



U.S. GDP Detrended Analysis

Pan Hu¹(✉), Peiyao Ji², Huishan Xu³, Xingyu Shi⁴, and Yi Wu⁵

¹ University of Cincinnati, Cincinnati, OH 45202, USA
hupa@mail.uc.edu

² University of Glasgow, Glasgow G12 8QQ, UK

³ Qingdao No. 58 Middle School, Qingdao 266100, China

⁴ Huaer Zizhu Academy, Shanghai 201102, China

⁵ Suzhou Science and Technology Town Foreign Language High School, Suzhou 215001, China

Abstract. This paper uses a detrending approach to examine the factors influencing U.S. GDP. We selected U. S GDP data from 1981 to 2021 from the Bureau of Economic Analysis to make the sample reliable. We estimate factors that affect GDP, including consumption, investment, and government spending. We analyzed the trend of the data by adding the linear regression method. Through the detrending treatment of the influencing factors, we found that taking a short-term perspective; Investment is more volatile than consumption, so the government should stimulate investment. From a long-term perspective, it would be more prudent for the government to encourage consumption because consumption is less volatile than investment. There will be steady growth in the GDP. GDP influences government spending over two years.

Keywords: Gross Domestic Product · Detrended · Cyclical · Standard Deviation · Correlation

1 Introduction

GDP measures the dollar value of final goods and services produced within the nation's borders in one year. Specifically, the components of GDP include consumption, investment, government spending, and net exports. Nowadays, GDP is becoming an increasingly reliable source to reflect the economic strength of the country. Thus, plenty of methods appear to analyze GDP. This paper uses detrending as an approach, and since GDP are time series data, we can effectively observe the cyclical change of GDP. We collected the data from BEA, including U.S. GDP from 1981 to 2021. According to the data, we design co-movement charts for the cyclical components of U.S. GDP consumption, investment, and government spending. Through actual data trends, we applied linear fitting to regress data into a straight line. Additionally, we calculated the standard deviation of the cyclical components of U.S. GDP, consumption, investment, and government spending. Furthermore, we calculated the correlation between cyclical components of

P. Hu, P. Ji, H. Xu, X. Shi and Y. Wu—Contributed equally to this work and should be considered co-first authors.

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U.S. GDP and the three variations. Consequently, for a short-term economic crisis, the government should stimulate investment. Since investment has high risks, it results in high-profit returns or a significant loss. If the government invests successfully, it can gain tremendous money to face the short-term economic crisis. Whereas for a long-term financial crisis, the government is supposed to stimulate consumption. It is appropriate that if we want to achieve a high consumption level, we need a relatively long period, and if we approach this high level, it is hard to fall from the high consumption level. That is, the increased consumption level is stable. Furthermore, if there is no noticeable change in long-term or short-term economic crisis, government spending can play a vital role in assisting.

2 Literature Review

The vast majority of articles published to date have focused on filtering techniques to extract the ‘trend’ and ‘cyclical’ components of time series. For example, Canova shows that Gross national product, investment, and consumption play a significant role in the de-trending of standard macroeconomic time series. In addition, there is a mathematical correlation between the ‘cycle’ and the standard deviation of Gross national product, as well as the standard deviation of other factors such as investment and consumption relative to Gross national product [1]. On the other hand, Burnside comes to a different conclusion. Previously there were limitations to this approach through the use of extensive filtering techniques, i.e., extracting ‘trends’ and ‘cycles’ in time series. Therefore, the examination of models and data has emerged as an alternative to filtering techniques [2, 3].

