Statistical Measure of Macro-Financial Structure Risks and Its Application

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ABSTRACT

The macro-financial structure risk is an important part of financial risks. This paper constructs the sub-indices of foreign financial assets risks, monetary liquidity risks and mismatch structure risks for integration into the macro-financial structure risk index according to the index principle. The data of related indicators from January 2007 to April 2015 of China are collected for measuring each sub-index and their subsequent summarization into the total index of the macro-financial structure risk, and the trends of each sub-index and the total index are analyzed. After that, statistical tests and practical analysis are conducted to study the effectiveness, sensitivity and relevance of the macro-financial structure risk index. The practical analysis of the index shows that the macro-financial structure risks of China are on the rise, with prominent tendency characteristics, that the characteristics of each sub-index and their impact on the macro-financial structure risks are different, that the macro-financial structure risk index can be expected to play a leading role for predicting the macro economy and that the sub-indices are correlated to the total index to different degrees, despite their common action effects.

Keywords: macro-finance, structural risk, mismatch structural risk, statistical index analysis, index effectiveness evaluation

INTRODUCTION AND LITERATURE REVIEW

In the background of new normal in economic development, the financial development of China gradually takes on dual characteristics. On the one hand, the connection between finance and industrial capital becomes closer. The development of Internet and other technologies has brought about surging demands for finance, especially the Internet-based emerging finance. On the other hand, the relative independence of the financial system and the real economy is gradually enhanced. The capitalized pricing support mechanism in the financial system and the cost pricing support mechanism in the real economy are ever more prominent, enhancing the relative independence in the operation of the financial system from the real economy. As the dual feature becomes more obvious, the macro-financial risks are more conspicuous. And the duality is manifested in the market as abundant liquidity in the stock market and other financial systems and in the real economy as "difficult financing and expensive financing." This phenomenon has been explored in many studies from the perspective of financial resource mismatch and institutional mechanism, but insufficient analysis has been made of the macro-financial structure risks. In view of this situation, this thesis attempts at a discussion of the formulation of the macro-financial structure risk index and its application[1] in five parts. The first part is the introduction and literature review, in which literature related to

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[1] The term "financial structure" in this paper does not refer to general financial structures like financial product structure. It is originated from Goldsmith's research in *Financial Development and Structure*. In line with the research objective of this paper, the sovereign states are taken as the starting point, and the foreign financial assets, the monetary liquidity level and the mismatch structure between finance and the real economy are regarded as a country's macro-financial structure, and the risks incurred as

Contribution of this paper to the literature

- Against the backdrop of new normal in economic development and the superposition of the "three stages", micro adjustments should be exercised to prompt a downward trend.
- From the perspective of trend characteristics, the risks of foreign financial asset structure and the fluctuation of the monetary liquidity hierarchy tend to be stable, and within a stable and controllable range.
- The greater emphasis must be placed on the superposition effects of the sensitive period and shock period for the total index in adjusting economic policies.
- The changed targets are conducive to the control of macro-financial structure risks once they are applied for improving the match between the financial system structure and the real economy structure.

the macro-financial structure is studied. The second part includes the research hypotheses and the index preparation method. On the basis of briefly expounding the economic theory on macro-financial structure risks, the basic hypotheses for the sub-**indices** are put forth. The third part is the measurement of the macro-financial structure risk index and analysis of the results measured. The fourth part is an evaluation of the measured results in Part Three. In this part, macro-financial structure risks are evaluated from the three perspectives of effectiveness, sensitivity and relevance. The fifth part contains the basic conclusion.

Although only limited success was achieved in collecting specialized literature on macro-financial structure risks, the relevant literature can be regarded as exploration of risks from the perspective of macro-financial structure, specifically including currency mismatch, financial sector structure and risk assessment, as can be seen in the following review.

