Proceedings of the 7th International Conference on Economic Management and Green Development
DOI: 10.54254/2754-1169/39/20231969

The Impact of U.S. Quantitative Easing Policy on the Domestic Economic Cycle Based on HP Filtering

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Abstract: With the deepening of global economic integration, the trend of global trade and financial integration is increasing in parallel, while the degree of interconnectedness and mutual influence among national economies is also increasing. This paper uses HP Filtering method and Granger Causality Test to verify and analyze the effect of quantitative easing policy on economic cycle based on CPI and PPI data. After the comparative analysis, it is concluded that after the implementation of quantitative easing policy, the economic cycle of the United States is less volatile and more stable. And the time in the boom period is significantly extended. However, the speed of recession begins to accelerate after the increase in magnitude. Therefore, the quantitative easing policy is a strong agent, which has a strong effect on economic stability and growth, but it also brings non-negligible after-effects. Countries should pay attention to the reasonable and appropriate use, otherwise it will trigger larger economic fluctuations which bring economic crisis.

Keywords: economic cycle, quantitative easing, monetary policy cycle, Granger Causality, HP Filtering

1. Introduction

Inflation has a serious negative impact on people's lives, which has been proven throughout human history. Especially after the financial crisis in 2008, central banks in countries responded to the global recession by cutting interest rates to stimulate economic growth. However, as the short-term interest rates approached zero, those developed countries, such as the United States, turned to the implementation of quantitative easing. This policy increased the money supply indirectly by converting illiquid Treasuries and mortgage bonds held by commercial banks into monetary assets through open market operations. Despite the quantitative easing monetary policy adopted by countries in turn, the price level did not show a significant increase. Instead, the GDP growth rate dropped sharply. As the largest economy in the world, and with the obvious tendency of synchronization of economic cycles in various countries, the changes in the monetary policy of the United States have a huge impact on its own economy and the economies of other countries [1, 2].

Under the situation of economic globalization, the economic development of each country is closely connected. When analyzing the monetary policy of a certain country, it must be discussed in

DOI: 10.54254/2754-1169/39/20231969

the global context. The statistics show that quantitative easing from 2000 to 2020 did not bring the danger of inflation, and controlled inflation is a prerequisite for the introduction of quantitative easing in the U.S. The specific indicators announced by the Federal Reserve are that long-term market interest rates will not increase significantly, and from the U.S. economic data during the period of quantitative easing, these conditions are met one-by-one U.S. Treasury Market reflected on the U.S. inflation in the next decade expectations have been at around 2%. There is no danger of inflation making the Fed more patient in its use of quantitative easing. However, due to the global spread of the epidemic, the Fed's inflation rate increases rapidly to 7% since 2020. Although it decreases in 2022, it is still a non-negligible increase compared to the last decade [3, 4].

Unconventional Monetary Policy (UMP) has been used and studied for more than 20 years. Since Japan first adopted quantitative easing in 2001, the world has experienced a series of crisis events, including the U.S. subprime mortgage crisis, the turmoil in international financial markets, the European debt crisis, the shortage of the U.S. dollar, and the trade frictions. Faced with these challenges, countries have turned to unconventional monetary policies as the main measure to cope with financial and real economic downturns and have been expanding and improving their operational systems. A large number of studies have shown that quantitative easing was a powerful instrument in the 2008 financial crisis, and its effect was remarkable. It avoided the greater losses brought by this crisis and thus accelerating the speed of economic recovery. For instance, Vasco & Woodford used the New Keynesian Model on the impact of changes in the size and structure of central bank balance sheets on the economy under quantitative easing monetary policy analyzing that the central bank asset purchases and balance sheet structural changes were effective in stimulating economic recovery when the monetary transmission mechanism was impeded under the prevailing financial system and economic development environment [5]. In the following year, Moukisha analyzed the characteristics and operational mechanisms of quantitative easing monetary policy and concluded that quantitative easing was a bold breakthrough from traditional policy, which innovated monetary policy tools, mitigated the worsening of the financial crisis to some extent, and became an important policy option for central banks to respond to the economic and financial crisis after the failure of traditional monetary policy [6]. Burns et al., on the other hand, predicted that if quantitative easing is no longer implemented in the United States, the inflows to emerging economies through asset portfolio adjustment will decline at a rate of 10% per year, or about 0.6% of their GDP, which will cause emerging economies to have to curtail their fiscal spending, thus affecting their economic growth [7].

