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# EMD-Based Study of the Volatility Mechanism in Economic Growth

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**ABSTRACT**

In this paper, Empirical Mode Decomposition (EMD) is used for decomposing the quarterly data of year-on-year GDP growth rate from 2000 to 2016. Four intrinsic modes of different frequency scales and inclusive of economic growth volatility are obtained, together with one smooth residual term. Based on the validity information of the decomposed waveforms, the statistical method and the economic significance information are identified for exploring the inherent law of economic growth, before concluding that the economic growth volatility mechanism is comprised of the short-, medium- and long-term influential factors and a relatively stable basic element. Empirical analysis has found that the impacts of long-term volatility factors are dominant and tend to be determined by the business cycle.

**Keywords:** EMD, economic growth, volatility mechanism

## INTRODUCTION

Since the reform and opening up, China has witnessed three decades of rapid economic growth. However, underlying the rapid economic development there is the increasing economic volatility, which affects not only the actual rate of economic growth, but also the potential economic growth rate, and even the resource allocation (Abate, 2016; Liu Yajun et al., 2016; Yang Guang et al., 2015; Dejuan & Gurr, 2004; Mills, 2000). The great impact of economic volatility on China's economic development necessitates analysis of its formation mechanism.

In recent years, domestic and foreign scholars have obtained considerable new research findings on the impact of economic volatility. The increasing fluctuation in real estate prices and excessively slow urbanization are both likely to increase economic volatility and are thus not conducive to the steady development of the economy. (Yang Junjie, 2012; Li Lu, 2016). Technology diffusion, R & D investment and bank capital buffering can all influence economic volatility (Stolz & Wedow, 2011; Dietsch & Vandaele, 2011; Atici & Gursoy, 2011; Xu Shu et al., 2011; Huang Xian et al., 2013; Prokop, Pavol, et al., 2016) Some scholars have approached the issue from the perspective of policies. For example, Yang Canming and Zhan Xinyu (2016) held that under different bias of macro tax-burden policies, the range and stabilization time of economic volatility can be significantly different. Based on their study of fiscal policies and economic volatility, Yuan Shenguo et al. (2011) and Xue Liguo (2016) took into consideration the effects of the financial accelerator, maintaining that lack of consideration for it would lead to misjudged impact of the corresponding policies on economic volatility. Other scholars have analyzed economic volatility from the perspective of the financial structure market, believing that the impact of financial market shocks on economic volatility should not be ignored, and that changes in financial structure would curb it(Wahid et al., 2010; Kunieda et al., 2011 ; Chen Leyi et al., 2016). However, economic volatility has been primarily studied from the perspective of industrial structure adjustment. For example, Li Meng (2010) believed that about 15% to 20% of China's economic volatility should be attributed to the impact of industrial structure. However, the rationalization and upgrade of the industrial structure are known to have a significant stabilizing effect on the stabilization of economic volatility, and the effect is known to be accentuated with progress in industrial structure upgrade (Fang Fuqian et al., 2011; Peng Chong et al., 2013; Hsueh, & Su, 2016). However, industrial hollowing often accompanies industrial structure upgrade and increased industrial hollowing hollow can significantly exacerbate a country's economic volatility together with increased uncertainty (Chen Leyi, 2016). Therefore, industry structure must be upgraded in reasonable aspects, in order to better mitigate economic volatility.


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**Contribution of this paper to the literature**

- It verifies the validity of the EMD method in decomposing the volatility information characteristics of the economic growth rate. The EMD method is capable of adaptively decomposing non-linear and non-stationary economic growth rate index waveforms based on empirical data characteristics.
- They are significantly different in fluctuation characteristics and operation mode, indicating that short-term, medium-term and long-term impact factors are different in mechanism and effectiveness for influencing the trend of economic growth rate.
- Economic growth mechanism resultant from different waveforms are reflective of different economic information. The information contained in the residual term is running smoothly, reflecting the trend of China's economic growth in the 17-year period. It is the basic stable part of the economic growth rate.

Some scholars have divided the mechanism of economic volatility into external shocks and internal structural adjustments. Sun Gongsheng (2009) argued that external shocks had significantly contributed China's economic volatility, and were thus an important factor in its macroeconomic volatility, while the domestic economical marketization, industrial restructuring and macroeconomic policy adjustment were not the main causes. In other words, he believed that China's economic volatility mainly sprang from external shocks rather than internal adjustment. Zhang Xuegong and Li Nannan (2017) also argued that structural transformation was the main reason for China's cyclical economic fluctuations and its asymmetric economic growth. They did analyze the driving mechanism of China's economic volatility, but they did not study the driving mechanism of China's economic volatility at different frequencies (long-term, medium-term and short-term). In addition, they failed to conduct in-depth analysis, and did not clarify whether the driving mechanism meant institutional transformation or structural transformation.