It can be seen from the case of sovereign states that currency mismatch is an important factor for triggering financial crises. The currency mismatch is primarily incurred by use of foreign currency valuation for the balance or expenditure of an economic entity but domestic currency valuation for the assets and incomes. Mishkin (1996, 1999) first proposed the concept of currency mismatch in his study of currency structure for sovereign debt and financial crisis. Later, other scholars studied the causes and measures of currency mismatch. Goldestein et al (2004) studied the degree of currency mismatch from the angles of stock and flow. However, neither the studies of influential factors nor those of measurement methods could avoid the issues of liabilities structure for foreign assets and the distribution of foreign financial assets of sovereign states. The one-way original-sin indices, the two-way net foreign currency positions and ratio of foreign currency assets against foreign currency liabilities, and AECM, MISMATCH, ACMAQ and other core multi-dimensional indicators are invariably based on the asset-liability ratio or the ratio of domestic and foreign assets against domestic and foreign liabilities of sovereign states. However, those researches did not theoretically analyze the risks caused by the financial structure of their assets and liabilities. Their goals for measuring currency mismatch were not measuring macro-financial structure risks. In addition, more often than not, they tended to focus on maturity mismatch or other related issues.

Seen from within the sovereign states, financial risk assessment is more often made of the financial sector, while the sector structure, especially the structural problems between the financial sector and the corporate sector, were not sufficiently considered. Tarashev et al. (2009) argued that financial risks stemmed from systematically important financial institutions, which featured three mutually-influencing risk-driven factors. The first one is the risk of individual institutions; the second is the degree of conglomeration within the system, that is, the concentration of scale, and the third one is the institutional exposure to systemic risk factors. Aside from the first factor, which is a feature of the financial institutions *per se*, the rest two factors are related to the overall characteristics of the system. Tan Hongtao, Cai Li and Cai Chun (2011) held that the systematic risks of the banking sector in China had become its main source of systemic financial risks because of the particularity in its financial system structure featuring the banking system, which was engaged in currency and risk management. In addition, the banks' balance sheets, bad assets and other indicators aggravated the systematic risks. The credit creators represented by commercial banks and the inherent characteristics of related lenders brought about inherent instability to the financial system, and consequently the endogeneity of the financial markets constituted an important reason for the occurrence of financial crises (Minsky, 1992). Borio & Philip (2002) maintained that excessive prosperity of asset prices increased the likelihood of systematic risks. Adrian & Shin (2009) found that changes in investment bank leverage were pro-cyclical, indicating that they were at risk when the economy was operating well. However, once the economic situation took a reverse trend, they would sell large amounts of risky assets, indicating that asset price fluctuation was closely linked to financial risks. It can be seen from those papers that the study of financial risks within sovereign states ignored the basic functions of finance--serving the real

the macro-financial structure risks. Again, to suit the objectives of this paper, the term "macro-financial structure" is specifically used for distinction from general financial structures.

economy. Correspondingly, the financial risks caused by the macro-financial structure did not receive due attention. However, as can be seen from China's current situation, the emergence of irrational prosperity has a very strong correlation with financial structure risks (Zhong & Fan, 2016).

Methods for financial risk measurement are broadly divided into two categories. The first category consists of financial risk assessment based on the index system. Through the design of index system and the use of index preparation principles, Illing and Liu (2003) conducted evaluation and monitoring, and defined financial pressure as a continuous variable of financial crises, stating that it is positively correlated to expected financial losses and uncertainties. Moreover, since financial pressure was usually incurred in a vulnerable structure when it suffered external impact, its magnitude was dependent on that of the impact and the relay of the impact through the financial system (Wang, Lv and Zhao, 2016). They selected nine variables covering the four sectors of banking, the foreign exchange market, the bond market and the stock market and built a pressure index for monitoring financial pressure and risks. Considering that China's financial market featured an indirect financing system and most of the risks were concentrated in the banking system, Liu Chunhang and Zhu Yuanqian(2011) focused on measuring the systemic risks of the banking industry, drew on BLISHER the vulnerability assessment framework for the financial system and built a framework for measuring the systemic risks of China's banking industry. They then proceeded to build a multi-level systematic risk matrix from the perspectives of macroeconomic impact, the banks' vulnerability in management and impact diffusion. The second category consists of model-based financial risk assessment. McCallum (1984) established a dynamic optimization model based on rational maximization of personal utility, and pointed out that in a dynamic and effective economy, "non-Pengqi game" was a constraint for its cross-period budget. Chen Zhongyang, Liu Zhiyang and Song Yuying(2012) believed that an important manifest of financial risks caused by macro shock was the risk of jumping in the capital market. Starting with the jumping risk in the capital market, they utilized Merton's jumping model to locate the macro events incurring systemic risks in China and selected the indicators reflective of China's financial risks based on those macro events.

