

# The Unified Cycle Study of Global Financial Markets and Macro Indicators

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## ABSTRACT

Complex systems generally refer to intelligent and adaptive systems, whose internal relations are complex and undetectable, and can only be analyzed through signals of certain dimensions. The economic system is such a complex system, and the global economy is a complex system containing many sub-systems (national economies of different countries). Complex system has certain natural frequency or periodicity, and as the system goes on, there is a trend of synchronization within the system. Based on this, the periodicity shown by financial and economic data can be understood as the performance of fixed frequency of complex system in different observation dimensions. In this article, we analyze several market indexes which cover the global stock market, bond market, commodity market and foreign exchange market, as well as main macro indicators (CPI and GDP). We take the advantage of Fourier transformation and linear regression to investigate their periodicity, and find that both global financial markets and macro-economy are somewhat cyclical, with unified periods concentrated at about 4 years and 10 years.

**Keywords:** *economic cycle, Fourier transformation, complex system*

## 1. INTRODUCTION

The world is ultimately determined by the slow variable. If we stretch out the perspective and look at the world in terms of years, we will get a vague sense of the economic cycle. If you stretch out over 10 to 30 years, we can see changes in the age structure of the population, the impact of technological progress, the evolution of social ethos, the jump in economic development stages. If we stretch out the horizon to 50 to 100 years, we can see the rise and fall of countries, the adjustment of the world's political and economic structure, the change of war and peace. If we zoom out over hundreds to thousands of years, we can see the formation and deposition of cultures, the rise and fall of religions. If we zoom out over tens of thousands, hundreds of thousands, millions of years, we can see the evolution of life, the cycles of climate. If we zoom out hundreds of millions of years ago, we can even see the continents moving. The slow variable of the cycle is often referred to as the law of history. The market, just like the evolution of history, is the combined reaction of all people at each time point. Mark Twain said that history does not repeat itself, but with the same rhyme. The cycle of the market is the most fundamental "slow variable" that affects the change of asset prices. Each bull market and bear market are not

exactly the same, but they all follow similar rhymes and tread on similar rhythms.

Every school of economics has its own theory about the logic of economic cycles, such as Keynesianism [1], New Cambridge School [2], Neoclassical Synthesis [3], New Keynesianism [4], Freiburg School [5], monetarist school [6], economic liberalism [7] and so on. For the management of economic cycle, each school of economics has its own policy propositions. Governments of various countries are also actively looking for countermeasures, trying to suppress the cyclical fluctuations of the economy, so that the economy can run more smoothly. However, no matter from the financial market indicators or the observation indicators of the real economy, the economic cycle has been running stably in accordance with its own rules and has never been disturbed.

To investigate the cycle of the global financial market and economy, we select several representative indexes or indicators. Specifically, we select the broad-base market indexes from different countries around the world for equity market, the ten-year treasury yields of America and China for bond market, the Commodity Research Bureau (CRB) spot index for commodity market, US dollar index for currency market, as well as CPI and GDP

for macro indicators. We calculate year-on-year (YOY) for these data to remove the trend of financial data. To find out the cycle length, we use two statistical methods including linear regression [8] and Fourier transformation [9]. We find that the cycle length of these indexes and indicators are mainly concentrated at about 4 years and 10 years, which are corresponding to the Kitchin cycle [10] discovered by the American economist Joseph Kitchen in 1923 and Juglar cycle [11, 12] coined by the French doctor Clement Juglar, respectively.

The following of this article are organized as follows. In Section 2, we will introduce the financial indexes and macro indicators we used to represent the economic system. In Section 3, we will also explain the method and theory to seek the cycle length or frequency of the economic system. The main analysis results are presented in Section 4, and we will show the unified cycle of global financial market and economy. Finally, we will analyze the principle and logic of economic cycles from the perspective of complex system and make a brief conclusion for this article.

## 2. REPRESENTATIVE FINANCIAL INDEXES AND MACRO INDICATORS

In this section, we will make brief introduction to the indexes and indicators we select to characterize and represent the global financial market and economy, as well as the reason for choosing them. From the perspective of asset class, the financial market can be divided into stock market, bond market, commodity market and exchange market. From the perspective of economy, inflation and economic growth are two most basic and import aspects.