The existing literature provides a solid basis for studying economic volatility and its formation mechanism, as well as at least two aspects of research space for the present research project. Correspondingly, they have become the characteristics and innovation of this thesis. First, the economic volatility is decomposed and fragmented level by level for studying the formative mechanism for economic volatility. Most of the existing literature did not decompose economic volatility, but only studied it as a whole. The thesis took GDP growth rate as the example, decomposed it with EMD method to obtain the waveforms of different frequency cycles. Then information was extracted from each waveform to furnish the basis for the further decomposing economic volatility. Second, it differentiated institutional transformation from structural transformation in their capacity as the driving mechanism of economic volatility. Although the issue has been much studied in existing literature, there is no detailed research. In the present thesis, the GDP growth rate was decomposed with EMD method to obtain the economic volatility items at different frequencies (long term, medium term and short term). Then, information reconstructing was conducted according to the economic significance of each frequency to study the driving mechanism of economic volatility at different frequencies.

# CONSTRUCTION OF THE DECOMPOSITION MODEL FOR GDP GROWTH VOLATILITY

## Choice of the Decomposition Model for GDP Growth Volatility

Year-on-year GDP growth index is a relatively complete time series, which can be decomposed with various methods, including spectral analysis, deterministic analysis and Fourier series analysis. However, those methods either necessitates clear prior information or unduly emphasize mathematical rationale in interpreting the significance of the decomposed index for the economy. It is difficult for them to explain the practical significance. In order to analyze the formation mechanism of shocks in the fluctuation of economic growth rate, this paper attempts to draw on the Empirical Mode Decomposition (EMD) for directly decomposing the economic growth rate index, so as to keep its inherent characteristics, while reflecting its fluctuation in a simpler and clearer manner.

EMD is suitable for decomposition of economic growth fluctuations. In terms of concept, the core idea of EMD is to sift out a frequency and consider the reasonable assumption that the roles of the same factor in fluctuations tends to be relatively stable and form its own frequency characteristics. Therefore, EMD can be used to realize the decomposition of the self-influencing factors of economic growth fluctuations. In terms of the possibility for effective realization, EMD relies on the local time scale of the waveform data itself for adaptive decomposition. It can be used to decompose the non-linear and non-stationary economic growth index waveforms over one decade into multiple orthogonal independent smooth wave components containing the majority of the short-term and midium0term impact characteristics of the original data and a residual term integrating the long-term trend characteristics, thus achieving the goal of decomposing economic growth index into easily analyzable components.

Meanwhile, the decomposed waveforms can be subjected to Hilbert changes to obtain the instantaneous frequencies and instantaneous amplitudes of the various components of the economic growth fluctuation, making possible more accurate analysis of the microscopic information of factors for economic growth fluctuation and determination of the impact mechanism of each factor on economic growth fluctuation.

The realization process of EMD can be summarized as follows: the components of the economic growth fluctuation waveforms with different frequencies are regarded as the Intrinsic Mode Functions (IMF), and are extracted from the original economic growth fluctuation sequence level by level. The progressive level design is relative to the main signs of the IMF components. In terms of time, it refers to the growth of the price components. Then, secondary-high-frequency IMF is obtained from the residual term of the original series after subtracting the high-frequency IMP. The iterative process is repeated until the iteration conditions are terminated and cannot generate any new IMF.

### The Basic Process and Principle of the EMD Model

EMD-based decomposition of the economic growth waveforms is conducted in six basic steps:

Step 1: Identify all the maximal points (or minimal points) in the original waveforms of economic growth.

Step 2: Apply the cubic spline interpolation to the maximum points (minimum points) in all economic growth fluctuation data to fit $e_{\max}(t)$ and$e_{\min}(t)$, the upper and lower envelopes of $x(t)$.

$$m(t) = [e_{max}(t) + e_{min}(t)]/2. \tag{1}$$

Step 3: Calculate $m(t)$, that is the mean of the upper and lower envelopes, according to equation 1:

Step 4: Subtract $m(t)$ from $x(t)$, and the original economic growth waveform, and $d(t)$, the difference between the original economic growth waveform and the mean of economic growth, is obtained:

$$d(t) = x(t) - m(t). \tag{2}$$

Step 5: Determine the nature of $d(t)$, if it satisfies the following conditions:

a. The number of extreme points within it equal that of zero points or the difference between the two is one.
b. The average value for the envelop formed by local maximum values and that by local minimum values is zero.