CONSTRUCTION OF THE INDEX MEASURE MODEL OF MACRO-FINANCIAL STRUCTURE RISKS

The Hypotheses for Building the Macro-Financial Structure Risk Index

Macroeconomic financial risks of sovereign state are mainly seen in three aspects, namely, the foreign financial asset structure, monetary liquidity hierarchy, and the mismatch structure between finance and the real economy. Correspondingly, three hypotheses on constructing the macro-financial structure risk index are proposed.

Hypothesis 1: The external factors of macroeconomic stability are strongly related to the structure of foreign financial assets of sovereign countries; that is, sovereign financial asset structure is one of the main factors contributing to macro-financial structure risks.

The distribution of foreign financial assets and liabilities of sovereign countries is a reflection of its foreign financial assets and liabilities, as well as the reference information for their macroeconomic decision-making and foreign-related risk prevention in the market. Meanwhile, the amount and role of their financial asset return depends not only on asset size but also on asset structure. The imbalance of foreign assets and liabilities structure will expose them to greater risks, with significant impacts on their overall financial operation and risk situation, and exposing them to potential structural financial risks.

Hypothesis 2: The structure of monetary liquidity in sovereign countries has become one of the major sources of macro-financial structure risks, by virtue of its influence on the allocation of financial resources.

Currency liquidity hierarchical pressures have been known to culminate in stock and financial crises. The excessive pressure on the currency hierarchy will reduce the total market liquidity, thereby worsening the overall liquidity level of the market and leading to the dissemination of collapse between the banks and consequently to the collapse of the banking system. In the case of abundant stock and stock liquidity, the pressure of monetary liquidity hierarchy can lead to not only distorted resource allocation, but also large quantities of bad assets, idle assets and subside assets, incurring risks and structural imbalance. In the monetary liquidity hierarchy, the flow of currency to credit is relatively large, the financing channel is relatively monotonous, and the bond and equity market is underdeveloped. As a result, bank participation becomes excessive, financing risks are closely associated with banks, and the risks are unduly concentrated. A problem with any currency flow channel will bring about systemic financial risks impacting the entire system. In addition, the financial market does not release more liquidity by allocating large amounts of financial resources to the less productive infrastructure and real estate, resulting in potential risks of currency liquidity hierarchies.

Hypothesis 3: The mismatch of the asset structure between the financial sector and the real sector is one of the important factors leading to macro-financial structure risks. In other words, the mismatch structure risks are an important part of the macro-financial structure risks.

Due to the asset structure mismatch between the financial sector and the real sector, a lot of funds do not enter the real economy, but circulate within the financial system, resulting in distorted allocation of financial resources, while producing large amounts of idle assets and subside assets.

The relevance of the financial sector to the real sector can be analyzed with sectoral assets. Assets are the resources controlled by the financial sector and the material basis for enterprises to carry out production and operation. The greater the total assets are, the more solid the material basis is, and consequently the stronger the ability to resist risks. Debts are the aggregate liabilities to be repaid and essentially the claim made by the creditor to assets. The owners' equity is net assets, which are the remainder of the total assets after deduction of total debts. In terms of content, it includes the original capital invested and the accumulation made by the company in business operation. In the structure of assets and liabilities, the assets are essentially the funds in use. Primarily originated from two sources, i.e., the owners' equity and liabilities, those funds are reflective of the assets of the financial sector and their distribution. Assets and liabilities in the assets are faced with the risks in quickly realizing and compensating for their values, while the liabilities and owners' equity are perceptible to the risk of timely repayment. Meanwhile, as trading activities are increasing within the financial sector, internal circulation of funds will be prone and financial transactions can be expected to evolve into purely speculative or "relevance" activities, thus weakening or even severing the normal connection with the real economy. Consequently, mismatch risks are generated.

