

Use the Time Series Model to Analyse the Situation of Health Expenditure and Financing in the United States

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Abstract. As the GDP per capita continues to rise, the economy is developing rapidly. The demand for healthcare has increased accordingly, leading to a change in healthcare-related spending. Consequently, this paper collects data published by the Organisation for Economic Co-operation and Development on US health spending and pharmaceutical spending between 1987 and 2021 and conducts a time-series analysis of the data. It explores the changes that have occurred in health expenditure and financing in the U.S. and makes related forecasts. The analysis results find that health and pharmaceutical related expenditure in the United States shows growth and stability. However, there is a significant issue for these two huge costs, which is unsustainable spending on healthcare. In addition, the results of the predictive model show the United States will experience growth in the next decade to meet the increasing demand of people for health care and to promote a high-quality health care system in the country. Therefore, it is recommended to improve the management of the healthcare system and try to rationalize the allocation of healthcare-related expenses.

Keywords: Health spending; Pharmaceutical spending; Time series; Forecasts; Healthcare.

1. Introduction

As is well-known to all, the U.S. healthcare system is a global leader. The United States has always been an advocate for high-quality health care, and it has a huge innovation advantage in health care, in addition to the fact that the U.S. values healthcare and its costs much higher than any other country [1]. However, huge healthcare-related spending can have negative consequences. U.S. spending on health care is increasing at an unsustainable rate, which could be an issue for the sustainability of U.S. public finances and implies certain problems with the government-run healthcare system [2]. For example, the United States is the only developed country without universal health care coverage, and out-of-pocket health care expenditures and private insurance expenditures are high as a share of GDP [3]. This health care system management problem can lead to reduced incentives to seek care in order to avoid costs, consequently, health outcomes and avoidable mortality rates in the United States are not as high as they could be [3]. Considering the current healthcare expenses and medical status in the United States, and objectively analyses and evaluates the situation. In addition, provide recommendations for reforming the U.S. healthcare system, which will be of great significance in helping the U.S. to improve the sustainability of health care.

This study analyses the actual trends in health and pharmaceutical spending in the United States during this period based on time series data related to health expenditure and financing in the United States published by the Organisation for Economic Co-operation and Development for the last 30+ years. And perform forecasting and related fitting to provide effective recommendations for spending situations where the actual deviation from the fitted results is large and persistent growth in the future is occurring. In addition, this study graphs time-series data on health and pharmaceutical expenditure. Firstly, it presents and explores the plot about these two types of expenses over a period of nearly 30 years. Secondly, show the graph about the prediction of the ARIMA model for these two expenses after 10 years. Finally, fit the time series data for these two healthcare-related costs according to the forecasts. Compare and analyse the actual curves and the fitted curves Emphasise

the spending that differs significantly from the fitted results. And relevant and reasonable recommendations for health care are made.

The following sections of this paper are organised as follows: Part 2 describes the facts abouts the observed results of major healthcare-related expenditures in the United States over the past 30 years; Part 3 analyses the major healthcare expenses by using the time series model, which includes order identification about these two healthcare expenditures, forecasts these two healthcare costs for the next ten years by using ARIMA model, fit the data based on the predicted results and give suggestions for the two major healthcare development in the United States; Part 4 is the conclusion of this full study.

2. Stylized Facts

Health spending represents the final consumption of health care goods and services, and health care costs come from a variety of financing arrangements, including government expenditures, related mandatory insurance, private health insurance and private funds [4]. In addition, pharmaceutical spending mainly includes prescription drugs expenditure and costs on self-medication which is about over-the-counter medicines [5]. These two expenditures represent major health expenditure and financing in the United States. Then, the related exploration in these two expenses will be shown.

As shown in figure 1, the health spending and pharmaceutical spending show increasing trends respectively with a period of about over 30 years, but health cost has a stronger growth trend. Both of these rising costs may be attributed to the importance of healthcare in the United States and the American College of Physicians continues to advocate for high quality in healthcare [6]. In addition, there is no apparent seasonality in the data over this period and there is no evidence of any cyclic behaviour here.

