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Characteristics of Cyclical Fluctuations in the Development of the Chinese Construction Industry

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Abstract: In the course of operation, the construction industry will repeat deviations and adjustments to it equilibrium state. Understanding the development fluctuations of the construction industry is critical to the formulation of a country's sustainable development strategy. The purpose of this paper is to investigate the development trend and fluctuation periodicity of the construction industry, particularly the deviation and characteristics of the development. In this paper, based on the H-P filtering method, the residual method for measurement of macro-economic cycle fluctuation is used to divide the periodic fluctuation of the Chinese construction industry into five rounds of economic cycles since the reform and opening up. The results are tested by a random test model and a self-correlation coefficient test model. The longitudinal time-series of data investigated in this research is the constant-price, gross output values of the construction industry in China in the period of 1980–2017 for a total of 38 years based on the national annual statistics. The results of the mathematical test show that the peak or valley of the economic cycle fluctuation of the construction industry in China reappears about every seven years or so. It shows that since the reform and opening up, the peak position of the cycle fluctuation of the Chinese construction industry began to decrease gradually, the valley level began to rise gradually, the volatility showed a downward trend, and the construction industry cycle fluctuation entered a steady and smooth process. The results of this study provide new comprehension of the development trend of construction industry and build the theoretical basis for governments and enterprises to judge the future development trends when formulating the relevant policies.

Keywords: cyclical fluctuation; construction industry; H-P Filtering method; characteristics study

1. Introduction

In the course of its operation, the construction industry is affected by macroeconomic policies, its own industrial technology level, industrial structure adjustments, and capital compositions [1]. The development path of the construction industry shows a repetitive pattern of deviations from and adjustments back to its equilibrium or linear trajectory [2]. Its development path is in a forward wave [3]. The importance of the construction industry for the three elements of sustainable development, namely economic growth, social progress, and effective protection of the environment, cannot be disregarded [4–6]. Rapid increase in urbanization in developing countries led to a boom in construction activities, and hence increased the various impacts of the sector on the environment, society, and economy [7–9]. Related literature shows that the construction industry relates closely to the sustainable economic development of the country and the improvement of people's lives [10,11]. The correlation coefficient between the growth rate of Chinese construction industry and the growth rate of gross domestic product is 0.71 [12], which shows that the development trend of the construction industry will directly and significantly affect the operation of the national economy. It is very important for industry policymakers, business managers, and relevant research scholars to study the characteristics of the wave cycles of the industry development and grasp the future operation trend of the construction industry.

For the study of the cyclical fluctuations in the construction industry, many scholars focused on the influencing factors of fluctuations or the measurement of the cyclical fluctuations [1,3,13–19]. The research results showed that there was indeed a law of cyclical fluctuations in the construction industries, but the lengths and frequencies of the cycles were different in the development paths of the construction industries in various regions and stages [2,20–25]. The development of the Chinese construction industry began to have the characteristics of market volatility after its reform and opening up. For the determination of the fluctuation periods in Chinese construction industry, scholars mainly divided them directly from qualitative aspects, only considered the growth rates of the gross output values of the construction industry, or merely included the growth rates of the net output values of the construction industry. They predominantly used the indicators calculated from macro-level raw data, or only excluded the effect of price changes. They didn't consider the long-term trends of the variables represented by the indicators. Hence, the results were not consistent [18,26–29].

The main objective of this paper was to determine whether there are fluctuations in Chinese construction industry. The second goal was to describe the characteristics of the cyclical fluctuations in the Chinese construction industry. To study the fluctuations, the authors processed the time series of constant-price, gross output values (CP-GOV) of Chinese construction industry using the H-P Filtering method. The authors plotted the results of CP-GOV into the fluctuation chart of the total output value of the construction industry. According to the "valley-valley" division principle, there were five cycles in the development path of Chinese construction industry. Based on the fluctuation chart, the authors studied the heights, depths, amplitudes, standard deviations, and other characteristic cyclical fluctuations to calculate and describe the development of the construction industry. The scope of data collection in this research was 1980–2017 for the total output values of the Chinese construction industry. The structure of the paper includes the following sections. Section 2 reviews the related research on the cyclical fluctuations of the construction industry. Section 3 introduces the filtering model, the verification model, and the measurement steps in this research. Section 4 discusses the results and the analysis. The fifth part makes conclusions and provides some suggestions for future development of the industry.

2. Literature Review

The existing research results on the periodic fluctuations of the construction industries mainly focused on the following three aspects: (1) The relationships between the construction industries and national macro economy or other industries [11–14,30,31], (2) Influencing factors on the development cycles of the construction industries [1,3,19,32–34], and (3) Cyclical Patterns and characteristics of the construction industries [2,16–18,20,22,24,25,27,29]. Table 1 shows the main research methods and cycle lengths of the development paths of the construction industries.