Construction of the Macro-Financial Structure Risk Index

Construction of the sub-index for foreign financial asset structure risks

Construction of the sub-index for foreign financial asset structure risks has a strong correlation with the balance of international payments positions. Seen from international investment position, foreign financial assets include foreign direct investment, securities investment, other investment, reserve assets and financial derivatives. Foreign financial liabilities include foreign direct investment, securities investment, other investment and financial derivatives, and so on. Therefore, the structure of the foreign financial assets and liabilities of sovereign countries is:

$$OFDI + PI_a + OI_a + RA + DI_a = DFI + PI_l + OI_l + DI_l + FNW \qquad (1)$$

In equation (1), the five items on the left stand for foreign direct investment, securities investment, other investment, reserve assets and financial derivatives in the foreign financial assets respectively, while those on the right represent foreign direct investment, securities investment, other investment, financial derivatives and foreign net assets respectively.

The foreign assets of sovereign countries are mainly foreign exchange reserves, characterized by strong liquidity and controllability. And their liabilities are primarily foreign direct investment, with strong stability and controllable systemic risks. Assume that the proportions of securities investment, other investment and financial derivatives in the foreign assets and liabilities are small or can offset each other, and equation (1) can be simplified into:

$$OFDI + RA = DFI + FNW \qquad (2)$$

Equation (2) can be transformed as follows:

$$FNW = RA - (DFI - OFDI) \qquad (3)$$

In equation (3), RA stands for the reserve asset that can be used to measure the net assets of governmental departments. $DFI - OFDI$ stands for the result of foreign direct investment minus the outward direct investment; it is also used to calculate the net debts of the non-government sector. Based on this, we will use outward net assets as the FLDD for reflecting the distribution of foreign financial assets and liabilities of sovereign states. Meanwhile, macro-financial risks of sovereign states are also strongly associated with their economic strength. Therefore, FLDDI as the structural risk index of their foreign financial assets is defined as the ratio of FNW to GDP. Specifically, it can be calculated via equation (4):

$$FLDDI = \frac{FNW}{GDP} = \frac{RA - (DFI - OFDI)}{GDP} \qquad (4)$$

Construction of the structural risk sub-index of currency liquidity hierarchy

Currency liquidity is usually measured using the money supply, which can be classified into different levels. From the perspective of money supply, China's current monetary hierarchy includes $M0$, $M1$ and $M2$. Among them, $M1$ is often referred to as narrow money and $M2$ as broad money. $M1$ reflects the reality of the purchasing power in the economy, while $M2$not only reflects the reality of the purchasing power, but also the potential purchasing power. Fast growth of $M1$ indicates that consumption and the end market are active, while that of $M2$ indicates that the investment and the intermediate market are active. The central bank and the commercial banks can utilize the correlation to determine the monetary policy accordingly. The situation of unduly high $M2$ and low $M1$ indicates investment overheating and slack demand and therefore crises are prone to occur. That of unduly high $M1$ and low $M2$ indicates robust demand and insufficient investment, and therefore prices are like to rise. In order to reflect the hierarchical structure of monetary liquidity, the MLHSS index is proposed, as calculated according to equation (5):

$$MLHSSI = \frac{M2}{M1} = \frac{M1 + UD + ERD + TD + OD}{C + ED + RD + PD} \tag{5}$$

In equation (5), C stands for the cash in circulation; ED, RD and PD for corporate demand deposits, rural deposits and personally held deposits in credit cards respectively; UD, ERD, TD and OD for savings deposits of urban and rural residents, corporate deposits with a regular nature, trust deposits and other deposits respectively, and FB, MP and CD for financial bonds, commercial paper and large-denomination negotiable certificates of time deposits respectively.

Construction of mismatch structural risk sub-index

In order to reflect the adaptation of the asset structure between the financial sector and the real sector, the ASMAQ index is proposed as the absolute quantity indicator of asset structure mismatch, which is calculated as follows:

$$ASMAQ = FRA - FRL \tag{6}$$

In equation (6), ASMAQ stands for the absolute quantity of asset structure mismatch between the financial sector and the real sector, FRA for the assets acquired by the real sector from the financial sector and FRL for liabilities of the real sector to the financial sector.