3 Methodology and Data

This paragraph explains the definition of standard deviation, how it is measured, and reports the standard deviation values for the GDP, consumption, and investment components of the United States from 1981 to 2021, along with their ratios and meanings. Gorard and Stephen showed that the standard deviation is defined as the square root of the arithmetic mean of the standard value of each unit of the total and the square of the deviation from its mean [4]. Roberson et al. explained that Standard deviation is a statistic that measures the dispersion of a dataset relative to its mean [5].

$$SD = \sqrt{\frac{\sum (x_i - \bar{x})^2}{n}} \quad (1)$$

By calculation:

GDP Cyclical SD = 0.0264

Consumption Cyclical SD = 0.0328

Investment Cyclical SD = 0.1094

Consumption Cyclical SD/GDP Cyclical SD = 1.2

Investment Cyclical SD/GDP Cyclical SD = 4.1

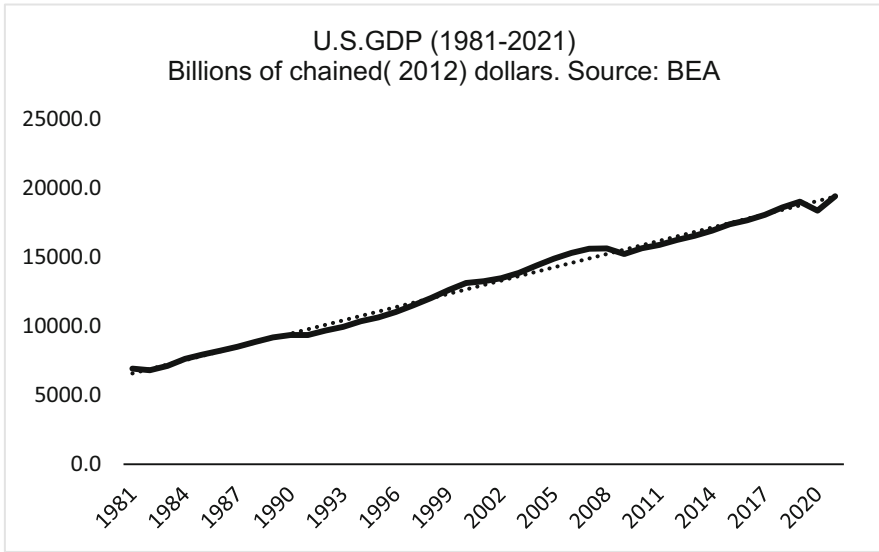


Fig. 1. U.S.GDP (1981–2021) Billions of chained (2012) dollars [Owner-draw].

The calculations revealed that the standard deviation of consumption is 1.2 times the standard deviation of GDP. This implies that the volatility of consumption is 1.2 times greater than the volatility of GDP. Furthermore, the standard deviation of investment is 4.1 times the standard deviation of GDP. This represents that the volatility of an investment is 4.1 times the volatility of GDP.

This paragraph presents the definition of correlation and what it measures and reports on the two correlation values of GDP with investment and consumption, respectively, in the US for the period from 1981 to 2021 and what they mean. The definition of correlation is a statistic that measures the degree to which two datasets move in coordination with one another. Furthermore, the value of correlation lies in the range of minus one to one. If the correlation value is close to 1, then the two show a positive correlation. If the correlation value is close to minus 1, the two are negatively correlated. If the correlation value is close to 0: then there is no correlation between the two. It is clear from the calculations that the Correlation between GDP and Consumption = 0. 9029. And the correlation between GDP and Investment = 0. 7953. Thus, GDP and consumption show a high positive correlation. Additionally, GDP and investment are highly positively correlated.

The data of Personal consumption and expenditures of the USA from 1981 to 2021 are cited from BEA (Bureau of Economic Analysis) as shown in Fig. 1, with the standard of billions of chained (2012) dollars.