Table 1. The main research methods and cycle length of building activity.

Author	Method and Implementation Area/Country	Time Scope	Cycle Length (Years)	Explanation
Kuznets (1930) [20]	Moving average method was used in the United States; Portland; United Kingdom; Germany; France; Belgium; and Other countries	1782–1922	15–25	To study the markets of wheat, corn, potatoes, cotton, anthracite coal, bituminous coal, petroleum, pig iron, steel
Barras and Ferguson (1985) [23]	Spectral analysis; Turning point analysis; and Dynamic modeling were used to study British	1945–1980	4–5 (demand cycle) 9 (supply cycle)	Industrial, commercial and residential; Different sectors of construction exhibit cycles with different lengths.
Gottlieb (1976) [21]	Europe and North America (eight countries)	Varies	15–25	
Harvey (1978) [22]	Theoretical model was used to study Britain, United States, and France	1800s–1930s	15–25	Investment cycles to the cycle of building
Wheaton (1987) [16]	Structural econometric model was used to study the United States	Mid-1960 to mid-1980	10–12	Office building construction (Supply is more responsive to market conditions than demand)
Leitner (1994) [2]	Three-year moving averages and Autocorrelation coefficient were used to study Dallas, Houston, Los Angeles Minneapolis; St Paul; San Francisco	1963–1985	4–5	Urban office cycle
Wheaton et al. (1997) [24]	Structural economic model was used in London office market	1970–1995	20	2 large swings in office rental rates in the last 20 years; only 1 building boom
Cheng (1995) [18]	Net output value growth rate of the construction industry in China	1953–1992	Long (8) Short (2) Average 4	9 cycles
Shi (1997) [26]	Annual growth rate of gross output value of the construction industry China	1953–1992	5.57	7 cycles
Zhu (2004) [27]	Qualitative analysis of China	1949–2003	10.5	4 stages
Yang (2009; 2011) [28,29]	Growth rate of gross output value of the construction industry in China	1991–2007	6.4	

"Cyclical patterns in construction activity have been a part of more general discussions of economic cycles for some time" [2]. Kuznets (1930; 1958) [20,33] first identified that there existed long-term fluctuations in periods of 15–25 years of durations in the construction economy, in which residential buildings were an important part of the economy. The cyclical fluctuations of residential buildings were closely related to the population growth cycles. After that, many scholars attempted to study the cycle fluctuations in building activity and began to measure fluctuations in all kinds of building cycles. Barras and Ferguson (1985) [23] considered the products of the construction industry included three types of buildings, namely, industrial buildings, commercial buildings, and residential buildings. The average duration of the cyclical fluctuations of the construction industry of was different between countries. The longest period was 9–10 years and the shortest period was 4–5 years in Britain [1,23]. Gottlieb (1976) [21] documented long building cycles in Europe and North America with periodicities of 14–25 years for the local cycles. Harvey (1978) [22] identified building development cycles of 15–25 years, which were strongly associated with the waves of investment in the build environment. Wheaton (1987) [16] determined that there were recurrent cycles with 10–12 year durations in the development of office buildings by estimating a structural econometric model from the mid-1960s to the mid-1980s in the United States. In the same way, Wheaton et al. (1997) [24] analyzed the office buildings constructed in London in 1970–1995. The data showed that London experienced two major cyclical fluctuations in office construction in this period, but only one important boom occurred, in the 1980s. Leitner (1994) [2] compared and analyzed the occurrences and durations of the prosperity and depression cyclic periods of the major US metropolitan office buildings from 1963 to 1986 using time-series data. Gornig and Michelsen (2015) [25] showed that the construction industry in Germany had a new peak in 2014 by establishing the autoregressive model. All these research projects describe the existence of fluctuations in the construction industries.

The Chinese construction industry also shows the cyclical volatility in its operation process. Some scholars began to study the cyclical fluctuations in the construction industry. Cheng (1995) [18] stated that the Chinese construction industry experienced a total of nine cycles of fluctuations in the period of 1953–1992. The longest cycle was eight years. The shortest cycle was two years. The average cycle was 4.4 years. He also pointed out that the fluctuation characteristics of this period included large amplitude, irregular cycle lengths, and periodic frequency distribution. Zhu (2004) [27] divided the development path of the Chinese construction industry from 1949 to present into four stages, which were as follows: (1) Industry formation and growth stage (1949~1957), (2) Stagnation and wandering stage (1958~1976), (3) Recovery stage (1977~1983), and (4) Development stage (1984~present). Zhu (2004) [27] also discussed in detail the characteristics of each stage and the development trend of the construction industry. Shi and Wan (1997) [26] studied the division of the development cycles of the construction industry by using the annual growth rate of the gross output value of the industry.

