Analysis on Relationship Between Economic Growth, Public Health, and Medical Service Level in China Based on One-Dimension Regression Model

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Abstract. This paper provides an empirical analysis of the linear relationship between economical condition of China, the health care industry, and public health conditions. These co-relationships are important since they can predict the future spending on medical health industry for China and people's health condition. This paper adopted statistics data (1978–2019) from China Statistical Yearbook (2020) and built a regression model about GDP per capita, life expectancy, expenditure of national health finance. The past 40 years of Chinese health care and economics statistics show that there is a robust and positive relationship (for every 1% increase in GDP the health expenditure increase by 0.99%) between health expenditure and GDP. GDP-increase directly stimulates the increase in medical service level. This research might also contribute to the financial health investment of other developing nations.

Keywords: Economic Growth · Regression Model · GDP · Public Health · Medical Service Level

1   Introduction

Improvement in health is the most critical and advantageous component of economic development [1]. (Koijen, R., Philipson, T) Medical innovations and improvements in medical infrastructures are mainly driven by economic development, while the public sector of health spending will also have a long-term effect on economics [2]. A lot of studies had been carried out to investigate factors of increase in health spending. The article by Newhouse first proposed the interrelationships between GDP and health expenditures [3]. Leu (1986) introduced more variables like the ratio of person under15 and over 65 and urbanization [4]. There is was more complex model then be proposed. The panel data analysis had been proposed to estimate the appropriate relationship of regression model. People have proposed a lot of determines of the health expenditure including age, open-ended finance, inflation [5]. According to Gerdtham and Jonsson points out that the cointegration of health expenditure and GDP relationship is not

conclusive [6]. The global interest in health expenditure put similar emphasis on cost-containment and the cost-effectiveness. Based on adequate research in the subject of economics and health expenditure, a predicted value of medical cost by using regression model would be viable and efficient to estimate the government spending on health care subsidy. Moreover, during the COVID pandemic, every country's health service has shown some deficiencies and shortages. The health service of a country becomes very crucial in this age when people are facing epidemic and severe diseases like cancers. Thus, it is important for government to understand the relationship between economic growth and health care expenditure in order to control the health care cost and optimize the development of the medical industry. This paper will investigate Chinese health expenditure's connection to the GDP in the past 40 years.

This paper will also specifically examine the environment for development of health care industry in China especially after the outbreak of COVID-19. At this point that medical industry surges because of pandemic, the regression model could be helpful by pointing out the equilibrium cost that an individual spends as the economics increase. Besides, the structural problem of health spending has been revealed by the pandemic. The impact of increase in health spending on local economics could be examined by using the data from pandemic.

2   Research Methods

2.1   Data Sources

The data that have been used for regression analysis in this paper is adopted from Chinese Statistics Yearbook (2020). There are some years with null data that have been deleted.

2.2   Research Method

By using regression model, the relationship between two GDP growth and financial sector of health could be revealed comprehensively. The relationship will be tested by linear regression model with data from Chinese Statistics Yearbook (2020). There are some columns of data with null data and those had been deleted. The regression model is simply one-dimensional $y = a + bx$, where a is the intercept and b is slope of regression line. The Data are collected from the year 1978 to 2020. The x component of the one-dimension regression model will be a year. The y component includes categories of data includes GDP, CPI, the ratio of financial health expenditure, life expectancy. The accuracy of each model will be compared by calculating R2 for each model. Use the statistic function of Excel to create a regression model for those data.