Consumption as one of the four constituent sectors of gross domestic product cannot be neglected when analyzing the GDP trend (see Fig. 2). Consumption is one of the embodiments of the economic capabilities of a nation. Nevertheless, the fluctuation of the total expenditure could show changes in citizens' income quantitatively; furthermore, within the consumption analysis, more problems can be found and displayed. The consumption sector is categorized into three sections, durable goods, nondurable goods,

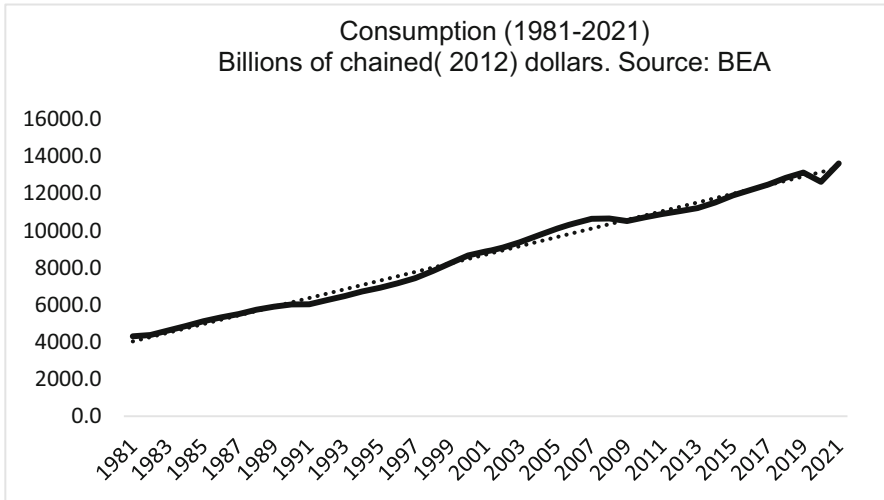


Fig. 2. Consumption (1981–2021) Billions of chained (2012) dollars [Owner-draw].

and services. Specifically, nondurable goods are any consumer goods in an economy that are either consumed in one use or used over a short period and must be repurchased in successive purchases. The opposite of nondurable goods is durable goods; the lifetime is expected to be greater than 3 years. During the analysis, the nondurable goods are not considered an economic indicator due to their stable figure; by contrast, because purchases of durable goods increase during economic growth and decrease during a recession, they are considered a reliable economic indicator.

To find the relationship between domestic consumption and GDP, the correlation between consumption and GDP is required to be observed; the closer the number gets to 1, the more positively correlated, while the number far away from 1, it is more negatively correlated. As the data shows, the GDP and consumption are a highly positive correlation, which represents that when one variable varies, the other one will be significantly influenced. Observing the graph at the point of 2019, the trend of the GDP and consumption is similar. However, the consumption tendency is more volatile, corroborating the strong correlation between the two factors.

Regarding the quantity of the consumption of the US, the overall trend of the total consumption of US civilians has been upward since 1981, from 4310 bn to 13624.8 bn and 62% of the GDP in 1981 to 70% of GDP in 2021. The Balance of Payments and Direct Investment Position Data in The USA shows a growing trend from 1981 to 2021 which means that the American economic field in investment has stable growth. From the data collected by the BEA website, the Balance of Payments and Direct Investment Position in all countries increased from 207725 million to 6489012 million between 1981 and 2021.

Figure 3 shows the data on the Balance of Payments and Direct Investment Position Data in all countries in total. It shows the steady rise in American investment. And the dotted line is the best fit line of the Balance of Payments and Direct Investment Position