ASMAQ can be used for measuring the mismatch between the financial sector and the real sector, but it cannot eliminate the impact of economic size, or reflect the actual size of asset structure mismatch and its impact on finance and the economy. Therefore, we suggest using the GDP of the country at issue for its adjustment, and excluding the impact of economic scale, for reasonably explaining the influence of capital mismatch on the formation of financial structural risks. The revised ASMAQ index is:

$$ASMAQI = \frac{ASMAQ}{GDP} \tag{7}$$

The Synthesis of the Macro-Financial Structure Risk Index

According to the previous definition, the macro-financial structure risk is composed of three indices: PLDDI for the foreign financial asset structure, MLHSSI for the monetary liquidity hierarchy, and ASMAQI for the financial and real economic mismatch structure. Considering the different significance of different macro-financial structures for risks, the three sub-indices are aggregated by weighting, and SFRI the general index of macro-financial structure is obtained. The specific calculation is based on equation (8)

$$SFRI = w_1 PLDDI + w_2 MLHSSI + w_3 ASMAQI \tag{8}$$

In equation (8), w_1, w_2 and w_3 stand for the respective weights of corresponding sub-indice**s**, satisfying $\sum_{i=1}^{3} w_i = 1$.

THE MEASURE OF THE MACRO-FINANCIAL RISK STRUCTURE INDEX

Data Selection and Processing

In view of the basic hypotheses of the study and the indicators that make up each sub-index, the indicators to be selected include foreign exchange reserve assets, foreign direct investment, direct investment in China, M1, M2, claims for non-financial sector, deposits of the non-financial sector and the gross domestic product (GDP). Among them, the proportion of gold reserves in reserve assets (RA) is relatively small, and thus will be replaced with foreign exchange reserve assets. Claims for non-financial sectors and deposits in non-financial sectors represent the assets acquired by the real sector from the financial sector and its liabilities to the latter respectively.

Considering that the sensitivity of the low frequency data variable to the financial reality is not high, and that the prediction accuracy of the leading variables is weakened, monthly data have been selected, on the ground that they are capable of more accurate description of the macroscopic financial structure problems. In terms of time span, the monthly data from January 2007 to April 2015 have been selected for empirical analysis, but quarterly data of GDP, foreign direct investment and direct investment in China have been used. The figures for the Foreign financial asset structure index has been acquired from the official website of China State Administration of Foreign Exchange, those for currency liquidity hierarchy financial risk sub-index and mismatch financial risk index from the website of the People's Bank of China and those for GDP from the National Bureau of Statistics. In addition, the data of net export, interbank interest rate, growth rate of industrial added value and GDP growth rate have been used in determining the index weights, and those data have been retrieved from the statistical database of China Economic Information Network.

In view of the specific needs, the data were subjected to the following processing: (1) The unit for the foreign direct investment and direct investment in China was converted from US dollars into RMB for unification. (2) For indicators with quarterly data only but no monthly data, the data were processed via same-frequency conversion. Take GDP for example. At first, difference was made for the cumulative quarterly values for the data of each quarter, before being converted with the Quadratic-match-Sum method. Data of foreign direct investment and direct investment in China were converted via the Quadratic-match-Average method. (3) In case of lacking monthly data, the smoothing method was adopted to fill the blanks. And the industrial added value growth rate in January is a typical example. (4) For the time series data containing the seasonal factors, the X-11 adjustment method was used to eliminate seasonal factors such as GDP.

The software used for data processing and empirical analysis in the thesis includes Eviews8.0 and Matlab7.1.

The Calculation of the Sub-Indices and Total Index of Macro-Financial Structure Risks

Based on the processed data, FLDDI, MLHSSI and ASMAQI were obtained using equation (4), (5) and (7), specifically as shown in **Table 1**.