Then, $d(t)$ will be the ith IMF, expressed as $\text{IMF}_i = d_i(t)$. Meanwhile, the residual $r(t) = x(t) - d(t)$ is defined as the residual signal after eliminating the high-frequency components, and $r(t)$ shall be taken as the new $x(t)$. If it does not satisfy the definition of IMF, it is recorded as a new $x(t)$ for proceeding to step 6.

Step 6: Repeat Step 1 to 5 until no new IMF can be produced from $x(t)$. By now, $x(t)$ is usually a constant term, a monotonic function, or a sequence with an extreme value.

After the above steps, the complex original price data can be decomposed into relatively simple and mutually independent IMFs with different frequency characteristics, and r the steadily changing residual. The original signal $x(t)$ can be expressed as the sum of all the decomposed IMFs and the residuals, specifically:

$$x(t) = \sum_{j=i}^{N} d_j(t) + r(t). \tag{3}$$

In equation (3), N is the number of IMFs. In general, it equals $\log_2 n$, with $n$ being the number of data points.

This way, the IMFs and residual terms can be derived from decomposing the economic growth waveforms. Then by analysis and identification of their effective information, the inherent regularity for volatility mechanism of economic growth can be studied.

## THE IDENTIFICATION AND CHARACTERISTICS OF DECOMPOSED VOLATILITY OF CHINA'S GDP GROWTH RATE

### Decomposed Volatility of China's GDP Growth Rate

According to the basic principles of EMD, China's GDP growth rate volatility was decomposed, as shown in **Figure 1**.

It can be seen in **Figure 1**, the GDP growth rate has been decomposed via EMD into five fluctuation curves of different frequencies, with the first four being IMFs and the last one the residual term. The IMF is a locally symmetric time sequence that fluctuates around the zero-level horizon, steadily increasing in frequency from IMF to IMF4. The residual term is a virtually linear curve. Steadily decreasing with time, it does not show any fluctuating feature.

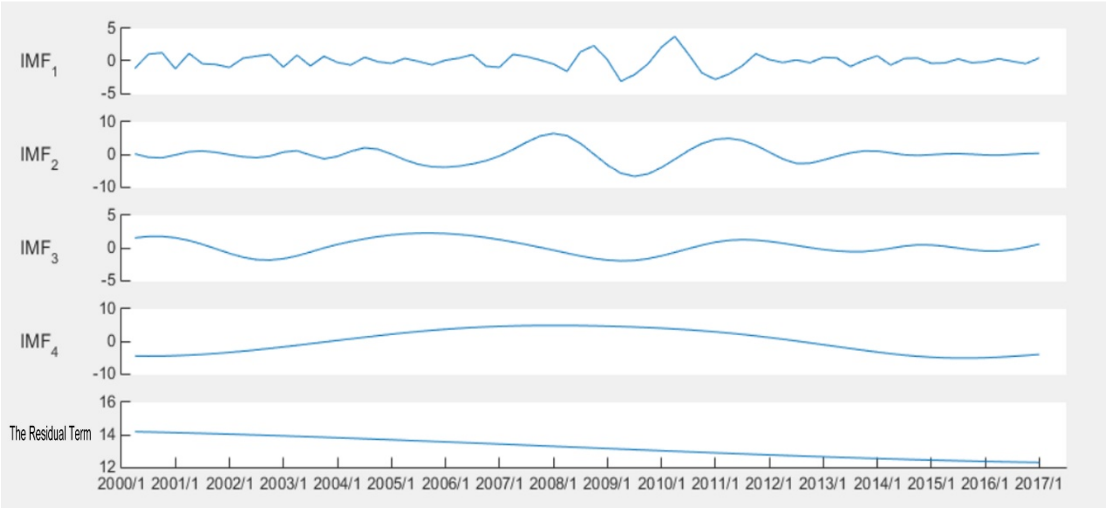


**Figure 1.** EMD Result of GDP Growth Rate

The resultant volatility curves are not significant enough, but the information carried by them is the focus of our research. First, it is necessary to test whether each fluctuating component contains the complete information of the decomposed curve so as to confirm the effectiveness of the EMD method. Secondly, the information of each fluctuating component is identified for analyzing the formation mechanism of economic growth fluctuation.

## Statistical Recognition of the Decomposition Result of China's GDP Growth Rate

In order to determine whether there is information loss, the results of decomposed growth rate is subjected to completeness test. The four IMFs and the residual term are summed up and the result is found to be equal to the original sequence of year-on-year GDP growth. This means that the EMD is normal and lossless waveform decomposition has been achieved realized. Meanwhile, it can be seen from the original sequence as a whole that there has been no energy loss in the decomposition waveforms, indicating that the EMD method is effective for breaking down the economic growth volatility mechanism.