Literatures showed that there were cyclical fluctuations in the construction industries [1–3,17,18,20,23,25,34]. But the lengths and frequencies of the development cycles of the construction industries varied tremendously in different regions and different stages of development process. Existing research studied the characteristics of periodical fluctuations of the construction industries either by theoretical analysis or with the change of the moving average or the growth rate of a certain index. All these methods are direct analysis methods. The main advantage of the direct methods is their simplicity and easiness. However, the direct division methods cannot effectively eliminate the long-term trend of the variables used in the methods when studying fluctuations, because the value of the variable in a direct division method would be affected by its value fluctuations in adjacent years. In this case, the cyclical fluctuations of the variable values would not be effectively observed or easily identified.

The monthly or quarterly time series Y of each economic indicator contains four variants: the trend T, the cycle C, the seasonal S, and the irregular I. Irregulars are based on the time series decomposition of the variables, the cyclical fluctuation C of the variables is used to measure the period fluctuation, which reflects the cyclical fluctuation of the relative deviation of the variables to their long-term trends.

This study will remove the long-term trends in the index variables, and the cyclical variation of the variables is used to describe the cyclical fluctuations in the construction industry.

3. Research Methodology

The main method of removing the trend components in the time series of variables is referred to as a filtering method. A filtering method eliminates the seasonal fluctuations (denoted as S) and the irregular factors (denoted as I) in the variable's time series. It obtains the cyclical sequence of the trend (denoted as TC) of the time series and then removes the long-term trend (denoted as T) contained in the variable. Finally, it obtains the cyclical fluctuation result (variable C) of the sequence. A filtering method can reasonably reflect the volatility of economic variables. Some commonly used filtering methods include H-P Filter [35], B-K Filter [36], and C-F Filter [37]. The gross output values of the construction industry in the time series usually show phenomenon of fluctuations in growth paths or fluctuations in reduction paths. The phenomenon is the combination results of the interactions of long-term trends and short-term fluctuations in the development of the industry. In this paper, the authors selected the H-P Filter method to exclude the long-term trends.

3.1. H-P Filtering Theory Model

The H-P Filter method was proposed by Hodrick and Prescott in 1980 [35] when studying the post-war economic climate in the United States. Later in the manuscript formally published in 1997, the method was named as the H-P Filter method. This method assumes that $\{Y_t\}$ is the economic time series that contains the trend and cyclical components, in which, $\left\{Y_t^T\right\}$ is the trend components and $\left\{Y_t^C\right\}$ is the fluctuation cocmponents. The time series $\{Y_t\}$ can be expressed as

$$Y_t = Y_t^T + Y_t^C, t = 1, 2, \ldots, T \tag{1}$$

The H-P Filter can separate $\left\{Y_t^T\right\}$ from $\{Y_t\}$. In general, the observable trend part of $\left\{Y_t^T\right\}$ in the time series is often defined as the solution of the following minimization problem:

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

where $c(L)$ represents the delay operator polynomial and the expression of $c(L)$ is shown as follows:

$$c(L) = (L^{-1} - 1) - (1 - L) \tag{3}$$

Substitute Equation (3) into Equation (2). The H-P Filtering problem is converted to find the minimum solution of the following loss function, which is

$$\min \left\{ \sum_{t=1}^{T} \left(Y_t - Y_t^T\right)^2 + \lambda \sum_{t=1}^{T} \left[\left(Y_{t+1}^T - Y_t^T\right) - \left(Y_t^T - Y_{t-1}^T\right) \right]^2 \right\} \tag{4}$$

Hence, the trend components $\left\{Y_t^T\right\}$ and the cycle components $\left\{Y_t^C\right\}$ can be obtained in the following equations, respectively:

$$Y_t^T = \left[1 + \lambda \left(1 - L^2\right)^2 \left(1 - L^{-1}\right)^2\right] Y_t \tag{5}$$

$$Y_t^C = \frac{\lambda \left(1 - L^2\right)^2 \left(1 - L^{-1}\right)^2}{1 + \lambda (1 - L^2)^2 (1 - L^{-1})^2} Y_t \tag{6}$$

The trend changes of the minimization problem of equation are adjusted through $\left[c(L) Y_t^T\right]^2$ and the numerical values of the changes increase with the increase of λ. When the H-P Filtering method is used to analyze fluctuation problems, the value of the scaling factor has a great influence on the filtering effect. According to the general experience, the value of λ is as follows: λ = 14,400 (on monthly data); λ = 1600 (on quarterly data); λ = 100 (on annual data). In this paper, the authors used the annual data of gross output values of the Chinese construction industry. So the value of λ is 100. In order to eliminate the difference of time series, the authors used logarithmic treatment on each sample data of the time series in the actual analysis.