For stock market, the broad-based market index is mostly used to reflect the overall performance of a country's stock market. For example, the S&P 500 index covers two major U.S. exchanges (New York Stock Exchange and Nasdaq) and tracks 500 publicly traded companies in the United States, which serves as a benchmark for U.S. equity portfolios. We selected nine major stock markets around the world and corresponding commonly used benchmarks as a representative of the global stock market. The detailed information about these 9 indexes are listed in Table 1. These indexes cover the developed markets such as the United States and the United Kingdom as well as emerging markets such as China and India. Generally speaking, developed markets have a longer time frame and a larger sample size.

**Table 1:** The detailed information of stock indexes.

Stock Index	Countries/Regions	Sample Number	Start Month	End Month
Australien S&P 200 Index	Australia	356	1992-05-29	2021-12-31
CAC 40 Index	France	414	1987-07-31	2021-12-31
DAX Index	Germany	747	1959-10-30	2021-12-30
Hang Seng Index	Hong Kong, China	673	1964-07-31	2021-12-31
London FTSE 100 Index	England	456	1984-01-31	2021-12-31
Mumbai Sensex30 Index	India	513	1979-04-27	2021-12-31
S&P 500 Index	America	1129	1927-12-30	2021-12-31
SSE Composite Index	China	373	1990-12-31	2021-12-31
Tokyo Nikkei 225 Index	Japan	872	1949-05-31	2021-12-30

For commodity market, commodities are priced by global supply and demand, and individual countries are price takers, so our analysis will mainly focus on the price of different commodity types. The CRB index is a price index compiled by the Commodity Research Bureau of the United States based on the prices of 19 basic economically sensitive commodities in the world market. Since CRB index includes the price fluctuation of core

commodities, it generally reflects the dynamic information of the prices of major commodities in the world, and is widely used to observe and analyze the price fluctuation of commodity markets and macroeconomic fluctuations, and to some extent reveals the future trend of macro-economy. The detailed information about the CRB index we used is summarized in Table 2.

**Table 2:** The detailed information of commodity indexes.

CRB Index	Type	Sample Number	Start Month	End Month
CRB Spot Index (Fat And Oil)	Fat And Oil	900	1947-01-31	2021-12-31
CRB Spot Index (Food)	Food	900	1947-01-31	2021-12-31
CRB Spot Index (Industrial Material)	Industrial Material	900	1947-01-31	2021-12-31
CRB Spot Index (Livestock)	Livestock	900	1947-01-31	2021-12-31
CRB Spot Index (Metal)	Metal	900	1947-01-31	2021-12-31
CRB Spot Index (Textile)	Textile	900	1947-01-31	2021-12-31

For bond market, since interest rates on long-term Treasury bonds are the benchmark for pricing other bonds, we use 10-year Treasury yields as the representation of the bond market performance. Because of data availability, we will focus on the American and

Chinese 10-year Treasury yields. For exchange market, we mainly analyze the U.S. Dollar Index since dollar is the basic settlement currency in the world economy. The detailed information about 10-year Treasury yields and U.S. Dollar Index are listed in Table 3.

**Table 3:** The detailed information of 10-year Treasury yields and U.S. Dollar Index.

Index	Countries/Regions	Sample Number	Start Month	End Month
Chinese 10-year Treasury Yields	China	240	2002-01-31	2021-12-31
U.S. 10-year Treasury Yields	America	825	1953-04-30	2021-12-31
U.S. Dollar Index	America	612	1971-01-31	2021-12-31

For macro economy, inflation and economic growth are two most closely watched and discussed indicators. In this article, macro indicators are defined as CPI and GDP. We use CPI and GDP to reflect the inflation and

economic growth of the world's major economies including America, China, England, France, Germany and Japan. The detailed information about these indicators are listed in Table 4.