Theoretically, the different IMFs are mutually irrelevant, and each has a different volatility mechanism. Analyzing their underlying information and relating them to the real economy is essential for analyzing the fluctuating characteristics of economic growth. First, the frequencies are the most basic scale feature of the intrinsic mode functions resultant from EMD decomposition, and the key for determining the economic significance of the IMF. The inverse of the IMF frequencies—the volatile cycle as the object of analysis contributes to more vivid understanding of the characteristics of the fluctuation mechanism of economic growth in each mode. According to the nature of EMD, the IMF's frequencies are constantly changing, without a uniform period. Therefore, this paper uses the average period as the mode fluctuation feature, to be calculated by dividing the overall time span of the sequence data with the number of crests or troughs in each IMF. Secondly, the correlation between the IMFs and the residual term is reflective of that between the original sequence and the decomposition result. In the thesis, the Pearson Correlation Coefficient and the Kendall Correlation Coefficient are used as the measure of correlation degree. The Pearson Correlation Coefficient is used to determine the correlation between the two sequences based on the degree at which the two sequences are simultaneously above or below their respective mean levels. This is mainly intended to measure the correlation between the two sequences. The Kendall Correlation Coefficient is also used to determine the correlation coefficient between the two sequences by calculating the variation ratio in their values between the same time point and preceding one. This is mainly intended to measure the rank correlation between the two sequences. The greater the correlation coefficient is, the stronger the correlation between the two sequences. In other words, the decomposition sequence has a greater influence on the original growth rate sequence. In addition, the variance can reflect the degree of fluctuation of the sequence in data form, which is itself descriptive as information. Since the modes are mutually independent, and the IMP and residual term variances are less than the variance of the original sequence, the variance of all mode can be summed up for analyzing its contribution to the variance of the original sequence. The greater the variance contribution is, the more the information of the original sequence contained in the decomposition sequence and the greater the extent to which the original sequence of the trend is determine. Based on this, the above indicators are tested and the results are shown in **Table 1**.

**Table 1.** The Statistical Recognition of the Decomposition Sequences

| Sequence | Average Period (weeks) | Pearson Correlation Coefficient | Kendall Correlation Coefficient | Variance | Contribution To The Original Sequence Variance (%) | Contribution To Mode Total Variance (%) |
|---|---|---|---|---|---|---|
| $IMF_1$ | 44.11 (11.03) | 0.159 | 0.142 | 1.24 | 5.18 | 5.32 |
| $IMF_2$ | 105.29 (26.32) (2.19) | 0.525** | 0.287** | 6.97 | 29.07 | 29.85 |
| $IMF_3$ | 204.00 (51) (4.25) | 0.345** | 0.237** | 1.44 | 6.02 | 6.18 |
| $IMF_4$ | 709.57 (177.39)(14.78) | 0.759** | 0.580** | 13.33 | 55.60 | 57.10 |
| Residual term | | 0.245* | 0.173* | 0.36 | 1.51 | 1.55 |
| Sum | | | | 23.34 | 97.38 | |
| The original sequence | | | | 23.96 | | |

Note: * indicates that the correlation is significant at the 0.05 level.
** indicates that the correlation is significant at the 0.01 level.

### Statistical Characteristics of Decomposition Results of China's GDP Growth Rate

The statistical information focuses on the characteristic laws of the decomposition data. The four intrinsic mode functions and the residual terms are derived from the time series curve of the GDP growth rate. Therefore, the most obvious statistical feature analysis is carried out on the fluctuating sequence data.

