Drs
16	1	1	1	—
17	0.882	1	0.882	Drs
18	0.506	0.544	0.931	Irs
19	1	1	1	—
20	0.535	0.682	0.785	Irs
21	0.927	1	0.927	Irs
22	0.970	0.972	0.998	Irs
23	1	1	1	—
24	1	1	1	—
25	1	1	1	—
26	1	1	1	—
27	0.881	0.939	0.938	Drs
28	0.715	0.825	0.866	Drs
29	1	1	1	—
30	0.512	1	0.512	Drs
31	1	1	1	—
32	1	1	1	—
33	1	1	1	—
34	1	1	1	—
35	1	1	1	—
36	1	1	1	—
37	0.715	0.748	0.955	Drs
38	0.980	1	0.980	Irs
39	0.896	0.908	0.986	Irs
40	0.731	1	0.731	Drs
41	0.690	0.873	0.791	Drs

42	0.676	1	0.676	Irs
43	0.673	1	0.673	Irs
44	1	1	1	—
45	1	1	1	—
46	0.354	0.500	0.709	Irs
47	0.802	0.830	0.966	Drs
48	0.814	1	0.814	Irs
49	0.146	0.600	0.243	Irs
50	0.900	0.942	0.955	Drs

Note: "—" denotes constant returns to scale, Irs denotes increasing returns to scale, and Drs denotes decreasing returns to scale.

Table 3 Basic description of the efficiency of institutional elderly-care service values in Wuhan (n=50)

Indicator	Mean value	Standard deviation	Minimum value	Maximum value
Integrated Technical Efficiency (TE)	0.829	0.203	0.150	1
Pure Technical Efficiency (PTE)	0.928	0.074	0.500	1
Scale Efficiency (SE)	0.884	0.185	0.240	1

6 Tobit Analysis of the Impact of government expenditure on the Efficiency of institutional elderly-care service

The sample size selected in this essay is small, and it is not suitable to include multiple variables in the regression model at the same time, therefore, the independent variables and control variables are firstly determined through the correlation analysis of each variable with the comprehensive technical efficiency. The determination of independent variables and control variables is based on the following three principles: (1) focusing on and selecting the factors influencing the efficiency of institutional elderly-care service in existing research as control variables; (2) not including the input and output variables selected in the analysis of the efficiency of institutional elderly-care service; (3) the significance level of $P < 0.10$. Then, a tobit regression model is fitted with the value of efficiency of institutional elderly-care service as the dependent variable, with the identified independent variables and selected control variables.

6.1 Dependent and independent variables

6.1.1 Dependent variables

In order to examine the impact of government expenditure on the efficiency of institutional elderly-care service, this essay fits three independent Tobit models with the integrated technical efficiency value (TE), pure technical efficiency value (PTE), and scale efficiency value (SE) of institutional elderly-care service in Wuhan as dependent variables, respectively.

6.1.2 Independent variables

The government's purchase of institutional elderly-care service is divided into public-private, public-private and public-subsidised methods, of which public-private and

public-subsidised have become the mainstream models (Zhang Naiying and Wang Chenyao, 2012). According to Hu Wei (2014), the government's purchase of institutional elderly-care service can be interpreted from both broad and narrow perspectives, with the broader meaning referring to the two forms of public-private and public-subsidised, and the narrower meaning referring to public-private only. The “government purchase of institutional elderly-care service” in this essay is based on a broad perspective, which includes both public-private, private-private and public-subsidised (government subsidies to private-private institutions), as well as government subsidies to public-private institutions for elderly-care beds that are open to the community. In terms of the specific ways in which the government purchases institutional elderly-care service, in addition to providing financial support to elderly-care service institutions, the government's provision of interest-free loans to elderly-care service institutions carrying out the construction of facilities and equipment, and the implementation of tax incentives are all positive initiatives of the government's cooperative mechanism for the purchase of institutional elderly-care service (Kang Rui and Lv Xuejing, 2016). The main purchasing methods can be divided into three categories: direct government investment, fiscal subsidies (five guarantees subsidy, bed operation subsidy, construction subsidy, fire protection subsidy, upgrading subsidy, etc.), and tax and fee concessions. Given that data on tax and fee concessions are difficult to obtain, government expenditure for institutional elderly-care is mainly government direct investment and fiscal subsidies in this essay. Initially, the two are used as independent variables, and then the independent variables for fitting the Tobit model are determined based on the results of the correlation analysis.