Meanwhile, many other scholars have conducted empirical analyses of quantitative easing policy in boosting the confidence of market economic agents, improving financing conditions, and repairing the transmission mechanism of monetary policy, concluding that quantitative easing policy does help the economy recover smoothly [8, 9]. With the improvement of economic conditions in the United States and even the world, most scholars focus on the positive effects brought by quantitative easing policy. The research results of previous scholars cannot be ignored, but there are some parts that can be innovated, such as studying the changes of more different indicators under this policy, etc. Also, because the world economic system is a multi-node interacting whole, a single consideration of the impact between two countries is not enough, and in addition to studying the impact of quantitative easing policy on their own countries, the spillover effects on other countries can also be considered for analysis [10].

Therefore, on the premise of many scientific studies, in order to further interpret the association between economic cycle fluctuations and unconventional monetary policies like quantitative easing, this paper chooses the representative U.S. and its U.S. dollar as the research object. It based on the historical data of the U.S., and starts the study of the impact of quantitative easing monetary policy on the economic cycle of the U.S. as well as its spillover effects. The main research focus of the paper

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is put on the impact on the economic cycle. The spillover effects are only slightly mentioned in this paper.

2. Methodology

2.1. Data Source

This paper selects three indicators, Consumer Price Index (CPI), Producer Price Index (PPI) and base money (B), based on quarterly data from 1982 to 2022. The purpose of the indicators is clear, and the cyclical component obtained from the separation of CPI and PPI data represents the fluctuation of economic cycle, and the change in the data of base currency represents the implementation of quantitative easing policy [11]. Secondly, the years of indicators are selected for the past four decades, and the data are selected from the U.S. Department of Labor and various news, which are sufficient to help the analysis of this paper. In addition, the indicators are operational, and the model can be built to predict the subsequent economic development cycle and to conduct quantitative analysis.

2.2. Indicator Selection and Description

In this paper, two macro indicators, CPI and PPI, are used as tools to estimate the macroeconomic level and economic cycle. By using Augmented Dickey-Fuller test (ADF test) to test the smoothness of the two indicators before the beginning of the study, it is found that they are non-stationary series and there is a trend term. The Hodrick-Prescott Filter method (HP filtering method) was then used to decompose CPI and PPI based on the premise of quarterly data from 1982-2008 and 2009-2022 respectively, to obtain the cyclical component, the trend component and their graphs, where the cyclical component represented by CPI and PPI represents the economic cycle of changes.

Then, by using the image comparison method, this paper compares the differences between the economic cycles in the period of 1982-2008 when quantitative easing was not started and the period of 2009-2022 when quantitative easing was started respectively, to derive the impact of quantitative easing policy on the economic cycle in the United States.

Finally, to ensure logical rigor, a Granger causality test will be used to analyze whether Base Money (B) is the Granger cause of CPI and PPI changes. Because the cycle components of CPI and PPI are used to represent the economic cycle, and the quantitative easing policy mainly brings the change of base money. If B is the Granger cause of the change of CPI and PPI, then it can indirectly prove that quantitative easing is indeed one of the causes of the change of economic cycle.

2.3. Introduction to the Method

2.3.1. ADF Test

The following autoregressive model was estimated for the obtained data series using Ordinary least squares estimators method (OLS method):

$$Y_t = \alpha + \beta t + \gamma Y_{t-1} + \sum_{i=1}^{p} \alpha_i \Delta Y_{t-i} + \varepsilon_t \quad (1)$$

where:

$$\Delta Y_t = Y_t - Y_{t-1} \quad (2)$$

The OLS estimate $\hat{\gamma}$ of γ is obtained, where ε_t is the white noise with independent identical distribution and zero mean and constant variance, and p is the order of autoregressive model of Y_t.

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The original hypothesis H0: γ = 1 is proposed, and the conventional t-statistic is used as the test statistic:

$$t = \frac{\hat{\gamma}-\gamma}{\hat{\sigma}_{\hat{\gamma}}} \tag{3}$$

where $\hat{\sigma}_{\hat{\gamma}}$ is the standard deviation of $\hat{\gamma}$.

This paper calculates the t-values at different significance levels (1%, 5%, 10%) under the original hypothesis holds, and query the critical values of MacKinnon's unit root test (-4.24, -3.54, -3.20, respectively). If the t-value is greater than the critical value, the original hypothesis cannot be rejected and it is a non-stationary series, otherwise the opposite.