3.2. Verification Model

In order to verify that the fluctuations of the construction industry economy are not random, but have certain regularities, the authors carried out the following calculations on the H-P Filtering results. A random test can only test the randomness of the series. The test of autocorrelation coefficient can further determine whether there is a regular pattern of changes. In this paper, the authors carried out the autocorrelation coefficient test on the basis of a random test.

3.2.1. Random Test

The random test is to verify whether the emergence of a turning point in a time series is random and to determine whether there are cyclical fluctuations. The turning points of the series refers to the points from rising to falling (peak point) and the points that from falling to rising (valley point). More turning points in the sequence of numbers indicate that the sequence is random. On the other hand, a few turning points in the sequence show that there are regular changes in the sequence, which indicates the existences of cyclical fluctuations. The criterion for judging the number of turning points of a sequence is the standard value of the turning point (donated as Z).

Suppose the sequence number of the series is n, the number of turning points of the series is p. The number of turning points of the random sequence obeys a normal distribution. The mathematical expectation (μ_p) and standard deviation (σ_p) of the number of turning points of the random sequence are, respectively, $\mu_p = 2(n-2)/3$, $\sigma_p = \sqrt{(16n-29)/90}$, The standard values for the number of turning points are calculated as follows: $Z = (p - \mu_p)/\sigma_p$, which obeys the N(0,1) distributions.

The basic steps of the test are listed as follows:

(1) Assume the series is random. (2) Calculate the value of Z. (3) If the statistically significant level is 5%, the critical value of the normal distribution is 1.96. If the absolute value of Z is greater than 1.96, the hypothesis of the randomness of the sequence will be rejected. There are regular changes in the sequence. If the absolute value of Z is less than or equal to 1.96, the hypothesis of the randomness of the sequence will be accepted and there are no cyclical fluctuations.

3.2.2. Test of Self-Correlation Coefficient

Bulleted lists look like this: the self-correlation coefficient is the correlation coefficient between a time series and the same series in different lag periods. It can effectively quantify the degrees of correlations between different values of a sequence. The steps of the test are listed as follows:

(1) The self-correlation coefficient of the economic growth series and its series of 1–12 lag periods r_k ($k = 1, 2, \ldots, 12$).
(2) The standard deviation of each self-correlation coefficient is obtained.

$$s_k = \sqrt{\frac{1 - r_k^2}{n - k - 2}} \tag{7}$$

(3) The comparison of the absolute value of r_k with the value of 1.96 r_k (with the significance level of 0.05) helps to determine whether the series can pass the statistical tests of significance. If the absolute value of r_k is greater than 1.96 r_k, it can pass the statistical significance test. If the absolute value of r_k is less than or equal to 1.96 r_k, it would fail the statistical significance test.

3.3. Samples and Data Sources

Research on economic cycles usually uses international and general indicators, with strong comparability, which can comprehensively reflect the overall levels of economic activities. They are used to describe the state of overall economic activity of a country or a certain industry. The gross output value of the construction industry is a comprehensive index which can reflect the level of economic activity in macro scale. In this study, the samples were from the annual time-series of the production values of China's construction industry in 1980–2017 [38].

3.4. Measurements Steps

In the process of calculation, the authors adopted the addition model of time series. The specific steps are as follows:

(1) Eliminate the impacts of price changes on output values. The first measurement step is to treat the time series of the gross output values of the construction industry with the price index of retail commodity in order to eliminate the impacts of price changes on output values. The results from this step will obtain the constant-price, gross output values (CP-GOV) sequence of the construction industry. The price in 1978 will be the base price.

(2) Take natural logarithm process on the CP-GOV sequence of the construction industry in order to eliminate the influence of the different variance in 1980–2017.

(3) Seasonal adjustment. Since the data used in this research is annual data, the time series of the construction industry does not need to be seasonally adjusted.

(4) H-P Filtering Method. Using EVIEWS7.2 measurement analysis software, the authors analyzed the logarithmic sequence of the CP-GOV of the construction industry by using H-P Filtering Method. The value of λ is 100, as recommended by Hodrick & Prescott (1980) [35].

(5) Determination of the cycles of economic fluctuations in the construction industry. Burns and Mitchell (1946) used the National Bureau of Economic Research (NBER)'s division method, which stated that a complete economic fluctuation could be determined from one wave to the next wave, from a trough to the next trough, or from an average value of some years to the value in the next time period in the same state (i.e., peak-to-peak, trough-to-trough or the entire cycles). In addition, an economic cycle should include four stages of recovery, prosperity, recession, depression in strict sense. According Burns and Mitchell (1946) [39], an economic cycle was observed when the economy runs from a peak to the next peak or from a trough to the adjacent trough, and the fluctuation time should last for more than 15 months. Meanwhile, the contraction or expansion of an economic cycle should continue for more than 5 months. Otherwise, it can only be considered as a temporary or irrelevant derailment of general economic activities. The same method was used by the United States Department of Commerce.