**Table 4:** The detailed information of macro indicators.

Macro Index	Countries/Regions	Sample Number	Start Month	End Month
CPI America	America	1296	1914-01-31	2021-12-31
CPI China	China	420	1987-01-31	2021-12-31
CPI England	England	396	1989-01-31	2021-12-31
CPI France	France	372	1991-01-31	2021-12-31
CPI Germany	Germany	360	1992-01-31	2021-12-31
CPI Japan	Japan	612	1971-01-31	2021-12-31
OECD GDP America	America	883	1948-02-29	2021-08-31
OECD GDP China	China	515	1979-01-31	2021-11-30
OECD GDP England	England	787	1956-02-29	2021-08-31
OECD GDP France	France	727	1961-02-28	2021-08-31
OECD GDP Germany	Germany	727	1961-02-28	2021-08-31
OECD GDP Japan	Japan	727	1961-02-28	2021-08-31

### 3. METHODS TO COMPUTE CYCLE LENGTH

In this section, we will demonstrate the statistical methods we employed to estimate the cycle length of the indexes or indicators mentioned in above section.

First, our estimation is based on the year-on-year (YOY) data instead of the original time series. For time series  $x_i, i = 1, 2, \dots$ , its YOY is  $y_j = (x_j - x_{j-12}) /$

$x_{j-12}, j = 13, 14 \dots$ . In the field of finance and economy, the data usually has tendency. The economy grows and GDP keeps increasing in the long term, which makes it hard to investigate periodic. Another example is S&P 500 Index, which also maintain the upward momentum in the long term. We take the YOY transformation to remove the trend of financial data, so that we can look at periodic fluctuations more clearly. Another advantage of YOY transformation is that it reflects marginal changes, which is often more concerned in the field of economy.

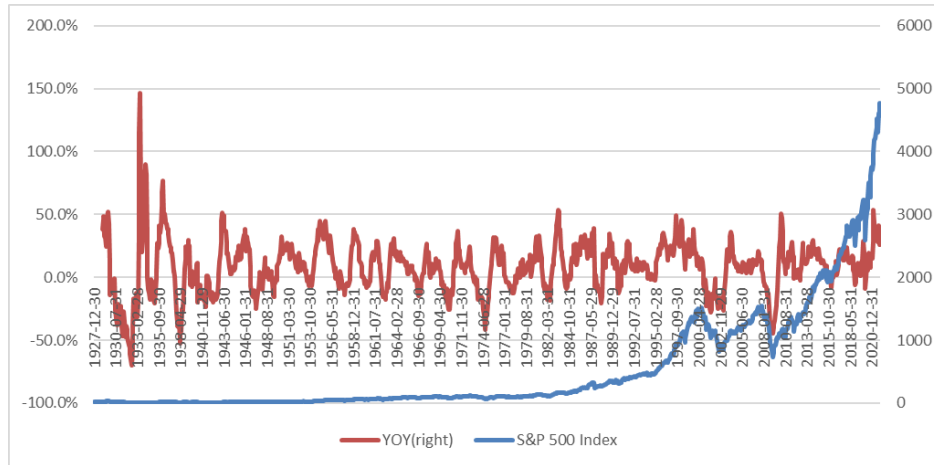


Figure 1: The S&P 500 Index and its YOY transformation.

We use two methods to estimate the cycle length. The first method is linear regression. Specifically, we build regression models between the YOY time series and the sine sequence with different cycle lengths (or frequencies) such as 2 months, 3 months..., and investigate the fitting degree (R-Square, R2) of different cycle lengths to determine the cycle length. The other method is Fourier transformation, which can represent a function satisfying certain conditions as a trigonometric function (sine and/or cosine). With Fourier transformation (FFT), we can observe the YOY time series from the perspective of frequency (or cycle length), and investigate the strength of YOY time series at different frequencies (called spectrum). We determine the cycle length by locating frequency with local maximum strength.

4. RESULTS

We take YOY transformation for the indexes and indicators mentioned in Section 2.1, and use the two methods in Section 2.2 to analyze the YOY time series. The results are shown in Figure 2- 12 and we left some results in the Appendix for simplicity. In terms of short cycle, we can see that the local maximum of both R2 (R-

Square, namely the determination coefficient of regression with the YOY time series and different cycle lengths) and FFT strength for most indexes located between 40 months and 60 months. In terms of median cycle, the local maximum mainly located between 90 months and 150 months. In terms of long cycle, the cycle length may be longer than 250 months. The long cycle can be observed more clearly in developed market with longer data, while it is not quite significant for emerging markets. The long cycle is not significant for emerging markets since most of them haven't or just gone through a full cycle.

