Economic Effects of Financial Investment for Traditional Chinese Medicine using Data Analysis

Yixuan Wen[1,a*] and Pengcheng Wen[2,b]

{121090600@link.cuhk.edu.cn[a] and cs583283648@mail.scut.edu.cn[b]}

School of Management and economics, The Chinese University of Hong Kong, Shenzhen, China[1]
School of Computer Science and Engineer, South China University of Technology, Guangdong, China [2]

Abstract. Traditional Chinese Medicine (TCM) has gone through thousands of years of inheritance and development, but it lacks the data-based analysis for policy formulation. This article quantitatively analyzes the economic effects of financial investment for TCM from the perspective of medical insurance expenditure. Currently there is no similar research. Based on data from 2001 to 2021, lots of regression models are used to analyze the relationship between TCM investment and medical insurance expenditure, while robustness tests are also conducted using lasso, Ridge, the parallel hypothesis, and the placebo test. Results show that the relationship is negative. This not only quantitatively characterizes the economic effects of TCM investment, but also proves the therapeutic effect, as which can reduce the medical expenditure. It is recommended that the financial investment should be increased for TCM, aiming to leverage the advantages of TCM and reduce the medical insurance expenditure.

Keywords: TCM, finance investment, aging population, medical insurance expenditure.

1 Introduction

TCM has been reliably validated such as in COVID-19[1]. Recently Chinese government has issued a series of policies to strongly promote its inheritance and innovation. However, due to various negative factors, TCM is confronted with lots of difficulties and challenges[2]. For example,its current financial investment accounts for a much smaller proportion of the whole medical investment, less than 10%[3]. The health policy formulation does not use data-driven decision-making tools[4], easily influenced by scarce resources such as pandemic threats and aging populations[5]. Thus the use of data-driven analysis tools such as multivariate logistic regression models is significantly required[6]. On the other hand, China has the largest elderly population, making the medical insurance system face greater challenges. The fundamental solution is to use methods such as TCM that have significant therapeutic effects but lower diagnostic and treatment costs [7,8]. There is a relationship between the efficacy of TCM and medical insurance expenditure. Recently,quantitative textual methods are used to analyze the development policies of TCM[9]. However, they did not consider the relationship between TCM financial investment and medical insurance expenditure. The marginal contribution here is not to invent the new statistical method, but to quantitatively discover the economic effect of TCM financial investment from the perspective of medical insurance expenditure, providing a basis for formulating TCM policies and medical insurance policies.

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2 Variable setting and correlation analysis

2.1 Variables and data

All variables are illustrated in Table 1. The medical insurance expenditure is the dependent variable, while TCM investment is the explanatory variable. In order to reduce the impact of heteroscedasticity, except for CPI, all other variables are logarithmically processed. The data from 2001 to 2021 is from multiple sources.The medical insurance expenditure is sourced from the annual National Basic Medical Security Development Statistical Bulletin. TCM investment is from the reference [10] and National Compilation of Traditional Chinese Medicine Statistics. Internet population comes from Statistical Report on Development of Internet in China. The data for the rest variables are from the China Statistical Yearbook.

Table 1. Illustrations of all variables

	Variable descriptions	Abbreviation
y	log(per capita medical insurance fund expenditure)	Medical insurance expenditure
x	log(the proportion of financial investment for TCM%)	TCM investment
z_1	log(per capita GDP)	GDP
z_2	CPI index	CPI
z_3	log(the proportion of aging population%)	Aging population
z_4	log(the proportion of internet population %)	Internet population
z_5	log(the proportion of residents with junior college%)	Education
z_6	log(per capita disposable personal income)	Personal income

2.2 Correlation analysis

In order to find the relationship between medical insurance expenditure and TCM investment, we first calculate the correlation between medical insurance expenditure and all other variables by SPSSAU. It can be seen from Table 2 that the medical insurance expenditure is not significantly related to CPI, but related to all other variables. Simultaneously, TCM investment has the significant correlation with GDP, Internet population, Education, and Personal income, indicating that there is the collinearity problem.