4. Results and Analyses

4.1. Results of Cycle Division

The logarithmic sequence of the CP-GOV of the construction industry is analyzed by H-P Filtering analysis using EVIEWS7.2 measurement analysis software. Figure 1 is the separation diagram of the CP-GOV of the construction industry and its long-term trend.

The solid line in Figure 1 is the CP-GOV of the construction industry and the dotted line is the long-term trend of the CP-GOV. The cyclical fluctuations of the CP-GOV of the construction industry can be obtained by the removal of the long-term trend of the CP-GOV, as shown in Figure 2.

According to the "valley-valley" division principle, there are five economic cycles shown in Figure 2 in the period of 1980–2017 in Chinese construction industry. The corresponding waves are 1981–1991, 1991–1995, 1995–2000, 2000–2008, and 2008–present. The longest fluctuation period is 10 years; the shortest is 4 years; and the average length is 6.75 years, which is slightly longer than the national macroeconomic cycle length (about 5 years). The wave from 2008 to 2017 is the fifth cycle and incomplete. Figure 2 shows that the length of the first cycle (1981~1991) is 10 years. Its fluctuation range is relatively large, with an expansion length of 5 years and a contraction length of 5 years. The cycle lengths of the second, third, and fourth cycles are shorter than the first one and the fluctuation ranges become gradual. The lengths of expansion and contraction vary at different time frames. The time frames include long expansion type and short expansion type, according to the ratio of the expansion length to the contraction length (L = expansion length/contraction length). In Figure 2, the first, second, and fourth cycles of the economic cyclical fluctuations in Chinese construction industry are long expansions (L > 1). The third and fifth cycles are short expansions (L < 1). These fluctuations are typical growth cycles. Table 2 shows the specific data of economic cyclical fluctuations of Chinese construction industry.

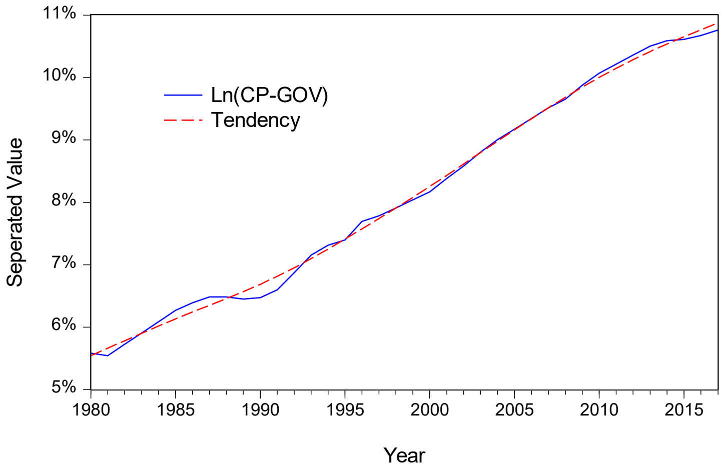

Figure 1. Separation diagram of the constant-price, gross output values (CP-GOV) values and tendency.

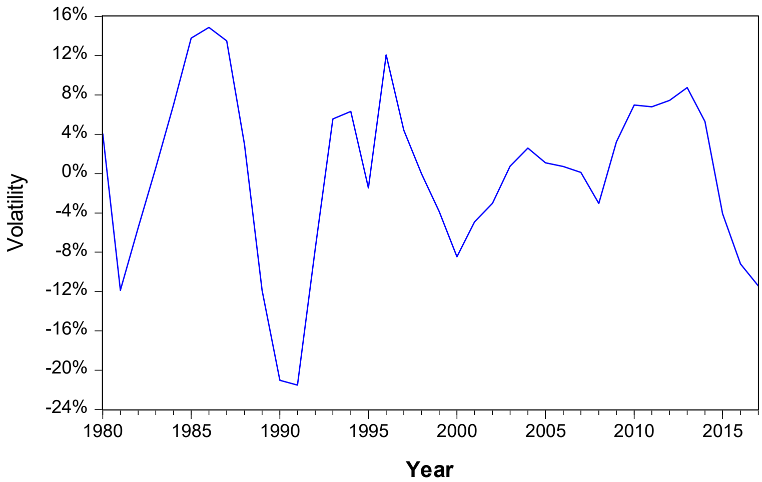

Figure 2. Cyclical fluctuations diagram.

Table 2. Division of economic cyclical fluctuations of the construction industry 1980–2017.

Number	Section	Cycle Duration (Years)	Extension (year)	Contraction Duration (year)	Type
1	1981–1991	10	5	5	Long
2	1991–1995	4	3	1	Long
3	1995–2000	5	1	4	Short
4	2000–2008	8	4	4	Long
5	2008-now		5	–	Short
Average value		6.75	–	–	–

4.2. Test Result

The tests used the logarithmic sequence of the CP-GOV of the construction industry. Before the tests, the authors calculated and obtained 3-year moving averages of the sequence to eliminate the random fluctuations in 3 years.