The local maximum for short, median and long cycles are summarized in Table 5. There is a clear unified cycle for global financial market and economy. To be specific, the short cycle is about 4 years (48 months), and the median cycle is about 10 years (120 months), and the long cycle is about 25 years (300 months). Put it another way, we can use three sine wave with cycle length 48, 120 and 300 months to reconstruct the YOY time series, and the reconstructed sequence can explain major fluctuations of the original YOY time series. Taking London FTSE 100 Index and Chinese CPI as example, we also show the reconstructed sequence in Figure 13 and 14.

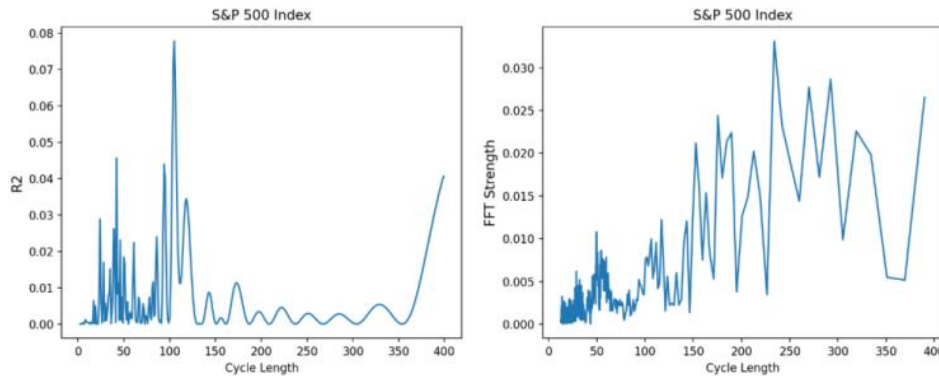


Figure 2: R2 and FFT strength of different cycle lengths for S&P 500 Index.

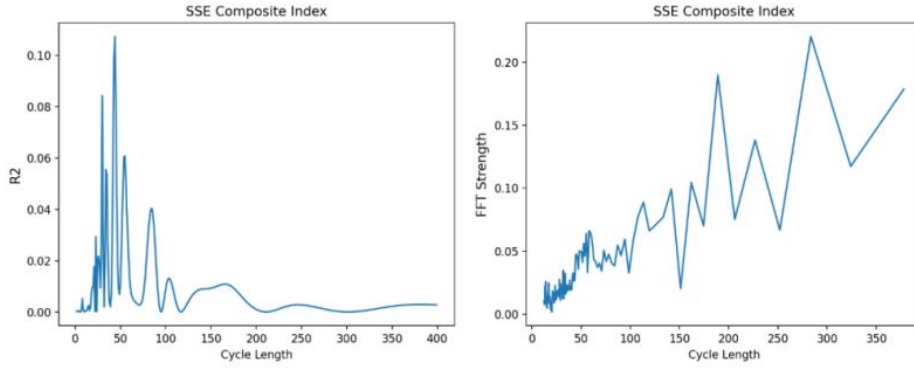


Figure 3: R2 and FFT strength of different cycle lengths for SSE Composite Index.

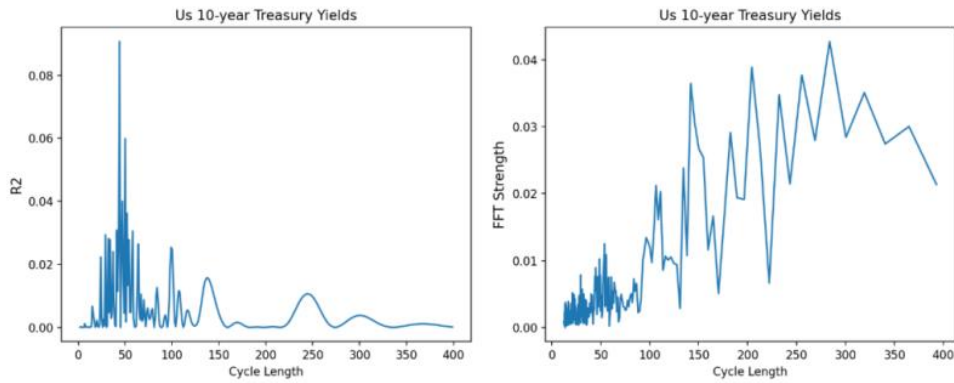


Figure 4: R2 and FFT strength of different cycle lengths for U.S. 10-year Treasury Yields.