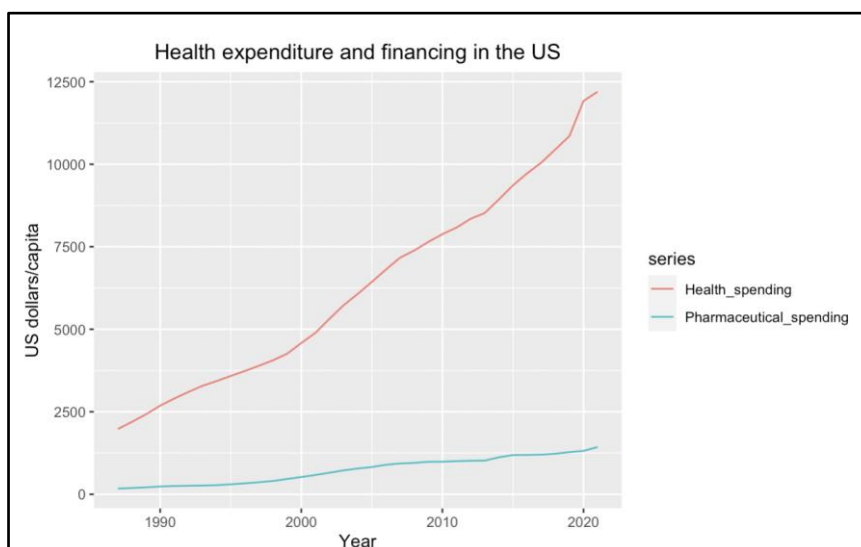


Fig. 1. Health and pharmaceutical spending in the U.S. between 1987 and 2021

Photo credit: Original

For figure 2, this scatterplot helps us to visualise the relationship between these two expenses. It is clear that there is a highly positive relationship between health spending and pharmaceutical spending. This situation implies that U.S. spending on these two major aspects of health care varies together in essentially fixed proportions from year to year, and that the annual change in one of these expenditures with respect to the other is relatively stable.

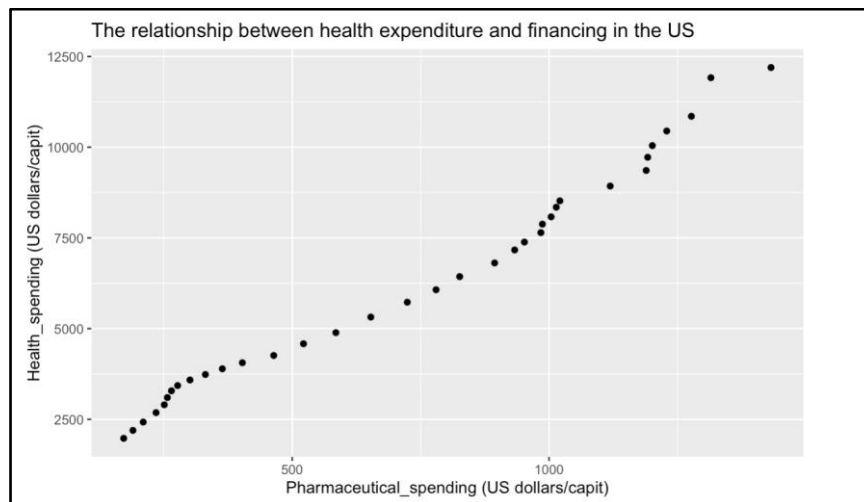


Fig. 2. Health spending plotted against pharmaceutical spending in the U.S. between 1987 and 2021

Photo credit: Original

3. Model Specification

3.1. Order Identification

Figure 3 shows the autocorrelations for health spending in the U.S. and figure 4 is about autocorrelations for pharmaceutical spending. From these two figures, there are large and positive autocorrelations for small lags, then the positive values decrease slowly as the lags increase. This indicates the time series data on health and pharmaceutical expenditure have a trend, which is consistent with the point made above. Moreover, there is no obvious large autocorrelation appearing seasonally, and the autocorrelation is gradually decreasing in both graphs. Therefore, for seasonality, the results are the same as above.