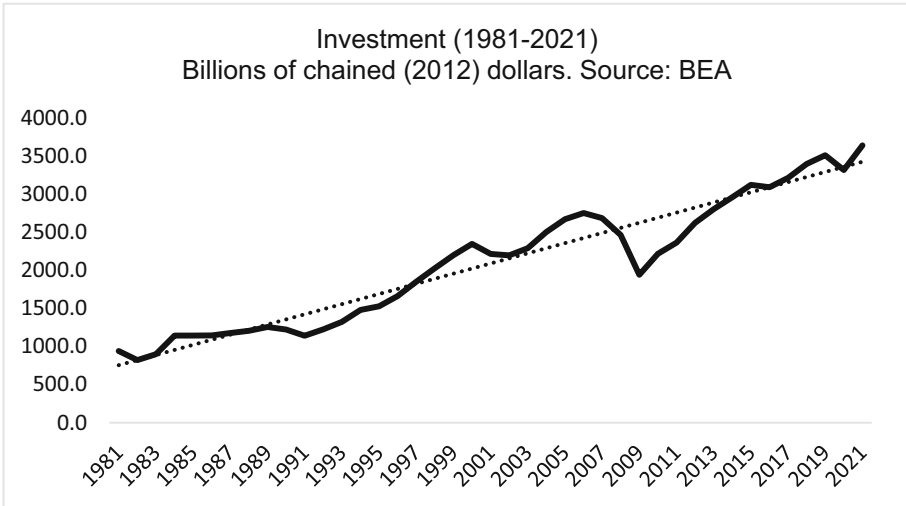


Fig. 3. Investment (1981–2021) Billions of chained (2012) dollars [Owner-draw].

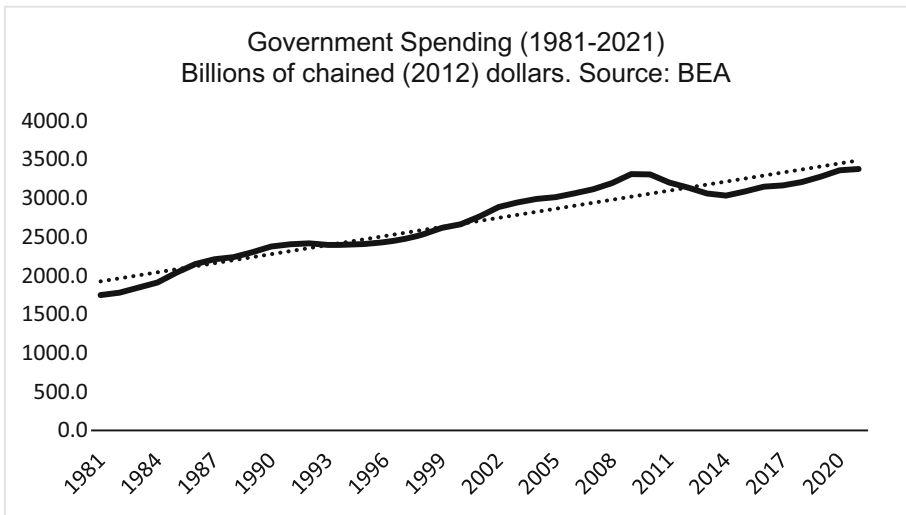


Fig. 4. Government Spending (1981–2021) Billions of chained (2012) dollars [Owner-draw].

Data in all country’s total trends. Used by the formula of $y = 66.722x + 689.04$, its graph can be calculated.

After comparing the cyclical components of GDP and government spending, we find that government spending changed relative to GDP, but the trend between the two lines is the same. They move up or down at the same time. In 1981, government spending decreased by 10.2%, following a decrease of 10.4% in 1982. Although it dropped until 1985, its descent range became smaller. Nevertheless, government spending increased

between 1986 and 1993. The rise is relatively small compared to the fall. Specifically, it increased by 1.3% in 1986, while increased by 0.1% in 1993. Government spending decreased again between 1994 and 2000, but the range is smaller than before. To be more exact, in 1994, it fell by 1.5%, in 1997, it dropped by 3.2%, and in 2000, it declined by 0.2%. However, government spending kept rising from 2001 to 2009, and it increased at an increasing rate; it raised by 2% in 2001, following an increase of 5.2% in 2006 and increased by 8.8 in 2009. Whereas from 2010 to 2011, government spending increased at a decreasing rate. In 2012, it stayed the same. Government spending decreased again from 2013 to 2021. Specifically, in 2013, government spending fell by 3.8%; in 2017, it decreased by 5.3%; and in 2021, it decreased by 3.3%. The cyclical component of government spending is 1.5 times the cyclical component of GDP. The correlation between GDP and government spending is 0.04, which shows that GDP and government spending are highly negatively correlated. Government spending dropped by 10.4% and reached its lowest point in 1981, while it increased by 8.8% and reached its highest point in 2009.