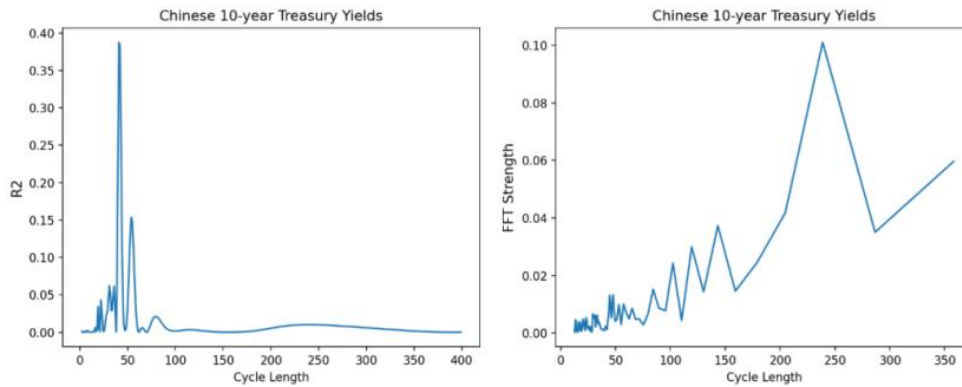


Figure 5: R2 and FFT strength of different cycle lengths for Chinese 10-year Treasury Yields.

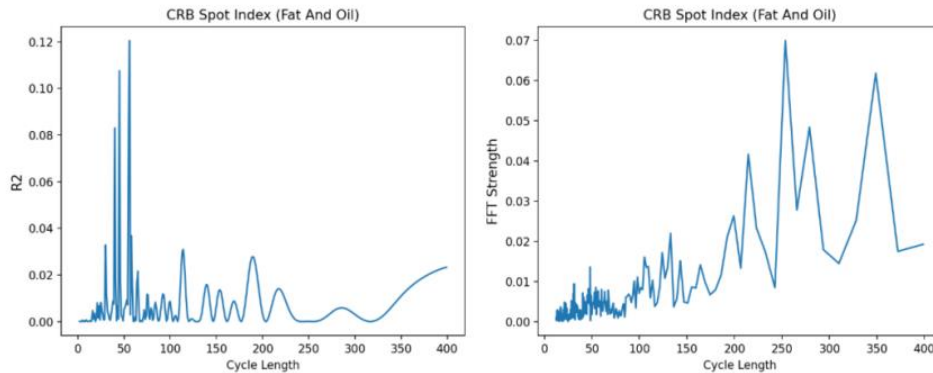
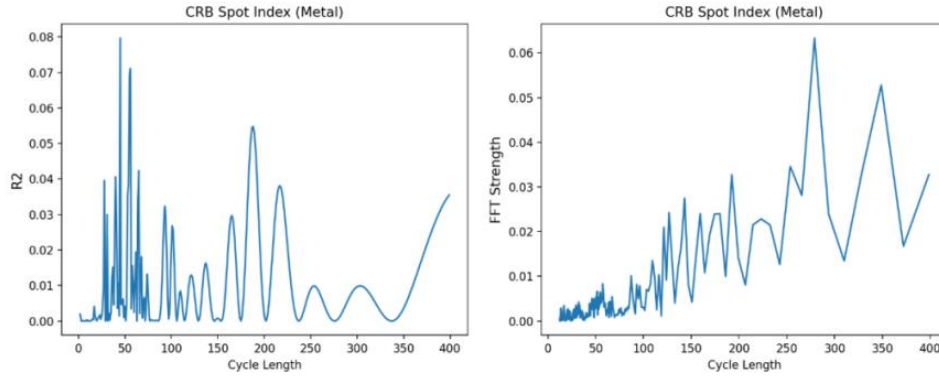
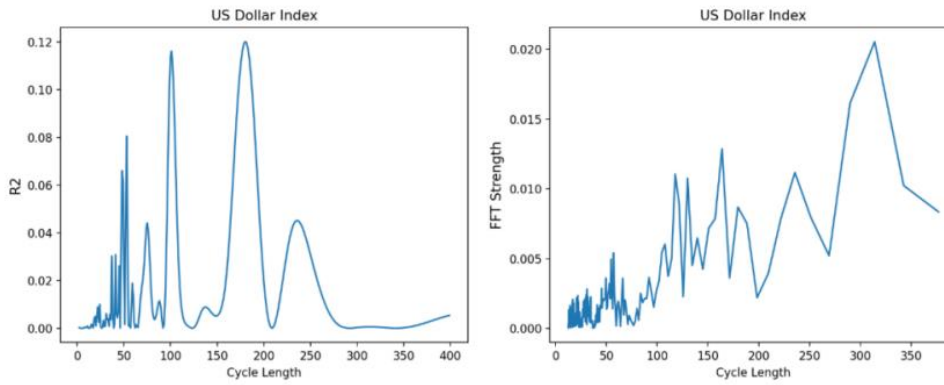