2.3.2. HP Filtering Method

The HP filtering method sets $\{Y_t\}$ to be an economic time series containing trend and fluctuation components, $\{Y_t^T\}$ to be the trend component and $\{Y_t^C\}$ to be the fluctuation component [11]. The equation is as follows:

$$Y_t = Y_t^T + Y_t^C, t = 1,2,3,\cdots,T \tag{4}$$

The trend component $\{Y_t^T\}$ is then separated from $\{Y_t\}$ by a method of solving the minimization problem, where $\{Y_t^T\}$ is the solution of the minimization problem below:

$$\min\{\sum_{t=1}^{T}(Y_t - Y_t^T) + \lambda[c(L)Y_t^T]^2\} \tag{5}$$

where: $c(L)$ is the delay operator polynomial.

$$c(L) = (L^{-1} - 1) - (1 - L) \tag{6}$$

where λ is the smoothing parameter, and the main discussion is also on the selection of λ. Since this paper is currently using quarterly data, it will choose λ = 1600 as the basis for the calculation based on general experience.

2.3.3. Granger Causality Test

Regress the current Y on all lags, i.e., Y on its lags Y_{t-1},Y_{t-2},…, and other variables, but do not include the lag X in this regression, which is a constrained regression. The constrained residual sum of squares RSS_R is then obtained from this regression, with the following equation:

$$Y_t = \sum_{i=1}^{s} \alpha_i Y_{t-i} + \mu_{1t} \tag{7}$$

Do a regression with a lag term x, i.e., add the lag term x to the previous regression equation, which is an unconstrained regression, and from this regression obtain the unconstrained residual sum of squares RSS_U, and the equation is as follows:

$$Y_t = \sum_{i=1}^{s} \alpha_i Y_{t-i} + \sum_{i=1}^{m} \beta_i X_{t-i} + \mu_{2t} \tag{8}$$

The null hypothesis is H_0:$\alpha_1 = \alpha_2 = \alpha_3 = \cdots = \alpha_q = 0$, i.e., the lag term X does not belong to this regression. To test this hypothesis, the F test is used, i.e.:

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$$F = \frac{RSS_R - RSS_U}{m} \Big/ \frac{RSS_U}{n-(s+m)} \tag{9}$$

It follows the F distribution with degrees of freedom m and $n-(s+m)$.

Here, n is the sample size, m is equal to the number of parameters to be estimated in the constrained regression equation, and $s+m$ is the number of parameters to be estimated in the unconstrained regression.

The null hypothesis is rejected if the F value calculated at the selected significance level α exceeds the critical value F_α, such that the lag term X belongs to this regression, indicating that X is the Granger cause of Y.

3. Results and Discussion

3.1. Test Results and Image Display

3.1.1. ADF Test Results

Before taking the ADF test, this paper found that the CPI and PPI indices have trend terms through observation. The paper selected the CPI and PPI data for a total of 40 years and 160 quarters from 1982 to 2022 for the ADF test containing time trends and calculated the t-values of -1.896 and -2.887 for the two respectively.

The MacKinnon critical values of the unit root test are -4.244, -3.544, -3.205 at 1%, 5%, and 10% significance levels respectively, and the t-statistic is greater than the response critical value, which cannot reject H_0, indicating that the CPI and PPI series have unit roots and are non-stationary series and need to be filtered. Where the CPI test equation is:

$$CPI_t = 6.785 + 0.085t - 0.074CPI_{t-1} + 0.547\Delta CPI_{t-1} - 0.255\Delta CPI_{t-2} + 0.356\Delta CPI_{t-3} + 0.225CPI_{t-4} \tag{10}$$

The PPI test equation is:

$$PPI_t = 5.509 + 0.061t - 0.066PPI_{t-1} + 0.491\Delta PPI_{t-1} \tag{11}$$

3.1.2. HP Filtering

According to relevant reports, the U.S. began implementing quantitative easing in October-December 2008. To facilitate comparison, this paper splits the data into 1982-2008 as the data without non-monetary policy (quantitative easing) and 2009-2022 as the data where the paper implemented quantitative easing, and filtered them separately to obtain the four graphs below, as Figure 1, 2, 3 and 4 shows.