4 Results and Discussion

Regarding the quantity of the consumption of the US, the overall trend of the total consumption of US civilians has been upward since 1981, from 4310 bn to 13624.8 bn. From 62% of the GDP in 1981 to 70% of the GDP in 2021. The rise of the USA's gross domestic output is embodied by the increasing trend of purchase of durable goods as they represent the commodities that require multiple and successive purchasing. Due to the lack of data, detailed data are available from 2002 to 2021. Specifically, it is 1405 billion in the growth of numbers which spans a very large scale. During the same period, the GDP has the same up and down trend in numbers. The furthermore information will be shown on the Fig. 4.

While observing the Fig. 5, the consumption and GDP have a similar movement and trend, and the tendency between the two factors are highly similar. To prove their correlations, using the equation by dividing their standard deviation, the result is 0.903775 which suggests that the GDP and total consumption have a high correlation, the movement of the consumption could cause the same effect on the GDP. At the beginning of 1981, the investment had a total of 940.1 billion, through forty years of development, this number has eventually reached 3640 bn which increased by 2700 bn. Despite the overall tendency, there are also fluctuations in the components. In the structure, for instance, the numbers fluctuated between 400 to 500 bn. The final number in 2021 is even lower than in 2002.

Observing the Fig. 6, the investment also has a similar trend compared with GDP but with more volatile movements. Compared with the trend chart of consumption, the trend of investment does not have much overlap with the image of GDP. Still, the roughly same fluctuation also confirms the correlation between the two parameters. After the calculation, the correlation between the two factors is 0.795, also close to 1. As a result, investment and GDP do have a strong relation.

Government consumption expenditures and gross investment consist of federal, national defense, nondefense, state and local, and the residual. Over the forty years

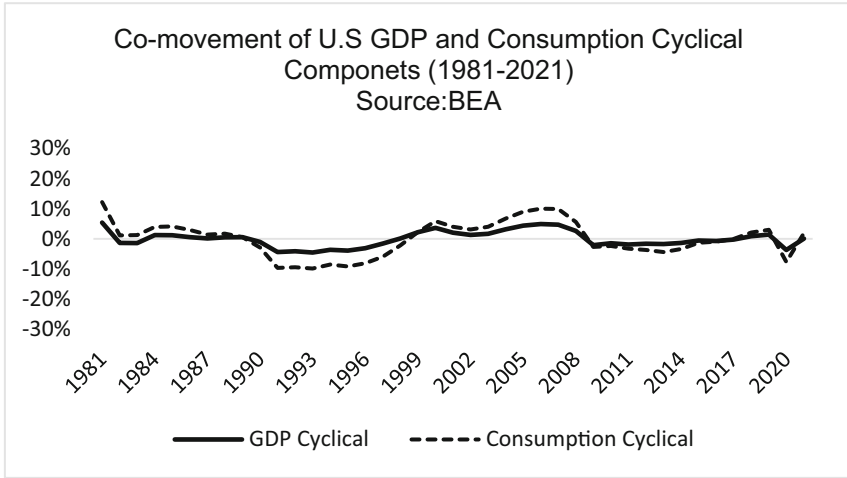


Fig. 5. Co-movement of U. S GDP and Consumption Cyclical Components (1981–2021) [Owner-draw].