Given that the value of integrated technical efficiency does not conform to normal distribution, therefore, for the continuous variables of government direct investment and fiscal subsidies, the correlation analysis of the variables and integrated technical efficiency is unfolded by Spearman correlation, as shown in Table 5. The results show that fiscal subsidies are positively correlated with integrated technical efficiency of elderly-care service institutions, and are significant at the test level of 0.01 (P=0.006). And although government direct investment is positively related to the integrated technical efficiency of elderly-care service institutions, it is not statistically significant. This means that the theoretical hypothesis H1 is not valid. Therefore, the independent variable was determined to be fiscal subsidies.

6.2 Control variables

In order to reduce the error caused by the model setting, this essay introduces other factors affecting the efficiency of institutional elderly-care service as control variables. In the literature of previous research on variables affecting the efficiency of institutional elderly-care service, scholars have different views. They believe that the variables include: the nature of the institution, the size of the institution, the management factors, the environmental factors, the fixed assets of the institution, the human resource factors, the quality of care, and the combination of health care and nursing care, etc., as shown in Table

4. Drawing on the results of previous research, 10 specific indicators in six areas are initially selected as control variables, including the nature of the institution, fixed assets and scale indicators (floor area, building area, number of approved beds), operation status indicators (years of operation, number of subsidised beds, occupancy rate, average fee rate), medical and nursing care combination indicators (own hospital), environmental indicators (location of the institution), and human resource development emphasis indicators (number of staff training sessions).

Table 4 Variables affecting the efficiency of institutional elderly-care service

Author (year of publication)	Variables affecting the efficiency of institutional elderly-care service
Sexton et al. (1989)	Poor management; sudden prolongation of management time; decline in quality of inputs; increase in quality of outputs; high employment rates; occupants constrained
Nyman and Bricker (1989)	Nature of institutional profitability
Fizel et al. (1992)	Nature of institutional profitability
Kooreman (1994)	Labour inputs
Rosko (1995)	Management and environmental factors
Ozcan (1998)	Ownership and size
Björkgren (2001)	Size of institution; nurses with practical experience; efficient internal management; resource allocation
Shimshak (2009)	Quality of care
Garavaglia et al. (2010)	Nature of the institution
Wu Min (2011)	Type of recreational facility; number of managers
Ren Jie (2016)	Total value of fixed assets of the institution; quality factors such as whether it is affiliated with a hospital or not
Yang Weiwei, Chang Chao (2019)	Number of professional and technical skilled personnel; number of beds
Kang Rui, Li Min (2023)	Nature of the elderly-care care institution

Data source: Based on relevant literature.

Given that the integrated technical efficiency values do not conform to a normal distribution, the correlation between the variables and the integrated technical efficiency was analysed by Spearman's correlation for continuous variables (see Table 5). For binary variables the rank sum test was used to determine the correlation between the control variables and the dependent variable integrated technical efficiency (see Table 6).

As shown in Table 5, the results of Spearman's correlation analysis indicate that the fixed assets and scale indicators (floor area, building area, number of approved beds) have a positive correlation with the efficiency of institutional elderly-care service, however, only the relationship between the number of beds and the integrated technical efficiency is significant at the test level of 0.10. Among the indicators of the operation status (years of operation, number of subsidised beds, occupancy rate, average fee rate), the average fee rate is significantly and negatively correlated with the integrated technical efficiency of the elderly-care service institutions (P=0.024), the occupancy rate of elderly-care service institutions significantly and positively correlated with the integrated technical efficiency of the elderly-care service institutions (P=0.020). The indicator of the degree of attention to human resources development (number of staff training sessions) is positively correlated with the integrated technical efficiency of elderly-care service institutions, but is not

statistically significant.