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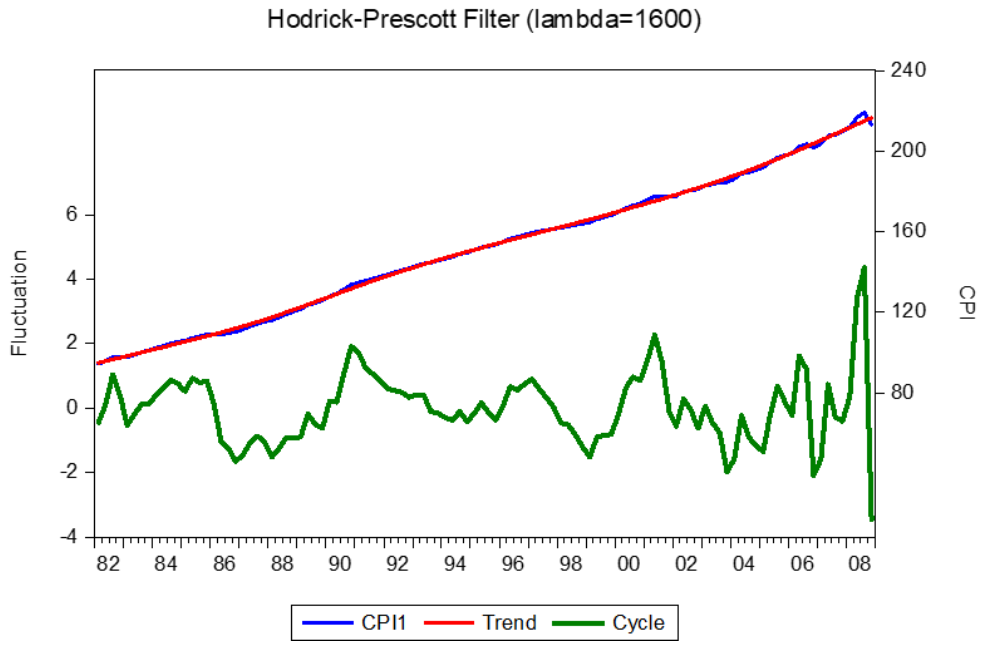

Figure 1: HP Filter of CPI from 1982 to 2008.

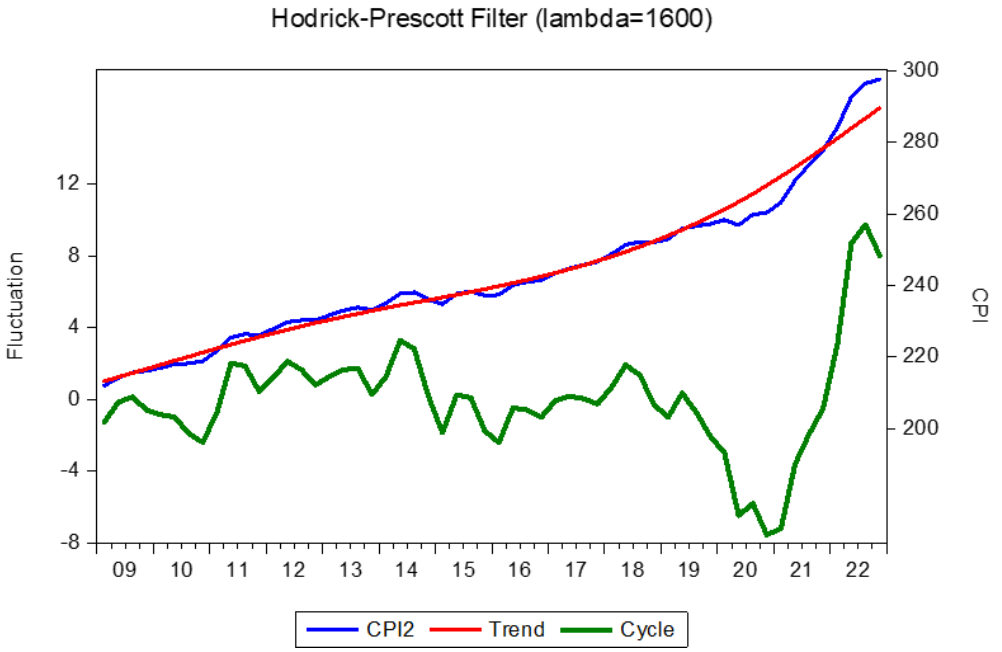

Figure 2: HP Filter of CPI from 2009 to 2022.