Table 1. The Measured Results of the Three Sub-Indices for Macro-financial Structure Risks (Monthly)

Time	FLDDI	MLHSSI	ASMAQI	Time	FLDDI	MLHSSI	ASMAQI
2007.01	1.4206	2.7357	1.7368	2011.03	2.1452	2.8474	2.9688
2007.02	1.3581	2.8407	1.7376	2011.04	2.1247	2.8391	2.9501
2007.03	1.3944	2.8472	1.6939	2011.05	2.1164	2.8349	2.9127
2007.04	1.6975	2.8770	2.0073	2011.06	2.1091	2.8428	2.8857
2007.05	1.7162	2.8380	1.9637	2011.07	2.1130	2.8569	2.9548
2007.06	1.7136	2.7813	1.9053	2011.08	2.1240	2.8561	2.9590
2007.07	1.7891	2.8178	1.9571	2011.09	2.1378	2.9470	3.0313
2007.08	1.8068	2.7463	1.9029	2011.10	2.1150	2.9536	3.0896
2007.09	1.8493	2.7568	1.8618	2011.11	2.0961	2.9334	3.1026
2007.10	1.8343	2.7252	1.9312	2011.12	2.0791	2.9381	3.0735
2007.11	1.8778	2.7009	1.8912	2012.01	2.0899	3.1699	3.4293
2007.12	1.8546	2.6449	1.8018	2012.02	2.0989	3.2080	3.4266
2008.01	1.8675	2.6980	2.2540	2012.03	2.1954	3.2215	3.5449
2008.02	1.8832	2.8036	2.2353	2012.04	2.0231	3.2351	3.3649
2008.03	1.8907	2.8041	2.1182	2012.05	1.9944	3.2300	3.3547
2008.04	1.9448	2.8301	2.1469	2012.06	1.9677	3.2171	3.3186
2008.05	1.9312	2.8447	2.0767	2012.07	1.9508	3.2466	3.3914
2008.06	1.8837	2.8623	2.0106	2012.08	1.9403	3.2368	3.4257
2008.07	1.9292	2.8799	2.0643	2012.09	1.9342	3.2905	3.4455
2008.08	1.9491	2.8609	2.0555	2012.10	1.9305	3.1925	3.5007
2008.09	1.9966	2.9079	2.0845	2012.11	1.9184	3.1825	3.5114
2008.10	2.0475	2.8826	2.1483	2012.12	1.9186	3.1560	3.4464
2008.11	2.0374	2.9060	2.0651	2013.01	2.2069	3.5679	3.5481
2008.12	2.0538	2.8587	2.0629	2013.02	2.2150	3.5745	3.7072
2009.01	1.7206	3.0030	2.3321	2013.03	2.3441	3.5421	3.8004
2009.02	1.7204	3.0497	2.4437	2013.04	2.1680	3.6021	3.5633
2009.03	1.7792	3.0057	2.5883	2013.05	2.1458	3.6063	3.5513
2009.04	1.6039	3.0328	2.3557	2013.06	2.1068	3.5421	3.5722
2009.05	1.5333	3.0120	2.3248	2013.07	2.0797	3.6042	3.6570
2009.06	1.5023	2.9456	2.3137	2013.08	2.0670	3.6067	3.6709
2009.07	1.4960	2.9256	2.3834	2013.09	2.0591	3.6735	3.7286
2009.08	1.4756	2.8778	2.4207	2013.10	2.0555	3.6383	3.7755
2009.09	1.5909	2.9022	2.4579	2013.11	2.0429	3.6066	3.6748
2009.10	1.5071	2.8266	2.4869	2013.12	2.0210	3.5292	3.7197
2009.11	1.5621	2.7982	2.5003	2014.01	2.0032	3.5679	3.7516
2009.12	1.6886	2.7556	2.3855	2014.02	2.0251	3.5745	3.8434
2010.01	2.1147	2.7249	2.6524	2014.03	2.1717	3.5421	3.8677
2010.02	2.0772	2.8360	2.7546	2014.04	1.9556	3.6021	3.5924
2010.03	2.1022	2.8333	2.6993	2014.05	1.9407	3.6063	3.6635
2010.04	2.0998	2.8069	2.6562	2014.06	1.9067	3.5421	3.5837
2010.05	2.0674	2.8049	2.6307	2014.07	1.8843	3.6042	3.7603
2010.06	2.0434	2.8012	2.6110	2014.08	1.8730	3.6067	3.7153
2010.07	2.0455	2.8008	2.6736	2014.09	1.8648	3.6735	3.7183
2010.08	2.0564	2.8137	2.6717	2014.10	1.8497	3.6383	3.7071
2010.09	2.0791	2.8565	2.7046	2014.11	1.8428	3.6066	3.6570
2010.10	2.1362	2.7625	2.7188	2014.12	1.8345	3.5292	3.6584
2010.11	2.1582	2.7382	2.7031	2015.01	1.8693	3.5699	3.7609
2010.12	2.1718	2.7224	2.6452	2015.02	1.9230	3.7597	3.6000
2011.01	2.1734	2.8036	3.1748	2015.03	1.9067	3.7820	3.5029
2011.02	2.1186	2.8400	3.0740	2015.04	1.8027	3.8074	3.4498