Table 2. Pearson correlation coefficients between all variables

	y	x	z_1	z_2	z_3	z_4	z_5	z_6
y	1							
x	-0.742**	1						
z_1	0.934**	-0.684**	1					
z_2	0.114	0.045	0.140	1				
z_3	0.902**	-0.511*	0.950**	0.006	1			
z_4	0.915**	-0.728**	0.980**	0.203	0.883**	1		
z_5	0.959**	-0.666**	0.978**	0.082	0.964**	0.945**	1	
z_6	0.937**	-0.659**	0.996**	0.092	0.969**	0.963**	0.985**	1

*p<0.05 **p<0.01

3 Model analysis

3.1 Econometric model

All variables are used to build the multiple linear regression model by the equation (1), where β, γ_i are the regression coefficients, $\epsilon_t$is the perturbation term that cannot be observed and satisfies the conditions of homoscedasticity and no autocorrelation, see equation (2).

$$y_t = \alpha + \beta x_t + \sum_{i=1}^{6} \gamma_i z_{it} + \epsilon_t \quad (1)$$

$$\mu = \begin{bmatrix} \mu_1 \\ \mu_2 \\ \vdots \\ \mu_n \end{bmatrix}, \mathrm{Var}(\mu|X) = \sigma^2 I_n = \begin{bmatrix} \sigma^2 & & 0 \\ & \ddots & \\ 0 & & \sigma^2 \end{bmatrix}_{n\times n} = \Sigma \quad (2)$$

where $\sum_{ij} = \mathrm{cov}(\mu_i, \mu_j)$, $\sum_{ii} = \mathrm{Var}(\mu_i) = \sigma^2$. The observed value is represented by the equation (3).

$$\widehat{y_t} = \widehat{\alpha} + \widehat{\beta} x_t + \sum_{i=1}^{6} \widehat{\gamma_i} z_{it} \quad (3)$$

where $\hat{\alpha}, \hat{\beta}, \widehat{\gamma_1}, \widehat{\gamma_2}, \widehat{\gamma_3}, \widehat{\gamma_4}, \widehat{\gamma_5}, \widehat{\gamma_6} = arg \min_{\alpha,\beta,\gamma_1,\dots,\gamma_6} (\sum_{t=1}^{n} (y_t - \hat{y}_t)^2)$. Subsequently, the following regression equation (4) can be obtained.

$$y = \widehat{\alpha} + \widehat{\beta} x + \sum_{i=1}^{6} \widehat{\gamma_i} z_i \quad (4)$$

where $\widehat{\beta}$represents the change caused by adding one unit for xwhile keeping other independent variables constant. Now we use the data to perform the linear regression by the equation (3) . Results can be found from Table 3 that the medical insurance expenditure has the significant negative correlation with TCM investment, while it is positively and significantly correlated with CPI and Aging population. Simultaneously,VIF is much larger than 10, indicating that there is a serious issue of collinearity. This is consistent with correlation analysis.

Table 3. Linear regression results for all variables

	Non standardized coefficients		Standardized coefficients			
	B	*Std Err*	*Beta*	*t*	*p*	*VIF*
Constant	-5.378	7.712	-	-0.697	0.498	
TCM investment	-1.810	0.435	-0.552	-4.166	0.001**	7.422
GDP	-2.119	0.983	-3.412	-2.155	0.050	1058.530
CPI	0.066	0.021	0.256	3.165	0.007**	2.755
Aging population	2.613	1.028	1.224	2.542	0.025*	97.875
Internet population	0.401	0.211	0.902	1.902	0.080	95.105
Education	0.330	0.365	0.339	0.904	0.383	59.444
Personal income	1.057	0.954	1.560	1.108	0.288	837.571
R^2	0.969					
F	*F* (7,13)=58.478,p=0.000					

The dependent variable: Medical insurance expenditure *p<0.05 **p<0.01

Thus we removed variables with insignificant correlation with medical insurance expenditure while CPI is also removed according to Pearson correlation coefficient. Then we obtain the benchmark regression model, see equation (5) .