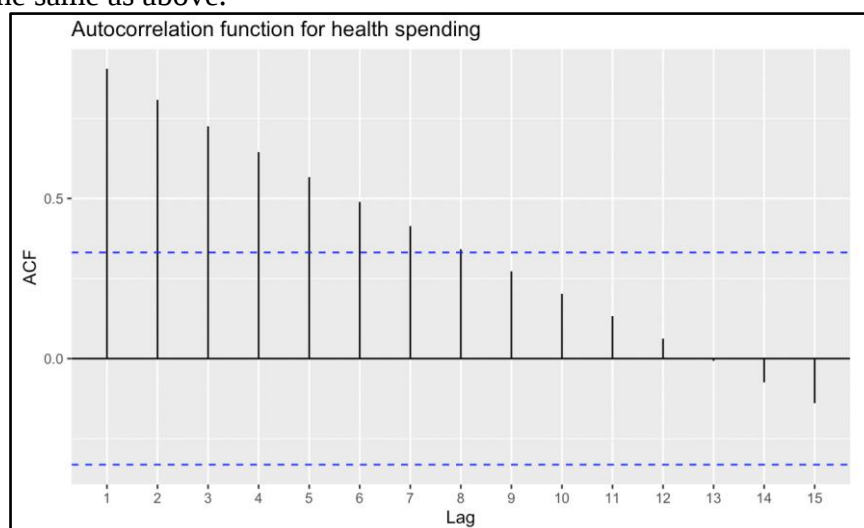


Fig. 3. Autocorrelation function for health spending

Photo credit: Original

The time series data on health and pharmaceutical expenditure are not white noise. For white noise time series, almost all autocorrelations are near zero, in other words, the 95% of the autocorrelations are expected to line within $\pm 2/\sqrt{T}$ or blue bounds and T is the length of the time series data [7]. In these two plots, each contains many large spikes outside these bounds. Thus, these two major healthcare cost data are not white noise, which will not affect the subsequent analysis and forecasts.

The reason is that modelling and forecasting will be impossible for time series that are white noise [8]. Therefore, these two healthcare expenditure data will be used to forecast later.

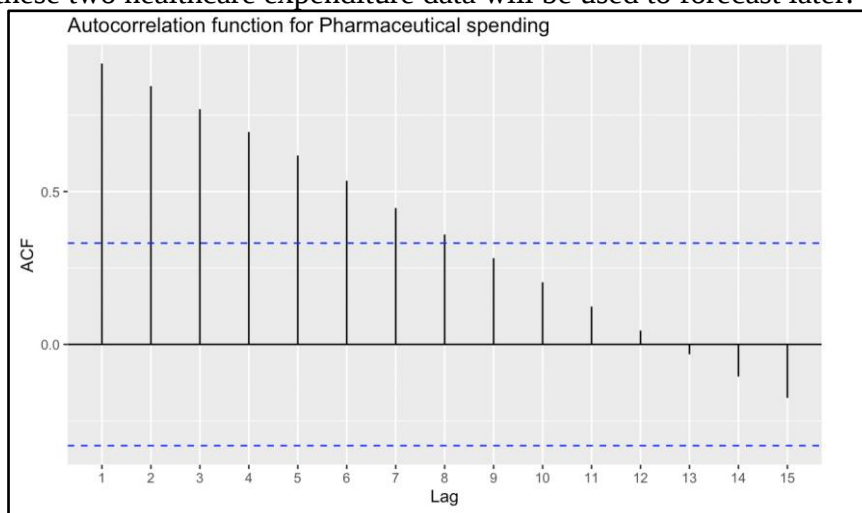


Fig. 4. Autocorrelation function for pharmaceutical spending.