It can be seen from analysis of **Table 1** that the four intrinsic mode functions of EMD assume a significant feature of average cycle, indicating the independence in the characteristics of the fluctuation cycle. The cycle is steadily increasing from IMF1 to IMF4, and the shortest average comes with IMF1, at 11.03 months and the cycle for IMF2 is 2.19 years. The cycles of the two modes are within the range of 1 to 2 years, and correspond to short-term economic growth fluctuations. The average cycle of IMF3 reaches 4.25 years, corresponding to medium-term economic fluctuations. IMF4 has the longest cycle of 14/78 years, and is thus defined as long-term economic fluctuation in this paper. Short-, medium- and long-term factors are the main causes contributing to short- , medium- and long-term economic volatility respectively. By analyzing the Pearson Correlation Coefficient and the Kendall Correlation Coefficient, the correlation between the decomposition waveforms and the original sequence is studied. The two coefficients of IMF1 are 0.157 and 0.142 respectively, without significant correlation to the original sequence, indicating that it has a weak influence on economic growth fluctuation. The IMF2 and IMF3 are significantly correlated to the original sequence at the confidence level of 0.01, indicating moderate influences. IMF4 is significantly correlated to the original sequence, and its Pearson correlation coefficient and the Kendall correlation coefficient are 0.759 and 0.580 respectively, indicating that it has a major influence on economic growth fluctuation. The residual term is significantly correlated to the original sequence at confidence level of 0.05, indicating weak impact. In terms of variance contributions, the contribution of residual term to the variance of the original sequence variance and the total variance of the mode are 1.51% and 1.55% respectively, both below 2%. Again, this testifies to the fact that the residual term has a weak influence on the original sequence. The variance contribution rate of IMF4 reaches 55% or above, indicating that it has an important impact on the original sequence; while that of IMF1 and IMF3 are 5% -6%, indicating weak influences. The variance contribution rate of IMF2 stands at about 30%, with certain influences on the original sequence variance. Therefore, it is a medium-intensity driving factor.

From the above analysis it can be seen that all EMD waveforms have distinct statistical characteristics. Among them, IMF4 is most strongly correlated to the original sequence waveform, with the greatest influence on economic growth fluctuations. From the statistical point of view, it contains the main information of the original sequence and reflects the overall trend of sequence operation. From the waveform physical characteristics it can be seen that IMF2 is closer to the original sequence waveform. In addition, despite its shorter average cycle, it contains a certain amount of information of the original sequence, and has a moderate correlation to it.

## VOLATILITY FACTORS OF CHINA'S GDP GROWTH RATE

### Principles of GDP Growth Rate Fluctuation Mechanism and Long-Term Trend Fluctuation

To further analyze the causes of economic growth, it is necessary to analyze the economic significance of internal information of each mode. The EMD method draws on fluctuation characteristics in decomposing the waveforms on multiple frequency scales adaptively, mainly based on the frequency of the waveform, rather than the economic relationship between the influence factor and the economic growth. Since each influencing factor acts on the trend

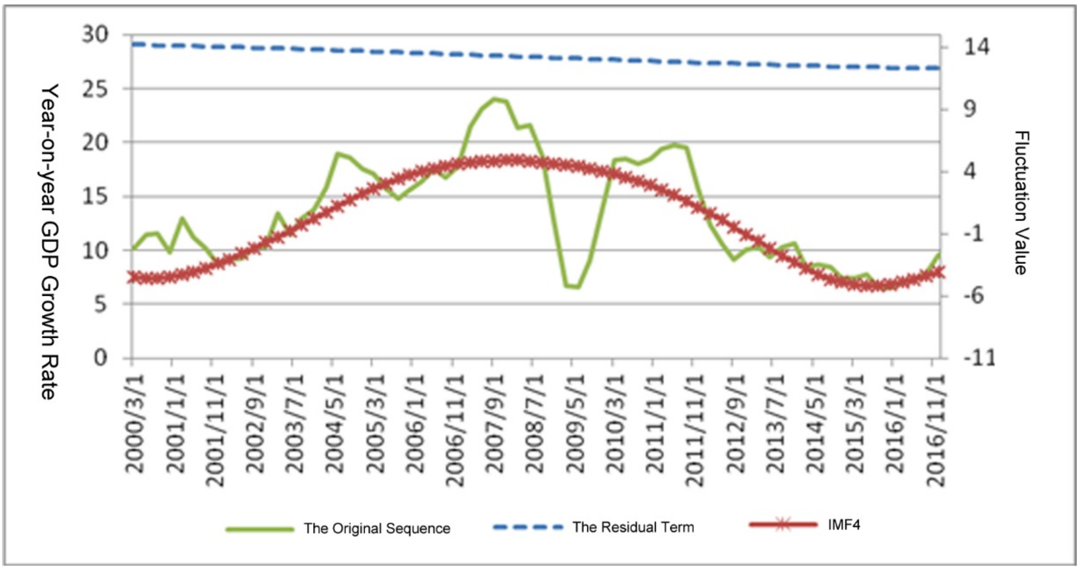


**Figure 2.** Comparison of the Residual Term, IMF4 and the Original Sequence

waveform of the economic growth index at a certain frequency, the complete information of the influence factor under this frequency scale must be contained in the waveform resultant from EMD method. Therefore, it is possible to combine the statistical information of the decomposition mode, the waveform and the economic environment and position the impact factor included in the mode, for further analyzing the role of the impact factor. In view of the correlation between each mode and sequence related to the original sequence and the variance contribution rate derived from the statistical information recognition, the economic significance recognition is started with the residual term, from the low frequency modes to the high frequency modes, according to priorities. Specifically, analysis is conducted from the residual terms to IMF4 and to IMF1.