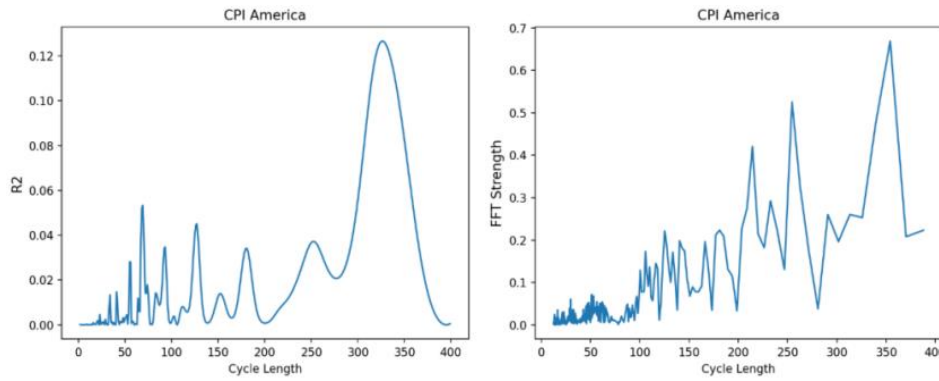
Figure 6: R2 and FFT strength of different cycle lengths for CRB Spot Index (Fat And Oil).



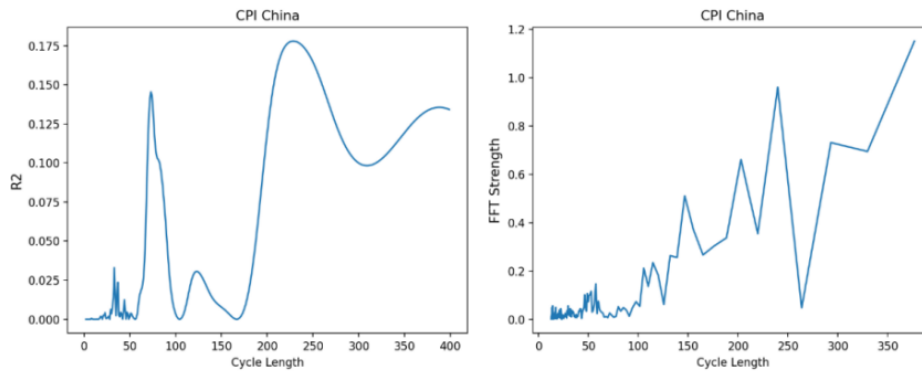
**Figure 7:** R2 and FFT strength of different cycle lengths for CRB Spot Index (Metal).