As shown in Table 6, the correlation analysis between the location environment of institutional elderly-care service (whether it is in the central city or not), the nature of elderly-care institutions (whether it is privately-run or not), the healthcare integration situation (whether it has a hospital or not) and the efficiency of institutional elderly-care service is conducted by using the rank-sum test in the non-parametric test. The results show that the effects of location environment of whether the elderly-care service institutions are in the central city (P=0.237) and healthcare integration situation (P=0.694) on the efficiency of institutional elderly-care service are not statistically significant. In contrast, there is a significant positive correlation between elderly-care service institutions according to their nature and the value of integrated service efficiency (P=0.038), indicating that the different natures of elderly-care service institutions have a significant positive impact on the efficiency of institutional elderly-care service. Moreover, the rank-mean value of efficiency of institutional elderly-care service in the private sector (28.06) is 48.23 % higher than the rank-mean value of efficiency of institutional elderly-care service in the public sector (18.93).

Through Spearman correlation analysis and rank sum test in non-parametric tests, three control variables are selected: the nature of the elderly-care service institution, the occupancy rate and the average fee rate at $P < 0.05$.

Table 5 Spearman's correlation analysis of variables with integrated technical efficiency values

	Floor area	Building area	Years of operation	Approved beds	Institutional occupancy rate	Training sessions	Subsidised beds	Average fee rate	Government direct investment	Fiscal subsidies
Correlation coefficient	0.220	0.126	-0.020	0.242*	0.329**	0.084	0.125	-0.318**	0.140	0.385***
P-value (bilateral)	0.125	0.384	0.889	0.091	0.020	0.561	0.386	0.024	0.333	0.006

Note: * indicates $P < 0.10$; ** indicates $P < 0.05$; *** indicates $P < 0.01$.

Table 6 Rank-sum test of the variables with the integrated technical efficiency values

Variables		n	Rank mean	P value
Whether it is in the central city	Yes (=1)	45	24.72	0.237
	No (=0)	5	32.50	
Whether it is privately-run	Yes (=1)	36	28.06	0.038**
	No (=0)	14	18.93	
Whether it has a hospital	Yes (=1)	10	23.95	0.694
	No (=0)	40	25.89	

Note: ** indicates $P < 0.05$.

6.3 Results of Tobit analysis

According to the results of the relevant analysis, Tobit regression analysis is conducted with fiscal subsidy ($P < 0.05$) as the independent variable, the nature of elderly-care service institutions, occupancy rate of elderly-care service institutions, and average fee rate at P <

0.05 as the control variables, and the integrated technical efficiency (TE) of elderly-care service institutions, the pure technical efficiency (PTE), and scale efficiency (SE) as the dependent variables. The form of the model is as follows:

$$y_i^* = \beta_0 + \beta_1 SUB_i + \sum_{j=1}^{4} \alpha_j x_{ij} + \varepsilon_i \quad (i=1,2,\ldots,50;\ j=1,2,\ldots,4) \qquad (2)$$

y_i^* is the value of the efficiency of the elderly-care service institution, SUB_i is the dependent variable fiscal subsidies, x_{ii} is a vector of control variables (nature of the elderly-care service institutions, occupancy rate of the elderly-care service institutions and average fee rate), β_0 is a constant term, β_1 is the regression coefficient of the independent variable fiscal subsidy, α_j is the regression coefficient corresponding to each control variabl, ε_i is a random error term and $\varepsilon_i \sim N(0,\sigma^2)$.

Stata software was applied to fit three independent Tobit models with the integrated technical efficiency value, pure technical efficiency value and scale efficiency value of institutional elderly-care service as the dependent variables respectively, and the model results are shown in Table 7.

Table 7 Tobit model estimation results of the effect of fiscal subsidies on the efficiency of institutional elderly-care service

Variables	Integrated Technical Efficiency (TE)		Pure Technical Efficiency (PTE)		Scale Efficiency (SE)	
	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value
Fiscal subsidies	0. 253***	0.029	0. 187***	0.016	0. 118	0.163
Occupancy rate	0.319***	0.004	-0.019	0.787	0.378***	0.000
Average fee rate	0.000199	0.949	0.000580	0.779	-0.000446	0.846
Nature of institution	0.150***	0.012	0.091***	0.021	0.099***	0.024

Note: *** indicates P < 0.01.