From the perspective of the long-term fluctuation trend, the original sequence, residual terms and IMF4 with the mode experience curve, are plotted in one diagram figure, as shown in **Figure 2**.

It can be seen from **Figure 2** that the residual term assumes no period attribute or fluctuation characteristics in its steadily downward trend in small amplitude. It gently declined from the peak of 14.19 in first quarter of 2000 to the bottom of 12.29 in the fourth quarter of 2016, down by 13.36%, and with a range of change below 2. Seen from the statistical information, the contribution rate of variance of the residual term to each mode is the lowest among all five decomposition waveforms, at only 1.55%. Meanwhile, the figure shows that it has a weak correlation to the original sequence. The residual term runs through the original sequence and reflects the approximate average level of its data during the study period. The overall trend of GDP growth from 2000 to 2016 showed a slight downward trend. From the economic point of view, China's economy has gradually entered a new stage of development and transformation. The external conditions and endogenous factors are changing, including labor supply and demand, export promotion, real estate demand, stage of urbanization, changes in resources and the environment. Therefore, the year-on-year GDP growth rate took a downward trend. Meanwhile, lowing economic growth rate at the new transition stage is conducive to structural adjustment and transformation, and transformation and upgrade of enterprises and market mechanisms.

It can be seen from statistical information that IMF4 assumes an average period of 709.6 weeks, or about 14.8 years and that it has a strong correlation to the original sequence of economic growth rate, and a significant contribution to economic growth information. In terms of waveform, during the 17-year observation period, it did not manifest a complete fluctuation cycle. It fluctuated within the range of less than zero from the first quarter of 2000 to the third quarter of 2003, reaching the peak of 4.87 in the fourth quarter of 2007. In combination with **Figure 3.2**, it can be seen that the fluctuation period of IMF4 is basically above 14 years. Since EMD method features self-adaptive decomposition, the resultant sequences are reflections and portraits of the original sequence at different frequencies. In frequency scale, it bears in trend apparent resemblance to the trend of the economic growth rate waveform. However, this similarity is not reflected in the local details, nor is it responsive to the several dramatic changes in economic growth rate in 2008. Instead, it seems to have stable operation regularity. In 2008, under the influence of the US subprime mortgage crisis, China's economic growth assumed a rapidly declining trend. However, due to the subsequent fiscal stimulus of "four trillions" and the hiking monetary growth, the economic growth rate showed a rapid upward trend. The dramatic fluctuation in economic growth within the short period of time was not reflected in the frequency scale of IMF4. Instead, it still maintained a stable law of operation. Therefore, this paper argues that IMF4 is formed by economic factors with a long cycle. It studied the operation

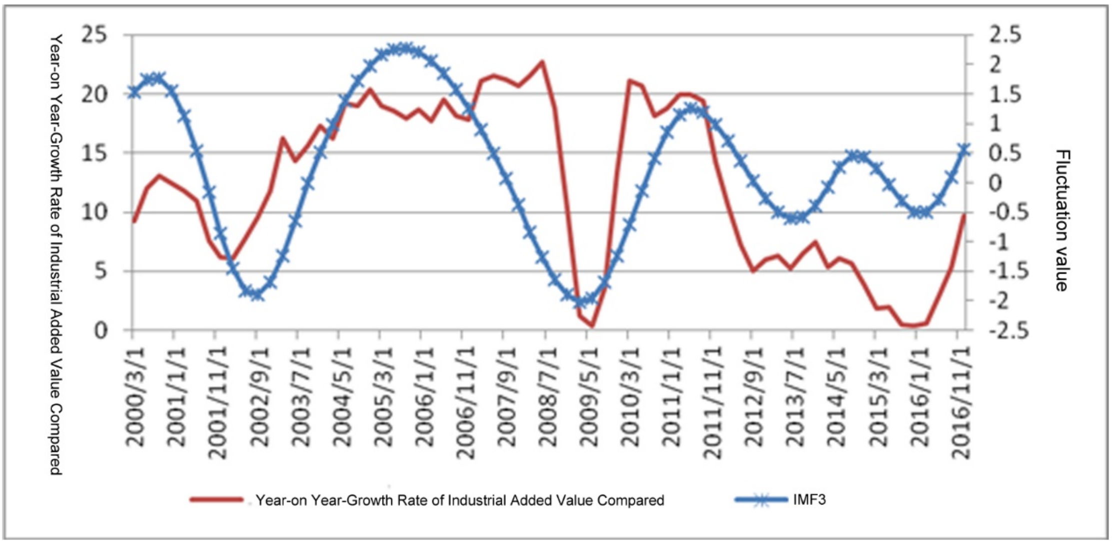


**Figure 3.** IMF3 and Year-on Year-Growth Rate of Industrial Added Value Compared

tendency of long-term factors, including fluctuating monetary supply, fixed asset investment achieved, real estate investment, consumer price index (CPI), production price index (PPI), total retail sales of social consumer goods, total import and export, industrial added value, the proportion of the tertiary industry and so on, and found them significantly correlated to IMF4 waveform.