Photo credit: Original

3.2. Forecast the time series data on health and pharmaceutical spending

It is important to use time series models for forecasting. Forecasting can help people to know the upcoming trends and approximate values in advance and helps them to make decisions [9]. And if an unfavourable situation is predicted, people can plan one step ahead.

Figure 5 and Figure 6 are the forecast plots about the time series data on health and pharmaceutical spending. And the ARIMA model is used to do the forecasts for the next ten years. By observing these plots, health and pharmaceutical expenditure will continue to increase over the next decade. And the trends of the next ten years for these two expenditures looks linear which means this forecast fits the previous time series trend. In addition, there are relatively wide prediction intervals in each plot which reflects the variation in the historical spending data.

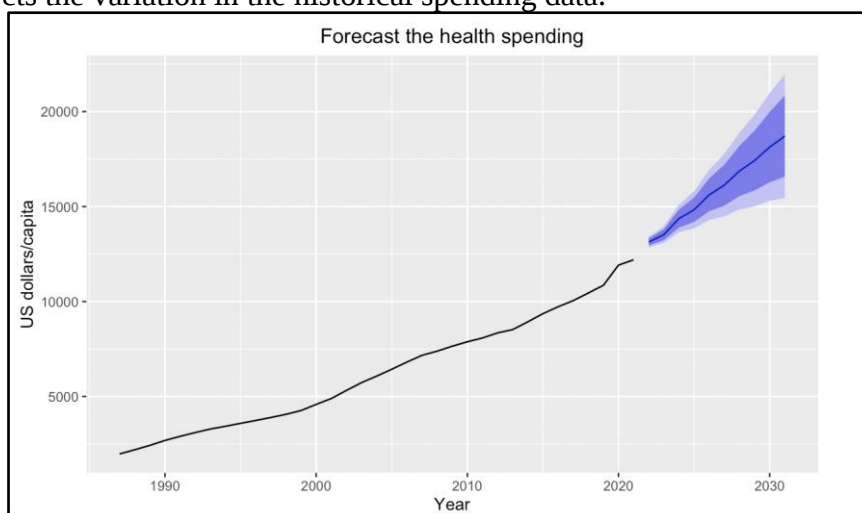


Fig. 5. Forecasts for health spending in the U.S. between 1987 and 2021

Photo credit: Original

Continued growth in spending on both of the major health care of the future is not a good thing for the United States. It can lead to government budget deficits and economic development problems [10]. In addition, the increasing health care costs are attributed to the lack of universal health insurance, high healthcare costs, loose regulation of drug prices, misallocation of health care resources, overuse of high tech care, which can lead to a reduction in the number of people in the U.S.

seeking medical care to avoid high healthcare costs [10]. As a result, the United States may have a higher mortality rate than other developed countries. Moreover, the American public has a higher incidence of chronic diseases such as obesity, diabetes, and heart disease [11]. This is due to the fact that the United States has a problem with the distribution of spending, where too much spending on health care leads to less spending on prevention and public health, hence, the morbidity rate of people in the United States is higher than in other developed countries and the health of people decline [11]. Problems are identified through forecasting, so solutions need to be figured out. After that, the prediction result will be fitted, and a reasonable suggestion will be given.