In order to synthesize the macro-financial structure risk index (SFRI), the weight of the three sub-indices in equation (8) had to be determined. So, correlation coefficients were selected to determine the correlation degree of the different types of risk sub-indices to the structural financial risks, while the correlation coefficients used for determining the weights were those between the various sub-indices and the indicators reflective of the market operation conditions. Based on this, the correlation coefficients between FLDDI and net export (after logarithm), MLHSSI and interbank interest rate, ASMAQI and industrial added value were calculated respectively. The results

Table 2. Weight of the Three Sub-Indices for Macro-Financial Structure Risks

Category	Symbol	Property Description	Weight
Risk Index of Foreign Financial Assets Structure	FLDDI	Reverse	0.1704
Risk Index of Currency Liquidity Hierarchy	MLHSSI	Moderate	0.3458
Risk Index of Mismatch Structure	ASMAQI	Positive	0.4838

Note: The moderate critical threshold interval MLHSSI is [2.98, 3.22].

Table 3. Measured Results of the Total Index for Macro-Financial Structure Risk

Time	SFRI	Time	SFRI	Time	SFRI	Time	SFRI
2007.01	1.7258	2009.02	1.9043	2011.03	2.1549	2013.04	2.5237
2007.02	1.7001	2009.03	1.9792	2011.04	2.1524	2013.05	2.5232
2007.03	1.6707	2009.04	1.8878	2011.05	2.1373	2013.06	2.5175
2007.04	1.7592	2009.05	1.8922	2011.06	2.1228	2013.07	2.5845
2007.05	1.7487	2009.06	1.9154	2011.07	2.1504	2013.08	2.5942
2007.06	1.7410	2009.07	1.9569	2011.08	2.1508	2013.09	2.6466
2007.07	1.7403	2009.08	1.9951	2011.09	2.1514	2013.10	2.6574
2007.08	1.7362	2009.09	1.9847	2011.10	2.1809	2013.11	2.6001
2007.09	1.7056	2009.10	2.0394	2011.11	2.1975	2013.12	2.5983
2007.10	1.7525	2009.11	2.0464	2011.12	2.1847	2014.01	2.6302
2007.11	1.7344	2009.12	1.9847	2012.01	2.3214	2014.02	2.6728
2007.12	1.7151	2010.01	2.0512	2012.02	2.3320	2014.03	2.6482
2008.01	1.9114	2010.02	2.0677	2012.03	2.3771	2014.04	2.5739
2008.02	1.8627	2010.03	2.0378	2012.04	2.3247	2014.05	2.6120
2008.03	1.8051	2010.04	2.0268	2012.05	2.3229	2014.06	2.5570
2008.04	1.8006	2010.05	2.0208	2012.06	2.3056	2014.07	2.6673
2008.05	1.7640	2010.06	2.0167	2012.07	2.3537	2014.08	2.6485
2008.06	1.7342	2010.07	2.0465	2012.08	2.3686	2014.09	2.6747
2008.07	1.7461	2010.08	2.0392	2012.09	2.3979	2014.10	2.6596
2008.08	1.7452	2010.09	2.0362	2012.10	2.3907	2014.11	2.6256
2008.09	1.7346	2010.10	2.0662	2012.11	2.3944	2014.12	2.6006
2008.10	1.7654	2010.11	2.0634	2012.12	2.3539	2015.01	2.6581
2008.11	1.7190	2010.12	2.0389	2013.01	2.4978	2015.02	2.6382
2008.12	1.7317	2011.01	2.2643	2013.02	2.5751	2015.03	2.6022
2009.01	1.8671	2011.02	2.2126	2013.03	2.5866	2015.04	2.6032