## The Medium-Term Fluctuation Mechanism and Influencing Factors of GDP Growth Rate

Theoretical analysis has found that the medium-term trend is mainly on the IMF3 curve, with an average period of 4.25 years, that is, at the magnitude of over 4 years. At the frequency scale of IMF3, the waveform of mode change has a strong overall correlation to that of industrial added value. The waveforms are plotted in contrast, as shown in **Figure 3**.

It can be seen from **Figure 3** that IMF3 and industrial added value manifested crests and troughs in the same periods. In other words, IMF3 reflected the trend of stabilized waveform of the industrial added value. From the middle of 2002 to the first quarter of 2009, IMF3 took on a ascending trend first and then a declining trend, creating a peak. Meanwhile, the industrial added value witnessed rapid rise in mid-2002 and then overall gradually slowed rise amid fluctuations, until reaching the peak in mid-2008. After that, it plummeted and then soared, to form a high amplitude trough. The IMF3 in this period presented a gentle trough. Due to the role of economic activities of all sectors, the overall trend of industrial added value was greatly influenced by the economic fluctuation, while the social industrial value in turn impacted on the activities of internal factors of economic fluctuation mechanism. Therefore, the fluctuation mechanism reflects the situation of industrial added value to a certain extent. It can be seen from analysis of IMF3 information that the volatility is being gradually reduced, and the fluctuation has been steady in nearly five years. It can also be seen from contrastive study that volatility in GDP growth rate over the past five years is relatively mild.

## The Short-Term Fluctuation Mechanism and Influencing Factors of GDP Growth Rate

IMF1 and IMF2 are both short-term fluctuations with relatively high fluctuation frequencies. Based on their economic significance, IMF1 and IMF2 were reconstructed to form the RIMF waveform. The RIMF and year-on-year GDP growth rate are compared in **Figure 4**.

Analysis of the characteristic trend of the fluctuation curve on the basis of **Figure 4** shows that RIMF is strongly correlated to the operation status of the original sequence waveform. The short-term volatility factors IMF1 and IMF2 are the result of the joint action by various short-term fluctuating factors. The reconstructed RIMF inherits the influence factors of all short-term volatility items. Therefore, by analyzing the trend of RIMF, the effect of and the effective direction of short-term economic impact factors on year-on-year GDP growth can be reflected in a concentrated manner. Compared with other waveforms from EMD, RIMF has the highest frequency of fluctuation, but its volatility is not unduly large. In terms of economic significance, the short-term economic fluctuation influencing factors have a shorter interval in changes. Therefore, their effectiveness on the economic cycle will not be very long, and consequently, they might heighten the frequency of change but not incur drastic overall volatility. The fluctuation periods and ranges of the two curves are highly similar, indicating that the short-term fluctuation