4.2.1. Random Test Result

There are a total of 38 data samples in 1980–2017. After performed three years of moving average to the series, the size of the samples was reduced by two and the value of n turned into 36. There are five "peak" values and five "valley" values during the five cycles. The authors calculated the following values: $\mu_p = 20.7$, $\sigma_p = 2.35$, $|Z| = 4.55 > 1.96$. Based on the above test results, the hypothesis that the sequence is random is rejected. There are some regular changes in the series.

4.2.2. Test Result of Self-Correlation Coefficient

The results of the self-correlation coefficient statistical tests show that the correlation coefficients of the logarithmic sequence of the CP-GOV of the construction industry and its series of seven lag periods have all passed the significant tests. These values fall outside the random range. This indicates that the economic cycle of the construction industry is approximately once per every 7 years. The test results are consistent with the average periodical length of 6.75 years of cyclical fluctuations calculated in Table 2 for the characteristics of the construction industry. The above test results show that there are indeed cyclical fluctuations in the course of the development of the construction industry in 1980–2017. The average length of the cycle is about 6~7 years. Table 3 shows the data analysis using the Statistical Package for Social Sciences (SPSS) software for autocorrelation coefficient.

Table 3. Result of statistical analysis of autocorrelation coefficient.

Lag Phase k	Self-Correlation Coefficient r_k	Standard Deviation s_k	1.96 s_k	Absolute Value $\|r_k\|$	If $\|r_k\| > 1.96\ s_k$
1	0.921	0.069	0.135	0.921	Greater
2	0.835	0.099	0.194	0.835	Greater
3	0.749	0.121	0.237	0.749	Greater
4	0.665	0.139	0.272	0.665	Greater
5	0.583	0.154	0.301	0.583	Greater
6	0.505	0.166	0.326	0.505	Greater
7	0.430	0.177	0.347	0.430	Greater
8	0.355	0.187	0.366	0.355	Less than
9	0.278	0.196	0.384	0.278	Less than
10	0.198	0.204	0.401	0.198	Less than
11	0.117	0.212	0.415	0.117	Less than
12	0.038	0.218	0.427	0.038	Less than

4.3. General Characteristics of Cyclical Fluctuations

To determine the characteristics of the cyclical fluctuations of the construction industry, it is important to further calculate the height, depth, magnitude, and standard deviation of the cyclical fluctuations. Table 4 shows the calculated results.

Table 4. Characteristics of economic cyclical fluctuations of the construction industry (1980–2017).

ID	Section	Cycle Length (Years)	Wave Height (%)	Wave Depth (%)	Fluctuation Range (%)	Standard Deviation σ	Average Potential	Extension Length	L
1	1981–1991	10	14.84	−21.58	36.42	13.56	6.24	5	
2	1991–1995	4	6.29	−1.44	7.73	6.57	7.18	3	>1
3	1995–2000	5	12.15	−7.88	20.03	7.68	7.91	1	<1
4	2000–2008	8	3.94	−2.42	6.36	2.87	9.05	4	=1
5	2008-now	-						5	<1

The following discussions summarize the characteristics of the economic cyclical fluctuations of the construction industry:

(1) The construction industry has experienced a total of five economic fluctuations in 1980–2017. The corresponding cycles in turn are 1981–1991, 1991–1995, 1995–2000, 2000–2008, and 2008–now. The longest fluctuation period is 10 years and the shortest is 4 years in the five rounds of economic fluctuations. The average cycle length is 6.75 years, which is slightly longer than the national macroeconomic cycle length (about 5 years). The cycle of 2008–2017 is the fifth incomplete cycle. No two cycles are exactly the same. The periodic fluctuations change irregularly.
(2) The waveforms and amplitudes of the cycles show that the amplitudes of the first two cycles are relatively large. The maximum amplitude was 36.42%. The height of the wave reached 14.84%. The depth of the wave reached −21.58%. The first two rounds of the cyclical fluctuations presented the feature of steep rise and steep drop. The fluctuation amplitudes of the later three cycles are obviously reduced. These phenomena show that the construction industry has experienced rapid growth and its stability began to gradually increase.
(3) According to the time sequence, the standard deviations of the fluctuation logarithmic sequence of CP-GOV of the construction industry in turn are 13.56, 6.57, 7.68, and 2.87. The standard deviation of the third round of fluctuation is slightly larger than the standard deviation of the second round. The overall trend of the standard deviations of the fluctuations is decreasing. It shows that the fluctuation range of the actual economic growth of the construction industry is gradually decreasing in deviations from the long-term trend. Currently, the economic growth of the construction industry is relatively stable.
(4) The average potential of the economic growth of the construction industry has gradually increased in 1980–2017, which shows that the overall level of economic growth in each cycle continues to improve. This also reflects that the economic growth of the construction industry rises gradually and is relatively stable. Cyclical fluctuations in the construction industry are typical in its growth path during this period.
(5) Judging from the expansion durations of the economic cyclical fluctuations of the construction industry, the first, second, and fourth cycles of fluctuations are long-expansion cycles ($L > 1$). The third and fifth cycles belong to short-expansion type ($L < 1$). These also show that the driving force of each expansion phase is not the same.