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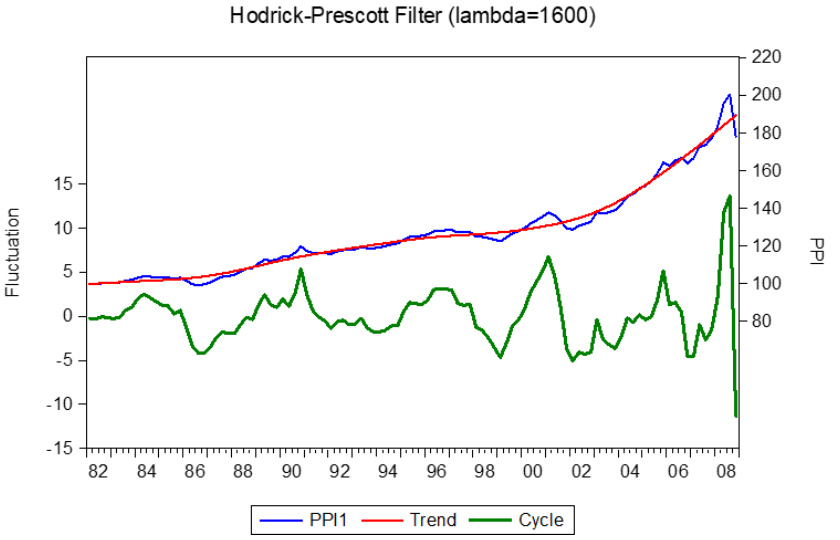

Figure 3: HP Filter of PPI from 1982 to 2008.

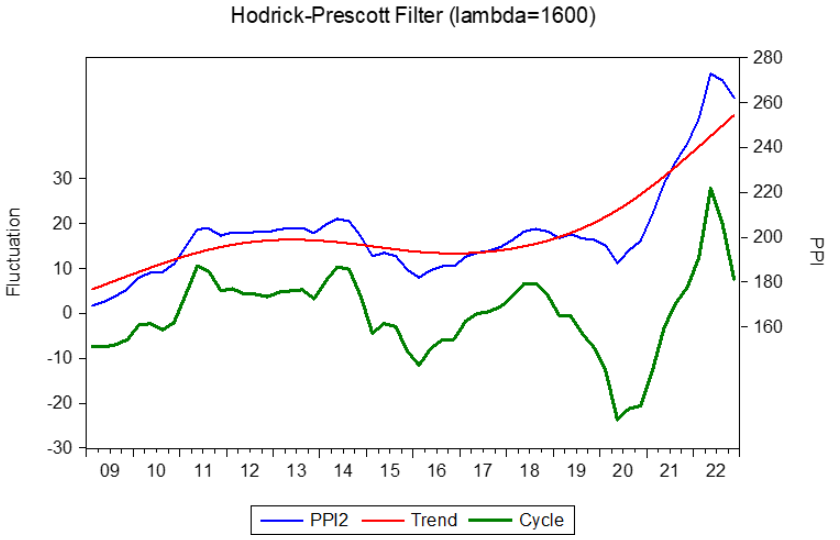

Figure 4: HP Filter of PPI from 2009 to 2022.

3.1.3. Granger Causality Test

To further identify it as the cause of the cyclical fluctuations, this paper use Granger Causality Test to determine B as its Granger cause. Under the condition of first-order lagged values, it can be seen that in the hypothesis, B is not the Granger cause of CPI and PPI which has p-values of 0.001 and 0.012 (Table1), which rejects the hypothesis. Therefore, B is the Granger cause of CPI and PPI changes, proving that the change in B is one of the causes of economic cycle changes, and indirectly proving that quantitative easing policy by changing the issuance of base money can be one of the causes of the changes in the economic cycle.

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Table 1: Granger causality test results.

Null Hypothesis:	Obs	F-Statistic	P.
CPI does not Granger Cause B	39	4.498	0.019
B does not Granger Cause CPI		8.537	0.001
PPI does not Granger Cause B	39	6.143	0.053
B does not Granger Cause PPI		5.048	0.012
PPI does not Granger Cause CPI	39	1.417	0.256
CPI does not Granger Cause B		13.179	0.000

3.2. Research Results

Under the ADF test, the CPI and PPI data from 1982-2022 were found to be non-stationary series, and the existence of their cyclical components was determined, which can be utilized as the basis for economic cycle data.