The results show that the effect of the independent variable fiscal subsidy on the scale efficiency of institutional elderly-care service is not statistically significant under the condition of controlling other variables. However, the effect on the integrated technical efficiency and pure technical efficiency of institutional elderly-care service is significant (P < 0.05), and the regression coefficients are 0.253 and 0.187 respectively, indicating that for every 10,000 yuan increase in the government fiscal subsidy, the value of integrated technical efficiency and pure technical efficiency of institutional elderly-care service will be increased by 0.253 and 0.187 respectively. This means that the theoretical hypothesis H2 is valid. In addition, the occupancy rate has a significant positive effect on the integrated technical efficiency and scale efficiency of institutional elderly-care service. The nature of elderly-care service institutions has a significant effect on the three kinds of efficiency of institutional elderly-care service, and the private category of elderly-care service institutions is higher than the public category by an average of 0.150, 0.091, and 0.021 in the integrated technical efficiency, pure technical efficiency, and scale efficiency.

Chen Zhiyong and Zhang Wei (2017) argue that the fiscal subsidy methods of China's institutional elderly-care service can be divided into two categories: the supplementary demand side (the elderly enjoying the services) and the subsidised side (the elderly-care service institutions). And how to choose the fiscal subsidy method scientifically has been a

difficult problem plaguing policy practice.Different scholars have different views on this, and Ding Xuena (2012) argues that a combination of the supplementary demand side and the subsidised side is better suited. Zhang Xiang and Lin Teng (2012), on the other hand, advocate a shift from “bricks subsidy” and “beds subsidy” to “heads subsidy”. Based on the perspective of the efficiency of institutional elderly-care service, this essay further explores the appropriateness of the different subsidy modes of “bricks subsidy”, “beds subsidy” and “heads subsidy”. We further refine the fiscal subsidies into construction subsidy (for bricks), bed subsidy (for beds), five guarantees subsidy (for headcount) and other subsidies. Among them, the construction subsidy and bed subsidy are to supplement the supply side, while the five guarantees subsidy is to supplement the demand side. Three independent Tobit models are further fitted with the integrated technical efficiency, pure technical efficiency and scale efficiency of institutional elderly-care service as dependent variables, and the model results are shown in Table 8. The results show that: on the one hand, the model is robust, and the effects of control variables such as the nature of elderly-care service institutions, occupancy rate, and the average fee rate on the efficiency of institutional elderly-care service are in line with Table 7. On the other hand, controlling for other variables, the effect of beds subsidy on the integrated technical efficiency, pure technical efficiency, and scale efficiency of institutional elderly-care service is significant ($p < 0.05$), with regression coefficients of 0.00270, 0.00184, and 0.00133, respectively. While the effect of construction subsidy, five-guarantee subsidy, and other subsidies on the scale efficiency are not statistically significant.

Table 8 Tobit model estimation results of the impact of "bricks subsidy", "beds subsidy" or "heads subsidy" on the efficiency of institutional elderly-care service

Variables	Integrated Technical Efficiency (TE)		Pure Technical Efficiency (PTE)		Scale Efficiency (SE)	
	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value
Construction subsidy	0.00259	0.123	0.000960	0.392	0.00182	0.141
Bed subsidy	0.00270***	0.004	0.00133***	0.030	0.00184***	0.007
Five Guarantees Subsidy	-0.00554	0.591	0.000878	0.209	-0.00118	0.123
Other subsidies	0.00254	0.484	0.00243	0.321	0.000377	0.887
Occupancy rate	0.291***	0.006	-0.031	0.648	0.356***	0.000
Average fee rate	0.000364	0.900	0.000664	0.735	-0.000306	0.886
Nature of institution	0.202***	0.001	0.139***	0.001	0.120***	0.008

Note: *** indicates $P < 0.01$.

7 Conclusions and recommendations

7.1 Research conclusions

The efficiency of institutional elderly-care service in Wuhan is analysed using the DEA method, and it is found that the integrated technical efficiency is at a high level, but there is a large difference between elderly-care service institutions; among the three efficiency values of institutional elderly-care service, the pure technical efficiency is the highest, and the differences among elderly-care service institutions are small. Correlation analysis shows that among government inputs, the effect of government direct investment on the efficiency