There are competing explanations for the generation and periodicity of building cycles [2]. Wheaton (1987) [16] explained that the most immediate influence on the development of construction activities was exerted by the behaviour of macroeconomic conditions. In China, after implementing the reform and opening up policies, changes happened in its economic development policies, which caused investment transformations in fixed assets. The irregularities of the investments in fixed assets might be the major cause of the cyclical fluctuations in the construction industry. In order to explain the relationship between the two, Figure 3 compares the volatility of the fixed asset investment (FAI) of the state and the total output value of the construction industry. The solid line in Figure 3 is the CP-GOV of the construction industry and the dotted line is the constant-price, total investment in fixed assets. Figure 3 explains that the volatility of the gross output value of the construction industry and the volatility of the fixed investment in the whole society are basically synchronized from the fluctuation trends of the waveforms, peaks, valleys, and stages. The trends indicate that the total output value of the construction industry and the total investment in fixed assets have a greater correlation between each other. The volatility of FAI in the country may be the driving factor influencing the fluctuation of the construction industry.

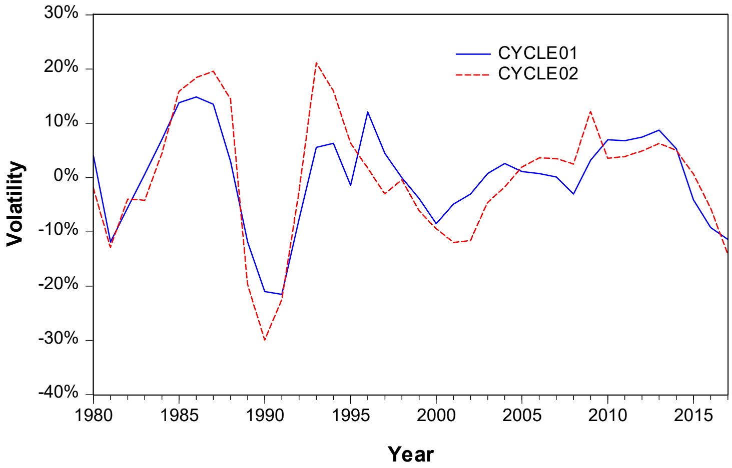

Figure 3. Fluctuation Comparison of national construction industry and constant-price, total investment in fixed assets.

4.4. Comparison with Regional Provinces

In order to further verify the results of the above cyclical fluctuations, the authors compared the cyclical fluctuations of the construction industry in the nation with the fluctuations in different provinces in China. There are 34 provincial-level administrative regions in China (4 municipalities, 23 provinces, 5 autonomous regions, and 2 special administrative regions). The locations are divided into seven geographical regions, which are: Northeast China (Heilongjiang, Jilin, Liaoning), North China (Beijing, Tianjin, Hebei, Shanxi, Inner Mongolia), Central China (Henan, Hubei, Hunan), East China (Shandong, Jiangsu, Anhui, Shanghai, Zhejiang, Jiangxi, Fujian, Taiwan), Southern China area (Guangdong, Guangxi, Hainan, Hongkong, Macao), Northwest (Shaanxi, Gansu, Ningxia, Qinghai, Xinjiang), and Southwest (Sichuan, Guizhou, Yunnan, Chongqing, Tibet). Seven representative provinces and municipalities (Beijing, Liaoning, Zhejiang, Hubei, Guangdong, Sichuan, and Shaanxi) were selected from the whole country. The fluctuations of CP-GOV of the regional construction industries were compared with the fluctuations of CP-GOV the national construction industry. For the asynchronous and incomplete regional data statistics, the authors compared the data of 1993–2017. The results of the comparisons are shown in Figure 4. The solid lines in figures are the constant-price fluctuations of the national construction industry and the dotted lines are the constant-price fluctuations of the regional construction industries.