3   The Relationship Between Economic Development and Medical Health

3.1   Measures of Economic Development

1) Per Capita GDP Development in China. GDP Per Capita measures the tendency of market value that had been created by each individual from 1978 to 2019. By
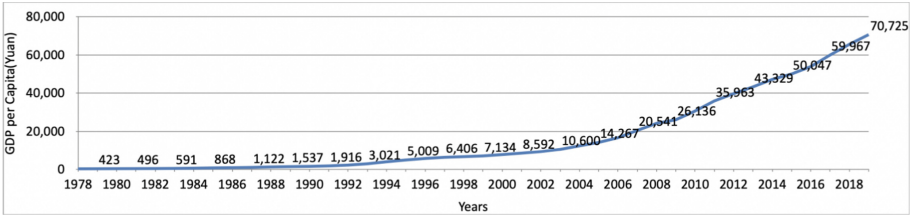
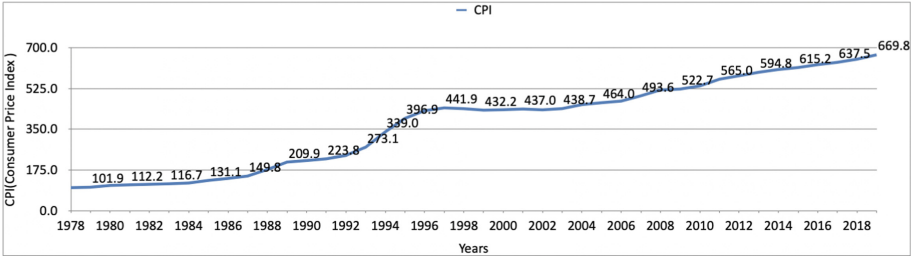**Fig. 1.** China per Capita GDP (1978–2018).

Fig. 2. China CPI (1978–2018).

adopting the per capita values, the externality of population growth on the overall look of economics is cancelled. The line chart indicates that Chinese economy is developing at an increasing rate in the past years (Fig. 1).

2) CPI (1978 = 100)

CPI is a deflator that measures the change in prices of products that consumers buy in the years. It can be used to measure the GDP without influence of price change. Taking the CPI of 1978 as 100, the CPI of flooding years are all related and can be compared. Each year's CPI measures are on the same scale with the same proportion (Fig. 2).

Overall, the CPI is increasing, except for1998 and 1999 because of the financial crisis that started in East Asia by 1997 with the drop of Thai baht [7]. Chronically, as a developing country, the economics of China is increasing without fluctuation [7].

3.2   Measurement Standard of Medical Level

1) *Per Capita Health Expenditure (Yuan):* Per capita health expenditure is the most. Direct measures of the development of medical industry. The line chart shows that per capita health care expenditure is increasing (Fig. 3).

2) *Fraction of Total Health Expenditure in GDP:* As the total health expenditure increases with the increase of GDP, the fraction of total health expenditure in GDP is not constantly increasing. With about five years or ten years of increase in the fraction, there is a decrease, but the fraction is overall increasing. The overall increase was contributed by the expansion of public health insurance led by Chinese government. The development of fraction of total health expenditure in GDP is determined
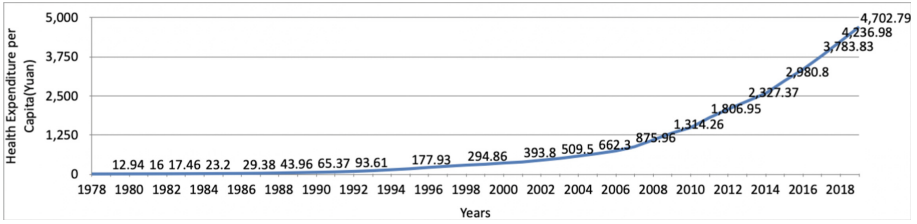
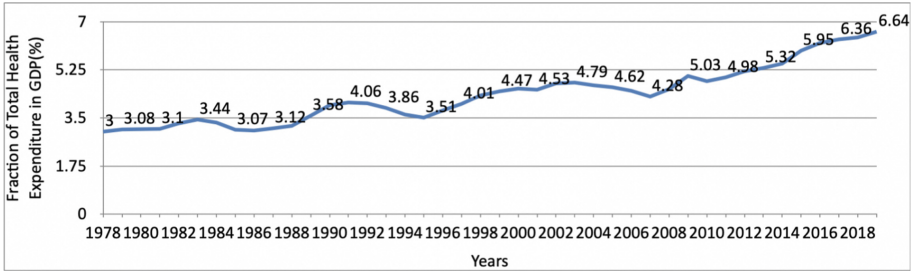**Fig. 3.** China per Capita Health Expenditure.