$$y = 5.836 - 1.245x + 1.513z_3 \quad (5)$$

It can be seen from Table 4 that the model has the good explanation and passed the F-test. The TCM investment has a significant negative impact on medical insurance. When other variables remain unchanged, for each 1% increase in TCM investment, the medical insurance expenditure will decrease by 1.245%. At present, the proportion of TCM investment is less than 10%. It has the larger room for the improvement. On the other hand, Aging population has a significant positive impact on medical insurance with the largest coefficient. When the proportion of the Aging population increases by 1%, the medical insurance expenditure needs an annual increase of 1.513%, which confirms that the Aging population does indeed bring enormous pressure to the medical insurance expenditure.

Table 4. Linear regression results on variables of TCM investment and Aging population

	Non standardized coefficients		Standardized coefficients			
	B	*Std Err*	*Beta*	*t*	*p*	*VIF*
Constant	5.836	0.747	-	7.817	0.000**	
TCM investment	-1.245	0.253	-0.380	-4.930	0.000**	1.353
Aging population	1.513	0.165	0.708	9.196	0.000**	1.353
R^2	0.921					
F	*F* (2,18)=105.004,p=0.000					

The dependent variable: Medical insurance expenditure *p<0.05 **p<0.01

3.2 Robustness testing

Robustness tests were conducted to validate conclusions of the benchmark regression model:

(1)The more complex regression model such as lasso is applied to verify that the relationship between TCM investment and Medical insurance expenditure remains unchanged. It can be found from Table 5 that the model has the good explanation and passed F-test. The regression coefficients are consistent with that of the benchmark regression model, indicating that conclusions of the benchmark regression model are robust.

Table 5. Lasso regression analysis results

	Non standardized coefficients		Standardized coefficients			
	B	*Std Err*	*Beta*	*t*	*p*	*VIF*
Constant	5.730	0.796	-	7.194	0.000**	
TCM investment	-1.017	0.270	-0.379	-3.764	0.001**	1.531
Aging population	1.365	0.176	0.702	7.751	0.000**	1.531
R^2	0.906					
F	*F* (2,18)=87.236,p =0.000					

The dependent variable: Medical insurance expenditure *p<0.05 **p<0.01

(2)There are significant events in the data that have had an impact on the TCM investment such as SRAS in 2003 and COVID-19 in 2019, where TCM made remarkable achievements. To demonstrate that these shocks do not alter conclusions of the benchmark model, we designed an experimental group and a control group. The experimental group excluded data response to the major event shocks, and then tested for systematic differences between two groups. Two groups should have similar time trends. It can be found from Table 4 and Table 6 that both relationships and significance have not changed, satisfying the parallel trend hypothesis, so that conclusions of the benchmark regression model are robust.

Table 6. Linear regression analysis results without major events

	Non standardized coefficients		Standardized coefficients			
	B	*Std Err*	*Beta*	*t*	*p*	*VIF*
Constant	6.503	0.915	-	7.105	0.000**	
TCM investment	-1.547	0.312	-0.421	-4.953	0.000**	1.531
Aging population	1.465	0.189	0.657	7.738	0.000**	1.531
R^2	0.934					
F	*F* (2,14)=99.168,p=0.000					

The dependent variable: Medical insurance expenditure *p<0.05 **p<0.01

(3)All variables and advanced regression method such as Ridge are used, which aims to address the issue of collinearity. It can be found from Table 7 that the model passed the F-test and has the good interpretability. The significance and signs of TCM investment and the sign of Aging population are consistent with that of the benchmark regression model, indicating that conclusions of the benchmark regression model are robust.