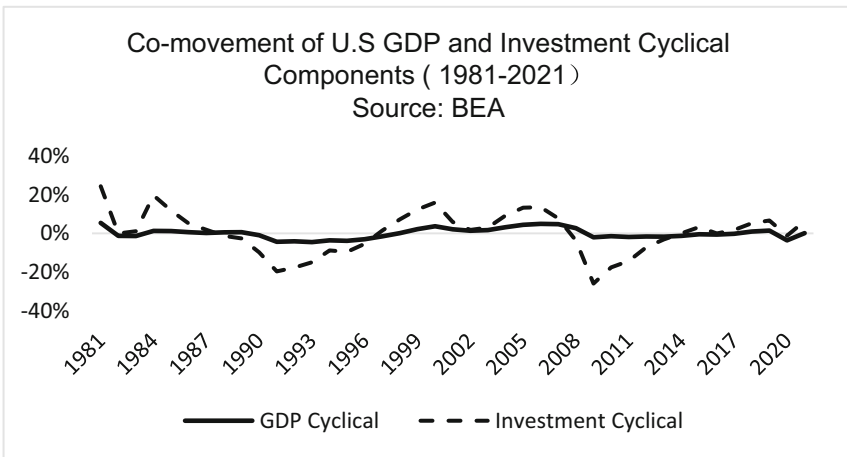


Fig. 6. Co-movement of U.S GDP and Investment Cyclical Components (1981–2021) [Owner-draw].

of the period of time, government spending enhanced by 1627 billion dollars. The cyclical component of government spending relative to GDP shows a trend of 2 years later. Moreover, the cyclical component of government spending moves between -10.4% to 8.8% .

While observing the Fig. 7, the tendency of government spending is completely different from the GDP graph, and it is hard to find similarities. Through the calculation, the correlation between the GDP and the government spending is 0.04012 which represents the weak relation between the two factors as the correlation is stronger when its number

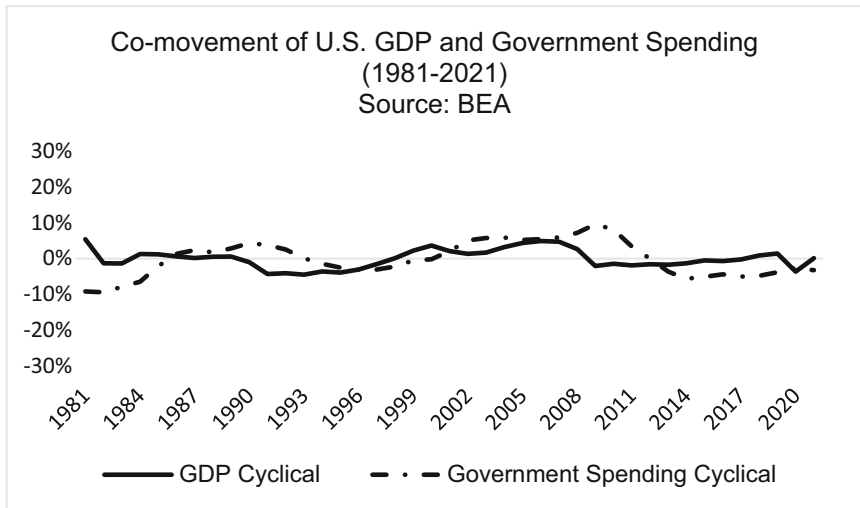


Fig. 7. Co-movement of U.S GDP and Government Spending (1981–2021) [Owner-draw].

is closer to 1. However, if the image of government spending is moved Slightly there will be several overlaps between the graph. To prove this hypothesis, a new calculation is introduced. The GDP cyclical's first year (1981) is removed, and the last year of the government cycle (2021) is also removed. After this process, as a result, the correlation between the two factors is higher than before. Repeat this method by cutting more years. The result is that for every two years, the correlations will be the greatest.

5 Conclusion

In this paper, the factors influencing US GDP are examined using a detrending approach. We will introduce the three main components of the article and the methods used to measure the results. All data come from BEA, and the graphs use co-movement. GDP measures the dollar value of final goods and services produced within the nation's borders in one year. The four parts make up the total GDP of America that are consumption, investment, government spending, and net exports. We draw co-movement pictures to illustrate the correlation between GDP and the others by using various calculations of detrending, standard deviation, and graphs. As a result, we found that investment is a tool that can be used in the short term and run money for the government quickly. Whereas consumption helps solve the long-term crisis and is much more stable than others. Government spending plays a role in assisting other methods when the outcome is far from the expectation. As for recommendations, the theories aren't appropriate in all situations. Therefore, which tool should be used is still decided by the problem faced.

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