Fig. 4. Chinese Health Expenditure Ratio

by both individual health spending and government health spending. The increase in the fraction could be reflected by the increase in public health insurance coverage rate. From the Government Medical insurance first implemented to the following policies like Rural Cooperative Medical Insurance, Urban Employee Basic Medical Insurance, New Rural Cooperative Medical Scheme, and Urban Resident Basic Medical Insurance (URBMI), the fraction increases with the increasing coverage. Those local minimum in this chart are still unsure but could possibly be explained by factors like population and consumption capacity of consumers (Fig. 4).

3) *Beds in Medical Institutions per 10000 People:* Data of Beds in Medical Institutions per 10000 People misses datas from 1978 to 2001. The count of amount of bed in medical institution would be a measure of medical development in China without influence of technology development. However, compared to those western developed country, the beds in medical institution in China is comparatively lower (Fig. 5).

4) *Life Expectancy:* The data of life expectancy is measured once every 5 years. As an indicator of health level, life expectancy kept increasing. Life expectancy is the major measure of the health level of a country. The increase in life expectancy proves the development in the medical industry and the success of health expenditure coverage insurance (Fig. 6).
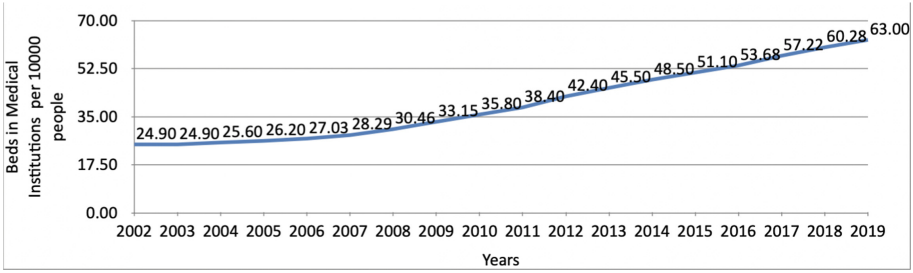
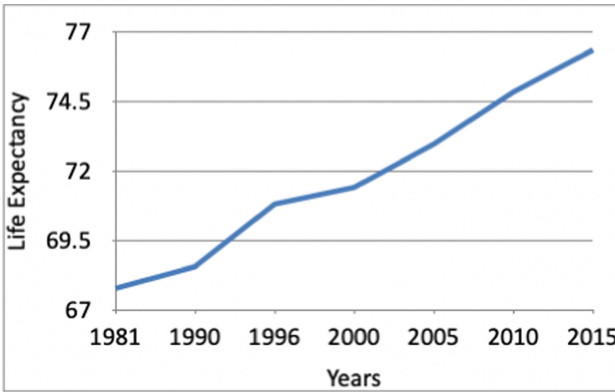**Fig. 5.** Beds in Medical Institution per 10000 People

Fig. 6. Life Expectancy in China

3.3 Analysis Model

The way to investigate the relationship between medical industry development and economic growth is to create a regression model between those to related variables. Table 1 includes the main data that would be adopted in regression models (Chinese Statistics Yearbook 2020) (Fig. 7).

Firstly, the correlation between health expenditure per capita and per capita GDP was examined. Their correlation is about 0.99, which is very close to one. There is a strong positive relationship between these two variables, so the regression model is meaningful.