**Figure 8:** R2 and FFT strength of different cycle lengths for U.S. Dollar Index.



**Figure 9:** R2 and FFT strength of different cycle lengths for American CPI.



**Figure 10:** R2 and FFT strength of different cycle lengths for Chinese CPI.

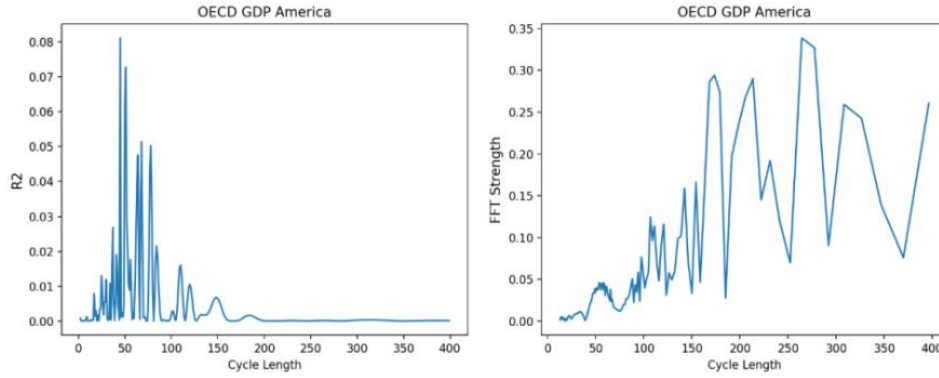


Figure 11: R2 and FFT strength of different cycle lengths for American GDP.

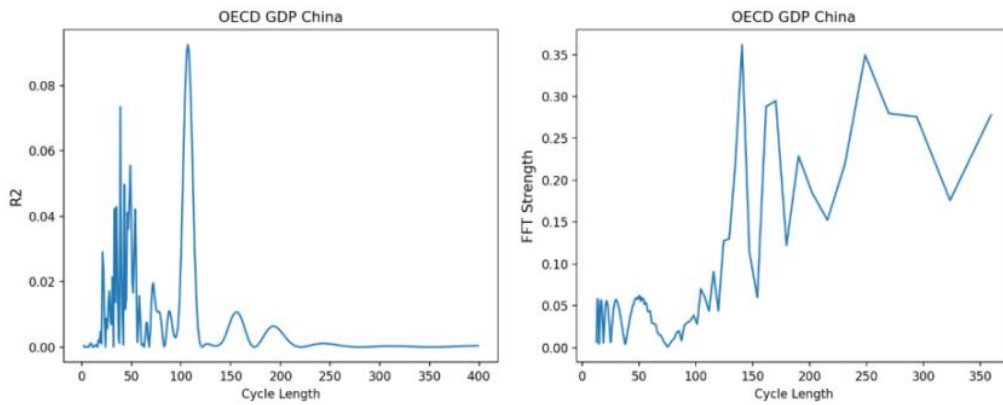


Figure 12: R2 and FFT strength of different cycle lengths for Chinese GDP.

Table 5: The local maximum for short, median and long cycles.

Index	Short	Median	Long	Index	Short	Median	Long
Australien S&P 200 Index	39	87	317	CRB Spot Index (Industrial Material)	45	92	399
CAC 40 Index	43	95	350	CRB Spot Index (Textile)	40	91	399
DAX Index	42	87	399	US Dollar Index	53	180	236
Hang Seng Index	41	83	224	CPI China	73	76	229
London FTSE 100 Index	74	76	399	CPI America	69	127	326
Mumbai Sensex30 Index	44	184	201	CPI France	61	111	244
S&P 500 Index	42	105	399	CPI Japan	66	200	215
SSE Composite Index	44	84	382	CPI England	66	195	201
Tokyo Nikkei 225 Index	41	105	201	CPI Germany	58	163	354
Us 10-year Treasury Yields	44	99	245	OECD GDP America	45	78	312
Chinese 10-year Treasury Yields	41	79	239	OECD GDP Japan	66	113	259
CRB Spot Index (Food)	45	190	399	OECD GDP China	39	107	201
CRB Spot Index (Fat And Oil)	56	114	399	OECD GDP England	68	104	280
CRB Spot Index (Livestock)	45	114	399	OECD GDP France	45	104	399
CRB Spot Index (Metal)	45	188	217	OECD GDP Germany	45	105	260
				Average	50.8	117.9	302.8