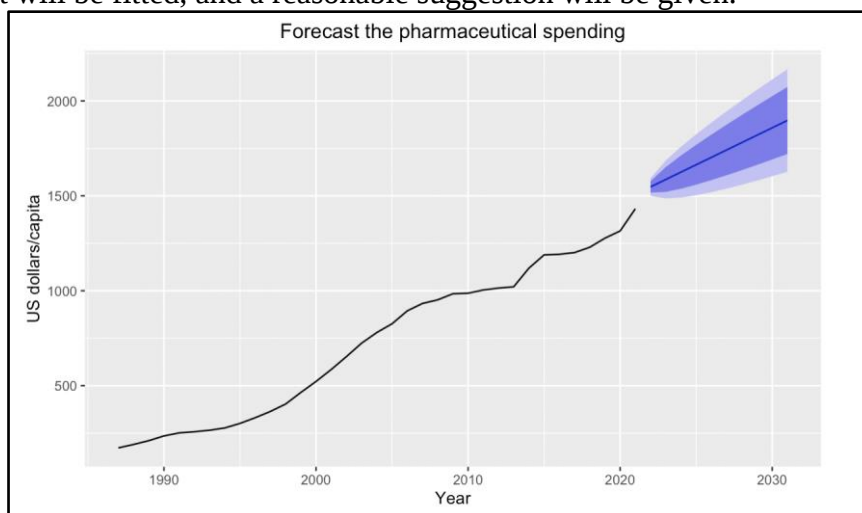


Fig. 6. Forecasts for pharmaceutical spending in the U.S. between 1987 and 2021

Photo credit: Original

3.3. Fit the time series data on major healthcare spending and give suggestions

Model fitting is critical to making accurate predictions and making the right decisions [12]. As shown in figure 7 and figure 8, the fitted values are close to the real data in each plot which means the difference between the one-step-ahead forecast values of the ARIMA model and the actual values is very small. Thus, it indicates the forecasting model is good and accurate. And the results of these forecasts can be trusted and used to make wise recommendations for the United States.

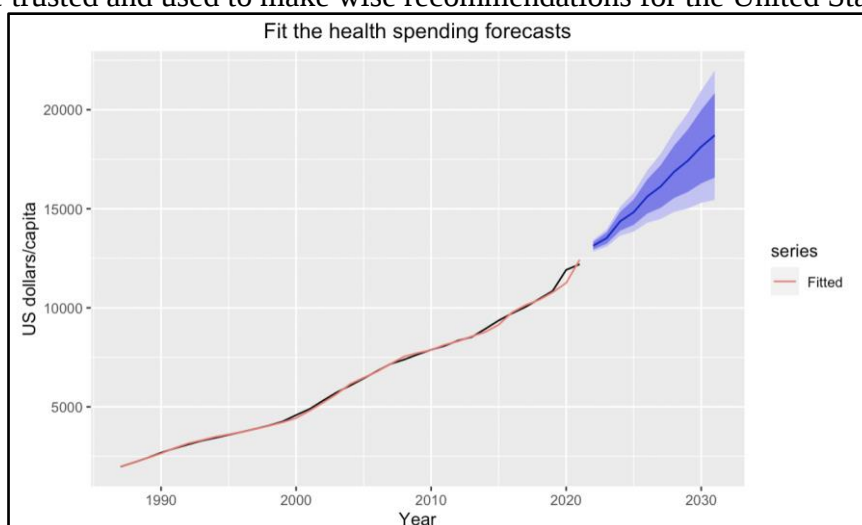


Fig. 7. Fitted model for health spending in the U.S. between 1987 and 2021.

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U.S. health care needs to be reformed in response to the issues that have arisen above regarding the continued increase in health and pharmaceutical spending. A number of proposals for reform will