In the summative paper by GERDTHAM, U.-G., AND B. JONSSON (2000), the general regression model is

$$HE_i = b0 + b1GDP_i + b2RP_i + b3DOCT_i + b4TEXMC_i + b5PF_i + b6FEE_i$$
$$+ b7GLOBAL_i + b8FP_i + b9AGE_i + b10URB_i + e_i,$$

where factors other than GDP are also considered. *RP* is relative prices, *DOCT* is the number of doctors, *TEXMC* is the ratio of in-patient to total spending, *PF* is the ratio of government to total *HE*, *FP* is the female participation ratio, *AGE* is the ratio between population 65 years of age and over and population aged 15 to 64, *URB* is urbanization, i.e. the fraction of population living in towns with over 500, 000 inhabitants (1980),

Table 1. REGRESSION DATA SET

	Health Expenditure Per Capita (Yuan)	HE/GDP (%)	GDP per Capita (Yuan)	CPI
1978	11.45	3.00	385	100.0
1979	12.94	3.08	423	101.9
Years	Per Capita Health Spending	Fraction of Total Health Expenditure in GDP	Per Capita GDP	CPI (1978 = 100)
1980	14.51	3.09	468	109.5
1981	16.00	3.10	496	112.2
1982	17.46	3.30	533	114.4
1983	20.14	3.44	591	116.7
1984	23.20	3.33	705	119.9
1985	26.36	3.07	868	131.1
1986	29.38	3.04	973	139.6
1987	34.73	3.12	1122	149.8
1988	43.96	3.21	1377	177.9
1989	54.61	3.58	1537	209.9
1990	65.37	3.96	1667	216.4
1991	77.14	4.06	1916	223.8
1992	93.61	4.03	2336	238.1
1993	116.25	3.86	3021	273.1
1994	146.95	3.62	4073	339.0
1995	177.93	3.51	5009	396.9
1996	221.38	3.77	5813	429.9
1997	258.58	4.01	6406	441.9
1998	294.86	4.32	6749	438.4
1999	321.78	4.47	7134	432.2
2000	361.88	4.57	7846	434.0
2001	393.80	4.53	8592	437.0
2002	450.75	4.76	9410	433.5
2003	509.50	4.79	10600	438.7
2004	583.92	4.69	12454	455.8
2005	662.30	4.62	14267	464.0
2006	748.84	4.49	16707	471.0
2007	875.96	4.28	20541	493.6

(*continued*)

Table 1. (*continued*)

| Years	Per Capita Health Spending	Fraction of Total Health Expenditure in GDP	Per Capita GDP	CPI (1978 = 100)
2008	1094.52	4.55	24250	519.0
2009	1314.26	5.03	26136	522.7
2010	1490.06	4.84	30676	536.1
2011	1806.95	4.98	35963	565.0
2012	2076.67	5.20	39782	579.7
2013	2327.37	5.32	43329	594.8
2014	2581.66	5.48	47233	606.7
2015	2980.80	5.95	50047	615.2
2016	3351.74	6.23	53922	627.5
2017	3783.83	6.36	59967	637.5
2018	4236.98	6.43	65650	650.9
2019	4702.79	6.64	70725	669.8
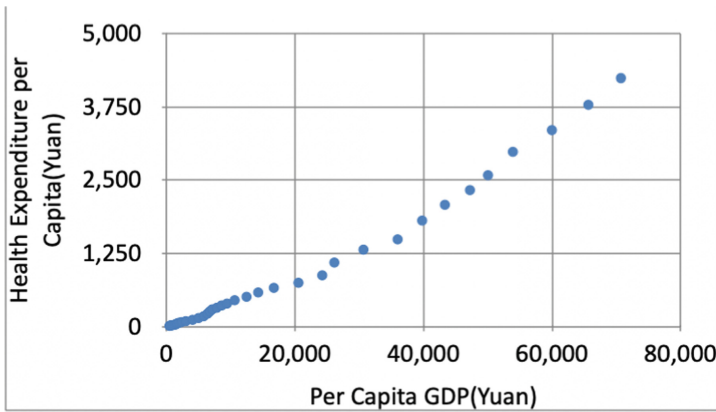
Fig. 7. Regression Model 1.