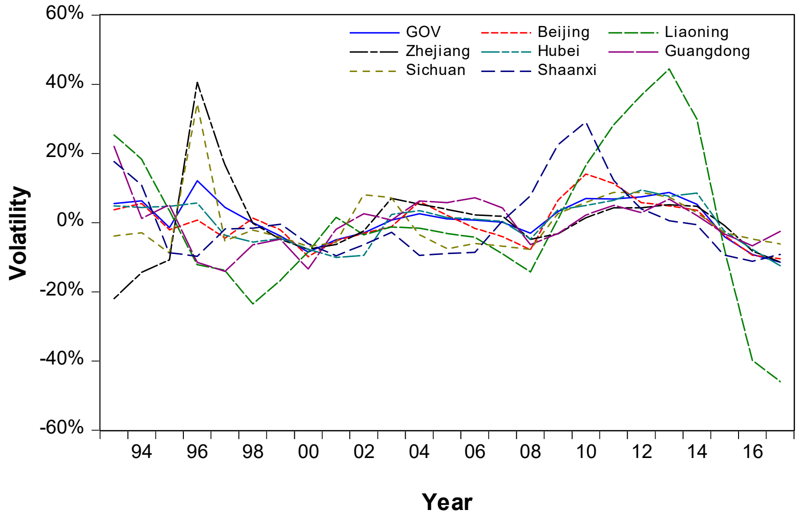

Figure 4. Fluctuation Comparison of seven regional construction industry and national construction industry.

As shown in Figure 4, the cyclical trends of the construction industries in various regions and the cyclical trend of the national construction industry are roughly consistent. But the degrees of anastomosis are not the same. The gross output values indicate that the fluctuations of the construction industries in Beijing, Zhejiang Province, and Shaanxi Province are in a high consistency with the fluctuations of the national construction industry. The other regions are not in close consistency. The "Peak" and "Valley" values of the fluctuations of the regional construction industries and those values of the national construction industry are different in magnitude and time. The cyclical fluctuation frequencies of the regional construction industries are more frequent compared to the national construction industry, while the cyclical fluctuations of the regional industries have less stability than the national one.

5. Conclusions

In view of the problems of whether there are periodic fluctuations in construction industry and what are the characteristics of periodic fluctuations in Chinese construction industry, this paper uses the residual method in the measure of macro-economic cycle fluctuations to divide the periodic fluctuations of Chinese construction industry into five economic cycles since the reform and opening up. The results of the mathematical tests showed that there were indeed cyclical fluctuations in the course of the development of the construction industry. The peaks or the valleys of the economic cycles in the construction industry repeated approximately every 6~7 years, which was consistent with the average period length (6.75 years) of the characteristic of cyclical fluctuations as the calculation result of the construction industry. It shows that since the reform and opening up, the peak position of the cycle fluctuation of Chinese construction industry began to decrease gradually, the valley level began to rise gradually, the volatility showed a downward trend, and the construction industry cycle fluctuation entered a steady and smooth process.

The steady trend of construction cycle fluctuation has a great relationship with the change in China's economic system. At the beginning of the time period, the construction industry began its rapid growth stage due to the transformation from the planned economy to the market economy of the country. Because the market economy system was not perfect, the fluctuation amplitude of the construction industry during this period was large. The development of the construction industry was very unstable. With the gradual establishment of the national macro-control and market mechanism, the peaks of cyclical fluctuation of the construction industry began to decrease gradually and the valleys began to rise gradually in recent years. The construction industry cycles have entered into a steady and smooth process. The cyclical fluctuations in the construction industry have been gradually transferred to the long and steady development state from the short periodical and frequently fluctuating state earlier. That is to say, the strong wave with obvious fluctuations is gradually changed into slow microwaves with a gentle growth trend. The cyclical fluctuations in the regional industries are generally consistent with the trend of cyclical fluctuations in the national construction industry, but the degree of coincidence is not the same.

The outbreak of the U.S. financial crisis in 2008 caused a strong impact on the construction industry in China. The construction industry entered a stage of depression since then. Under the influence of the investment in fixed assets of the Chinese government, the construction industry was expected to grow rapidly out of the depression stage. However, in 2013 the construction industry began to decline rapidly again. This showed that the construction industry was relatively weak in resisting external interference. Therefore, the construction enterprises should firstly accelerate the improvement of their own mechanisms, adjust the structure of the construction industry and improve the concentration of the industry in order to achieve both a core business and having diversified businesses. Chinese construction enterprises should enhance the external-resistance abilities and change from passive to active. Construction enterprises should change the patterns of economic growth from technology imports to independent innovation and take the road of intensive management to realize the transformation from quantity-increasing type to quality-benefit-oriented type.

This study enlightens us try to explore the overall law of the construction industry based on the vertical time series data, and we can also get unexpected gains, rather than just studying the development of the construction industry in a certain stage. In the study, this paper selects the gross output value of the construction industry to deal with and analyze. The added value of the construction industry is the gross output value of the construction industry minus the intermediate input, which can better reflect the development of the construction industry itself. However, due to the limitations of the data, only the annual data on gross output value of the construction industry is selected for processing and analysis. So, the more microscopic volatility of the construction industry is hidden. With the gradual supplementing and improvement of the statistical database, we can select more detailed data for different indicators to further understand the development fluctuations of the construction industry.

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