of institutional elderly-care service is not statistically significant. The results of Tobit regression analysis show that under the condition of controlling other variables, fiscal subsidies can improve the integrated technical efficiency and pure technical efficiency of institutional elderly-care service, and for every 10,000 yuan increase in the input of fiscal subsidies by the government finance, the value of the integrated technical efficiency and the value of the pure technical efficiency of institutional elderly-care service will be increased by 0.253 and 0.187, respectively. Among the forms of fiscal subsidies, the effect of "beds subsidy" on the integrated technical efficiency, pure technical efficiency, and scale efficiency of institutional elderly-care service is statistically significant, while the effect of "bricks subsidy" and "heads subsidy" on the scale efficiency of institutional elderly-care service is not statistically significant. The efficiency of institutional elderly-care service is higher in the private sector than in the public sector, and fiscal expenditure on private institutions can better fulfil the role of improving the efficiency of institutional elderly-care service.

7.2 Policy recommendations

7.2.1 Prefer fiscal subsidies over direct government investments

The main ways for the government to purchase institutional elderly-care service are direct investment and fiscal subsidies. The research shows that among the government inputs, there are differences in the effects of government direct investment and government fiscal subsidies on the efficiency of institutional elderly-care service. Government direct investment has no significant effect on the efficiency of institutional elderly-care service, while government fiscal subsidies have a significant positive effect on both integrated technical efficiency and pure technical efficiency of institutional elderly-care service. Therefore, when the government purchases institutional elderly-care service, it should make appropriate adjustments in the purchasing method: more use of fiscal subsidies and avoid direct investment.

7.2.2 Focus on the positive role of "beds subsidy" in improving the efficiency of institutional elderly-care service

The scientific choice of fiscal subsidies has been a difficult problem that has plagued policy practice. Different scholars have different views on this, and Ding Xuena (2012) argues that a combination of the supplementary demand side and the subsidised side is better suited. Zhang Xiang and Lin Teng (2012), on the other hand, advocate a shift from "bricks subsidy" and "beds subsidy" to "heads subsidy". At the same time, fiscal subsidies can be diversified. In addition to adopting special forms such as construction subsidies, upgrading subsidies and bed operation subsidies, a shift can be made from "bricks subsidy" and "beds subsidy" to "heads subsidy" on the basis of the actual number of elderly people served.

7.2.3 Guide social forces into the field of elderly-care services through fiscal subsidies

Research has shown that the private sector is on average 0.150, 0.091 and 0.021 higher

than the public sector in terms of integrated technical efficiency, pure technical efficiency and scale efficiency. The efficiency of institutional elderly-care service in the private sector is higher than that of the public sector, and the fiscal subsidies have guided the social forces to enter the field of elderly-care services, so that they can better play the role of improving the efficiency of institutional elderly-care service. There is still a big gap between the existing elderly-care service beds in Wuhan and the lower limit of 50-70 elderly-care service beds for 1,000 elderly people in developed countries. In order to alleviate the contradiction between the supply and demand of institutional elderly-care service, the government should encourage different nature of elderly-care service institutions to enter the field of elderly-care services, strengthen the policy guidance, financial support, market cultivation and supervision and management, and fully mobilise all aspects of society to actively participate in the development of the career of elderly-care services. The government can also purchase institutional elderly-care service from private elderly-care service institutions in the same way that it purchases institutional elderly-care service for the “three have-nots” in urban areas and the “five guarantees” in rural areas that are covered by public elderly-care service institutions. For private elderly-care service institutions that provide the same service, the government can provide subsidies equal to those provided by public elderly-care service institutions.

Funding information:

This research received specific grant. It was supported by the project of the National Social Science Fund of China “Research on the Coordination Mechanism of Atypical Labour Relations” (Project No. 2020XSH011).

Author contribution:

All authors have accepted responsibility for the entire content of this manuscript and consented to its submission to the journal, reviewed all the results and approved the final version of the manuscript. ZR, as the first author of this paper, was responsible for the research design, data collection and analysis, and paper writing. ZHR, as the corresponding author, was responsible for supervising and guiding, reviewing and revising the paper.

Conflict of interest:

There are no conflicts of interest in this study. All authors have read and approved this version of the article, and due care has been taken to ensure the integrity of the work. Neither the entire paper nor any part of its content has been published or has been accepted elsewhere. It is not being submitted to any other journal.

Data Availability Statement

All data generated or analysed during this study are included in this published article.

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