Table 7. Ridge regression analysis results

	Non standardized coefficients		Standardized coefficients			
	B	*Std Err*	*Beta*	*t*	*p*	*VIF*
Constant	5.899	0.795	-	7.421	0.000**	
TCM investment	-1.086	0.309	-0.331	-3.518	0.004**	2.377
GDP	0.950	0.326	0.445	2.912	0.012*	6.247
CPI	-0.118	0.068	-0.190	-1.724	0.108	3.249
Aging population	0.030	0.018	0.118	1.721	0.109	1.252
Internet population	-0.021	0.076	-0.046	-0.270	0.792	7.888
Education	0.515	0.182	0.529	2.829	0.014*	9.379
Personal income	-0.007	0.082	-0.010	-0.085	0.933	3.960
R^2	0.951					
F	*F* (7,13)=36.423,p =0.000					

The dependent variable: Medical insurance expenditure *p<0.05 **p<0.01

(4)The purpose of the placebo test is to demonstrate that the significant impact of TCM investment on medical insurance expenditure is not caused by accidental events. This article randomly sets the value of TCM investment and then uses a kernel density plot for placebo testing. Due to the random generated data, TCM investment should not have a significant impact on medical insurance expenditure. Its coefficient should be around zero, thus we randomly generate a numerical value,s_t, for the variable of TCM investment and then use the multiple linear regression equation (6) to calculate the regression coefficient $\hat{\beta}$.

$$\hat{y_t} = \hat{\alpha} + \hat{\beta}s_t + \sum_{i=1}^{6} \hat{\gamma_i} z_{it} \tag{6}$$

where $\hat{\alpha}, \hat{\beta}, \hat{\gamma_1}, \hat{\gamma_2}, \hat{\gamma_3}, \hat{\gamma_4}, \hat{\gamma_5}, \hat{\gamma_6} = arg \min_{\alpha,\beta,\gamma_1,\ldots,\gamma_6} (\sum_{t=1}^{n} (y_t - \hat{y}_t)^2)$.

Subsequently, we repeat the above random process n=1000 times to obtain the regression coefficients,$\hat{\beta_1}$, for TCM investment. Based on these coefficients, we use a Gaussian kernel to generate a kernel density map, see the equation (7).

$$\hat{p}_n(x) = \frac{1}{n}\frac{1}{h}\frac{1}{\sqrt{2\pi}}\sum_{i=1}^{n} e^{-\frac{(\hat{\beta}_i - x)^2}{2h^2}} \quad (7)$$

Results are shown in Fig.1, where *h*=1.0. It can be seen that the mean coefficient is 0.0000, close to 0, and the probability of most values is above 0.1. That is, the impact of TCM investment on medical insurance expenditure is not from the random event, indicating that conclusions of the benchmark regression model are reliable and robust.

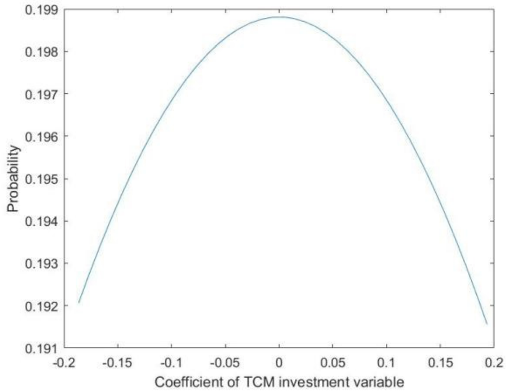

Fig. 1. Kernel density map of placebo test for TCM investment variable.

4 Conclusion and policy recommendations

This article quantitatively analyzes the economic effects of TCM investment from the perspective of medical insurance expenditure using multiple regression models. The results show that TCM investment is negatively correlated with medical insurance expenditure. Increasing TCM investment will reduce the medical insurance expenditure. In the case of more complex regression models, changes in data, and other conditions, this conclusion still holds and is robust. Based on the above research results, we propose the following policy recommendations: First, the government should further increase financial investment in TCM, support the scientific research and innovation, personnel training and clinical application of TCM, so as to give full play to its advantages in the medical and health field. Secondly, the status and role of TCM in the medical insurance system should be improved to encourage more people to use TCM services, so as to further reduce medical insurance expenditures. Finally, we should strengthen the international exchanges and cooperation of TCM, promote the internationalization process of TCM, and let this treasure of the Chinese nation play a greater role in the world.

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