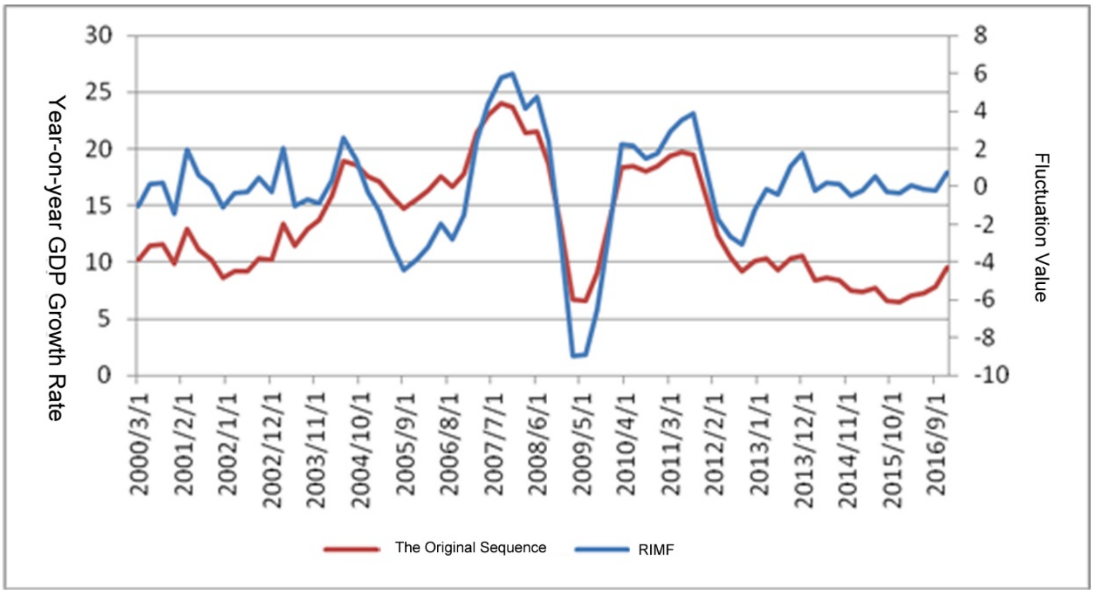


**Figure 4.** Time Series of Short-Term Waveform and GDP Growth Rate

factors are highly influential on each fluctuation fragment of the economic fluctuation and thus on the short-term economic fluctuation. The RIMF mode experienced slight fluctuations for most of the time, with a significant decline from mid-2004 to mid-2005. After a slow rise in 2006, it hiked in 2007 to the peak. At the same time, the GDP growth rate reached the peak of 24%. In 2008, RIMF took a sharp downward trend, under the influence of the short-term economic factors of US subprime mortgage crisis and the international financial crisis. This means that short-term impact factors were quite influential on economic volatility during this period. In the second quarter of 2009, the year-on-year GDP growth recorded a bottom of 6.72%, but rapidly recovered and remained steady amid fluctuations, after the rapid response of the government by policy adjustment.

## CONCLUSIONS

In this paper, the EMD method is used to decompose the economic growth rate index from 2000 to 2016, and four Intrinsic Mode Functions (IMF) and one residual term are obtained. Through comparative analysis of the IMFs and the residual term, the thesis has come to the following conclusions:

1. It verifies the validity of the EMD method in decomposing the volatility information characteristics of the economic growth rate. The EMD method is capable of adaptively decomposing non-linear and non-stationary economic growth rate index waveforms based on empirical data characteristics. The decomposition modes contain the waveform characteristics of different frequency scales in the economic growth rate sequence. Seen from the statistical results, they inherit the information of the original sequence. Under the framework of EMD, each mode is independently reflective of the details of economic growth rate fluctuations at different frequency scales in different periods.
2. The IMF wave forms from EMD are reflective of the different impact mechanisms created by the fluctuation characteristics of the economic growth rate. Analysis from the perspective of statistical methods and economic significance has shown that in the five modes, the residual term is a uni-polar sequence of smooth changes without fluctuation characteristics, while the four IMFs are locally symmetric zero-mean waveforms with different instantaneous frequency characteristics. Gradually increasing in frequency scale from IMF1 to IMF4, they are significantly different in fluctuation characteristics and operation mode, indicating that short-term, medium-term and long-term impact factors are different in mechanism and effectiveness for influencing the trend of economic growth rate.
3. Economic growth mechanism resultant from different waveforms are reflective of different economic information. The information contained in the residual term is running smoothly, reflecting the trend of China's economic growth in the 17-year period. It is the basic stable part of the economic growth rate. It took a gentle decline from 2000, indicating that the Chinese economy over the past 17 years had been generally in a medium- or long-term downward trend, because of the joint effects of the external and internal economic environment. IMF4 has an average cycle of 14.78 years, and contains a large amount of information. So, it had a greater influence on the economic growth index fluctuations. The IMF3 is a smooth waveform with an average cycle of 4.25 years, correlated to periodic economic indicators over a long period

of time. Its amplitude of fluctuation increases with the increase in economic growth. IMF1 and IMF2 are short in cycle, at 1 to 2 years. After reconstruction they are jointly reflective of the influence of high-frequency practices on economic growth fluctuation cycles in a short period of time. Those active short-term impact factors has limited influence on the original sequence, but when strong volatility occurs in economic growth, the reconstructed model will fluctuate accordingly, turning them into important forces manipulating the economic growth trend.

In general, the cyclical fluctuations in economic growth rate reflect the inherent development regularity of China's economic growth and the impact of external shocks on it. Due to the combined role of internal and external economic environment, the Chinese economy is on the whole in a medium- to long-term downward trend. However, thanks to the upward pull of the economic cycle, the downturn is continually being stabilized. On the whole, the descending force is greater than the lifting force.

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