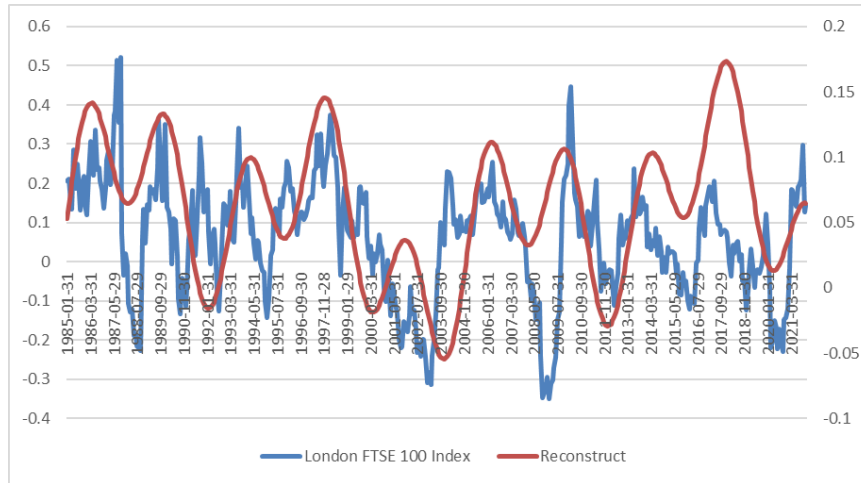


Figure 13: London FTSE 100 Index and its reconstructed series.

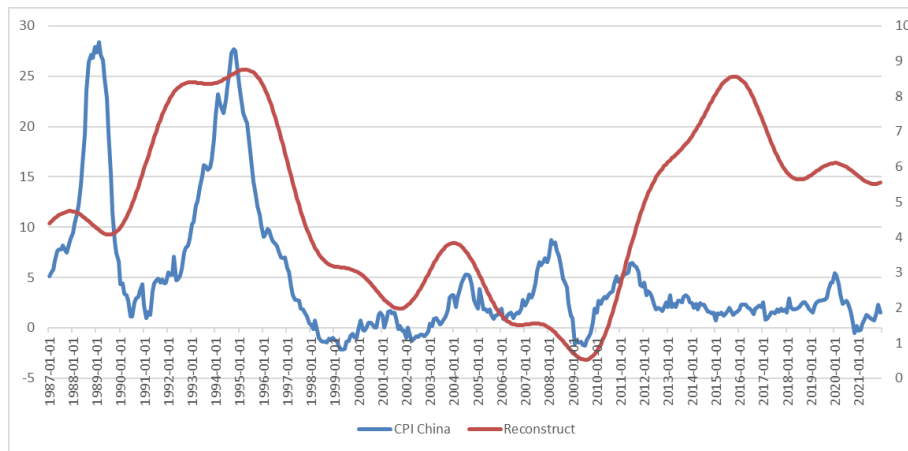


Figure 14: Chinese CPI and its reconstructed series.

## 5. CONCLUSIONS

In this article, we first select 18 representative indexes from several countries and across stock, bond, commodity and exchange market, as well as 12 macro indicators from 6 countries, to research the unified cycle of global financial market and economy. We conduct year-on-year transformation to remove the trend in the original series. We employ linear regression and Fourier transformation to investigate the strength of YOY series on different frequencies (or cycle lengths). We find that the local maximum of strength gathered in three intervals, which implies a short cycle about 48 months, a median cycle about 120 months and a long cycle around 300 months. We demonstrate that there is indeed a stable periodicity in the financial system and macro economy.

Our conclusions are consistent with the Kitchen cycle, Jugra cycle and Kuznets cycle proposed by classical economists. Among them, the shortest cycle is the economic cycle proposed by the British economist Kitchen, with an average length of about 40 months, known as "Kitchen cycle". The middle cycle for the French economist Jugra, a period of 9~10 years of economic cycle, the cycle is marked by national income, unemployment rate and most economic sectors of

production, profit and price fluctuations to be divided, known as the Jugra cycle. The long cycle is the economic cycle proposed by the American economist Kuznets based on the boom and decline of the construction industry, about 15 to 25 years, known as the "Kuznets cycle".

From the perspective of complex system, each variable in the financial and economic system has complex mutual influence, and they work as a whole which cannot be divided. Some interactions affect every corner of the system, while others are localized. Some interactions are long-lasting and stable, while others are short-lived. The cycles we want to find, in essence, should be system-level, continuous and stable factors. System level means that the impact should be felt throughout the system and be observed for most of the system's observed indicators. For example, if the inventory cycle were an economic cycle, we would have to observe similar cycle signals on a number of different macro variables. In this article, we validate the short, median and long cycle with comprehensive indexes and indicators, and we believe that they are systemically cyclical, namely, their year-over-year percentage change will repeat itself.



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