FEE is a dummy variable for the fee-for-service payment of doctors and *GLOBAL* is a dummy variable for global budgeting caps. The use of regression to determine the relationship between health expenditure and GDP is viable. Besides, the GDP is the most determinant factor of health expenditure and other factors are not significant compare to GDP. According to the research done in China, based on the panel analysis, the GDP is the most significant influential factor [8]. So, the simple regression method is viable for the data set in this paper.

Table 2. REGRESSION MODEL 1 PARAMETERS

Variables	Coefficient	std. error	t-stat.
GDP	0.0617077170596352	0.00123011	50.164579
Intercept	-116.35889	32.4101201	-3.5902024
R-squared	0.98435352		
Adjusted-R	0.98396235		

Table 3. REGRESSION MODEL 2 PARAMETERS

Variables	Coefficient	std. error	t-stat.
LnGDP	1.1318029	0.0072497	156.11798
Intercept	-4.310879	0.0640765	-67.27708
R-squared	0.9983615		
Adjusted-R	0.9983206		

Then, input the data GDP and Health Expenditure was input to build a model. Selecting GDP as x variable, which is independent, Health Expenditure as dependent variable y. Table 2 is the result of a linear regression model with the form of y = a + bx. Health Expenditure = $-116.36 + 0.0617$(GDP).

Though the R-squared is quite high and most of the real numerical value of GDP could be got from the regression equation. The large negative intercept (-116.35889) is unreasonable. A negative numerical value of GDP is not compatible with its setting in reality.

Then the model could be strengthened. According to Yangyansui (2016), in order to eliminate the potential heteroscedasticity problem, the natural logarithm of each variable sequence is processed. The relationship between those two variables by transforming it with logarithms since the previous scatter plot seems to be some kind of curve-like. ln y = bLn(a) + p (Table 3).

$$\text{Ln(Health Expenditure)} = b\text{LnGDP} + c \tag{1}$$

$$\text{Ln(Health Expenditure)} = 1.1318029\text{LnGDP} - 4.310879 \tag{2}$$

Based on the linear regression model, the health expenditure was found to have a significant positive relationship with GDP based on past years of GDP development. For every 1% of increase in GDP, the health expenditure will increase by 1.1318%. As including CPI in the measures, the increase in health expenditure clearly explains that GDP causes the medical industry development. The increasing rate of health expenditure is slightly greater than the GDP.

4   Roles of Health Expenditure and Implication for Public Policies

The COVID pandemic started in 2019 which keeps being rampant now is a potent test on health and medical system for every country. Besides the natural development of health industry led by GDP growth, people should also focus on the private section of health expenditure. While the consumption in China have developed drastically in the past years, the private section of health should also undertake the task of increasing the health coverage in the future. The rapid market development and also present a considerable future development of health institutions. Public and government should invest more in health industry in order to drive long-run economics, fulfill the demand of public, ad bring balance to social market.

5   Conclusion

This paper examined the relationship between health expenditure, GDP, and life expectancy. It confirms the idea of the previous studies that GDP is the strongest cause of the increase in health expenditure. While the spending on medical health increases, the proportion of people's spend on health in per capita GDP also increases, which indicates that people are more and more willing to care about their health conditions as they are getting wealthy. This research confirms the conclusion that the effect of per capita GDP (income) on health care expenditure is clearly positive and significant. The cost of medical care should be measured while the economy is developing in order to find the equilibrium of medical health development and economic development. The relationship between health expenditure and GDP is mutual. Not only GDP is causing the increase in health expenditure. The health expenditure and the supplementary medical development is also benefiting the economy. The private and public section of health spending should both be encouraged in order to increase the tenacity of the economy.

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