The filtered images of CPI and PPI are derived by HP Filtering method. Comparing the cyclical components in the images for the time periods of 1982-2008 and 2008-2022, it is found that the economic cycle fluctuations after 2008 are significantly smoother and less volatile than their previous ones. In the cycle component curve of CPI, it can be found that the U.S. economy started to recover in 2010 with an upward trend, and after reaching a peak in 2011, it stayed around the fluctuation value of 0 for about 8 years until 2019 for up and down, then started to decline rapidly after 2019, and reached the lowest value in mid-2020 to start recovery and complete an economic cycle for up to 20 years However, in the period of 1982-2008, it can be seen from the image that most of the time the economy completes the whole cycle of depression, recovery, prosperity and recession for 6-8 years, of which the peak period is only 1-2 years. The comparison between the two can be found after the implementation of quantitative easing policy, making the U.S. economic cycle has been extended. The prosperous period of substantial growth and policy implementation time to maintain a high degree of consistency, indicating that under the continuous implementation of the quantitative easing series of policies, the economy can remain at a high point for a long time. But after the policy stopped, the economy immediately appeared sharp recession, and continued to break through the lowest value, reaching an unprecedented low. The whole recession process came more rapidly and violently than before. Similar conclusions can be drawn from analyzing the image of PPI, and the two corroborate each other, indicating that the above changes do exist in the U.S. economic cycle.

Finally, the Granger Causality Test confirms that one of the causes of the whole change is the implementation of quantitative easing, reflecting the rigor of this paper's research.

3.3. Discussion

3.3.1. Long-term Causal Relationship

There is a significant long-term causal relationship between the volume of base money and economic cycle fluctuations. When a central bank adopts quantitative easing, it increases the supply of base money, which affects money market interest rates and credit market interest rates. Since interest rates are the equilibrium between risk and return in capital markets, changes in interest rates affect investment and consumer decisions. When interest rates are lower, firms and individuals have easier access to low-cost funds and are therefore more likely to invest and consume, which increases aggregate demand in the economy and raises the price level and employment rate. Also, as it can be seen from the image above, with each quantitative easing, the economy experiences an upswing.

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3.3.2. Spillover Effects of Quantitative Easing on Other Countries in the World

An increase in the volume of base money affects exchange rates and international trade. When the domestic money supply increases, the value of the currency decreases and the exchange rate depreciates, leading to an increase in exports and a decrease in imports, thus changing the international environment for economic growth. These transmission mechanisms work not only in the domestic economy, but may also have spillover effects on other countries, leading to changes in the global economy.

3.3.3. Implications

The results of this paper illustrate that the use of unconventional monetary policies such as quantitative easing is effective in the short term, but it can bring side effects after use. Therefore, the magnitude should be strictly controlled and not abused when adopting such policies, otherwise it will bring incalculable consequences. At the same time, attention should be paid to the changes in B so that timely measures can be taken to ensure stable economic development. Because when the money supply increases, the possibility of inflation will also increase. In addition, the effects of quantitative easing in the domestic economy may be transmitted to other countries through various channels. For example, if the domestic money supply increases, it may lead to an increase in the prices of domestic exports, which may affect the import demand of other countries, and it may also lead to domestic capital outflows, which may affect the capital flows of other countries. Therefore, when formulating quantitative easing policies, policy makers need to take into account its possible strong after-effects and the resulting international impact in a comprehensive manner, and take appropriate measures to mitigate its negative effects.

4. Conclusion

This paper uses the HP Filtering method to separate the data of CPI and PPI respectively, and takes the implementation of quantitative easing policy after the financial crisis as a node to compare the fluctuations of economic cycles in different periods before and after, by studying the impact of quantitative easing policy in the United States on the economic cycle of the country. Based on the above research on the fluctuation pattern of CPI and PPI and the consideration of global economic development, this paper concludes that quantitative easing policy does help the economy recover smoothly and ensure stable economic development, but attention needs to be paid to its moderate and appropriate use. When the government conducts macroeconomic regulation of money supply, it should rationally view the fluctuation of CPI and PPI within a reasonable range, correctly understand the fluctuation of the two indices and formulate economic, price and investment policies based on the full consideration of the fluctuation rules of CPI and PPI themselves. At the same time, it should coordinate with other economic policies, combine with global targeted price control policies, reform and innovate price control policies by taking into account market factors and residents' living conditions, so as to ensure that the fluctuations of domestic indices remain stable and controllable in the long run and promote stable global economic growth.

Authors Contribution

All the authors contributed equally and their names were listed in alphabetical order.

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