follow. First of all, the U.S. needs to expand Medicaid or Medicare coverage, with the goal of achieving universal health care, as in other developed countries, so that more low-income, poor people can have access to health care [13]. Second, to improve the efficiency of clinical problem-solving, for example, by avoiding over-treatment and the use of high-expensive care devices [14]. Such unnecessary costs are beyond the means of the average American citizen to receive health care. Costs can be saved by optimising the use of drugs and medical devices. And hospitals or clinics can adopt physician-patient shared decision-making programmes that allow for effective communication between patients and physicians, thereby reducing unnecessary procedures. Third, instead of over-allocating spending to health care, spending could be rationally allocated to a number of other areas related to health care, such as the prevention and improvement of chronic diseases, the integration of patient health, and interventions to address hospital-acquired infections [14]. This would provide the American public with a more holistic approach to medical service without putting too much strain on health care. Fourth, the United States Government should strengthen the regulation of healthcare-related prices, for example, the pricing of insurance companies, address the transparency and structure of prices in medical services, and control the prices of medicines [14]. For the general population of the United States of America, commercial health insurance is expensive, and payment reforms could be used to change the pricing accordingly. And, with regard to price transparency in medical service and drug pricing, the Government could further update its regulations to create a stricter regulatory climate for this purpose. Then, the United States could focus on developing high-value workforces to serve in primary behavioural health, dental care and community health care [15]. Currently, the U.S. has an overrepresentation of highly skilled healthcare workers and is concentrated in high-consumption areas, but there is also a need for primary healthcare services in under-resourced cities and regions. Therefore, the government could call for and encourage a high-value basic workforce and could implement government subsidies for healthcare workers who go to under-resourced states. This could help to reduce the uneven healthcare disparities between states in the United States and also promote a balanced and even development of healthcare in the United States.

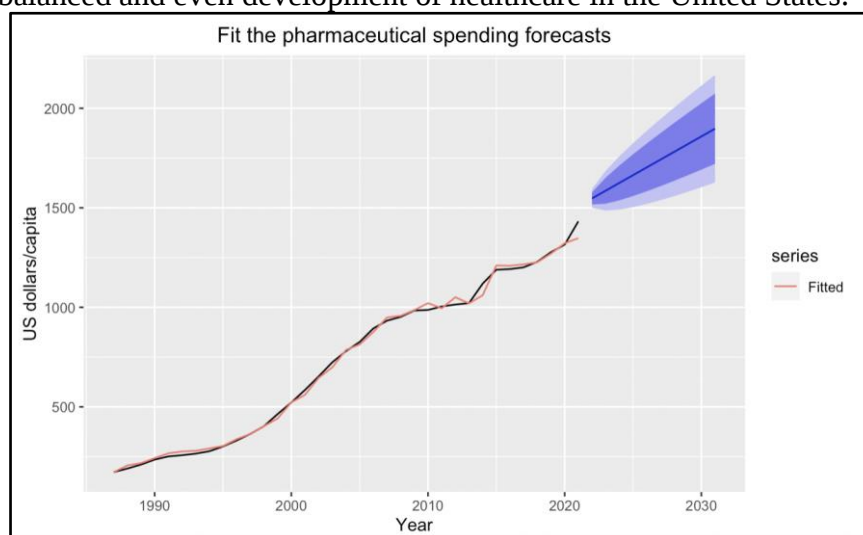


Fig. 8. Fitted model for pharmaceutical spending in the U.S. between 1987 and 2021

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4. Conclusion

This study finds that U.S. health and pharmaceutical spending have been on a continuous growth trend for more than three decades, and that both types of expenses will continue to grow over the next decade. Continued growth in health care costs will lead to increased financial burdens on the U.S., unaffordable health care costs for Americans, increased mortality and chronic disease rates in the U.S., and even an impact on the U.S. economy. The new development of healthcare in the United

States will be carried out through the universalisation of comprehensive health insurance, avoidance of unnecessary costs in health care, transparency and rationalisation of the prices of health care services and products, correcting the problem of excessively high prices in health insurance, rational allocation of healthcare costs, and the development of high-value human resources for basic health care.

The main contribution of this paper is to study and explore the issue of healthcare spending in the US and make reasonable recommendations that will help the US healthcare industry to move to the next level.

However, the current study is not comprehensive enough in terms of resource investigation, there are some resources that are not cited and considered, and the choice of predictive models does not guarantee that the predictions will match the actual future values. Future research will improve and progress in this area to make the article more accurate and reliable.

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