were 0.2100, 0.4263 and -0.5964 respectively. The signs of the correlation coefficients can be used to determine whether the indices are reverse or positive. Processing of the indices is described in the following section, and the absolute values of the correlation coefficients are selected in processing the weight. The calculated correlation coefficients were then used to obtain the weight of the three financial risk sub-indices under the premise of the constraint weights aggregating 1, as shown in **Table 2**.

Based on the analysis of the basic hypotheses, it can be seen from **Table 2** that FLDDI is reflective of the ability of sovereign countries to resist foreign structural financial risks. The greater its value is, the less likely the financial risks are. Therefore, it is essentially a reverse index. MLHSSI stands for structural pressure from money flow. An unduly large or small value means increased likelihood of structural financial risks. Therefore, it is a modest index. Its critical threshold is [2.98, 3.22] and the critical value is calculated from the mean and double variance of the index sequence. ASMAQI is reflective of the asset structure mismatch between the financial sector and the real sector. The greater its value is, the greater the separation of the asset structure and the greater the possibility of macro-financial financial risk. Therefore, it is a positive index. In view of this, the reverse and the moderate index have to be subjected to positive processing. Then, the weight coefficients are used for integrating the indices. The resultant total indices for macro-financial structure risks are shown in **Table 3**.

Analysis of the Characteristics of the Macro-Financial Structure Risk Index

Distribution characteristics of the macro-financial structure risk index

Based on the results calculated, the descriptive statistical results of FLDDI, MLHSSI, ASMAQI and SFRI are shown in **Table 4**.

Table 4. The Descriptive Statistical Results of the Macro-Financial Structure Risk Index

Index	Mean	Min.	Max.	Standard Deviation	Skewness	Kurtosis	J-B J-B	P Value	No. of Samples
FLDDI	1.9364	2.3441	1.3581	0.2057	-0.9217	3.3823	14.7683	0.0006	100
MLHSSI	3.1027	3.8074	2.6449	0.3484	0.6118	1.7756	12.4860	0.0019	100
ASMAQI	2.8897	3.8677	1.6939	0.6711	-0.1509	1.6033	8.5075	0.0142	100
SFRI	2.1729	2.6747	1.6707	0.3315	0.1124	1.6297	8.0349	0.0180	100
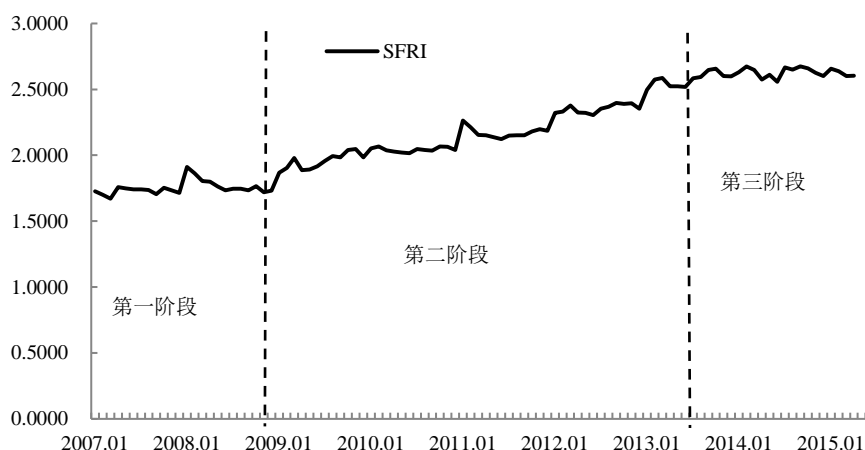
Figure 1. Trend Features of the Macro-Financial Structure Risk Index

It can be seen from **Table 4** that the FLDDI and ASMAQI sequences both have a long left trailing in distribution, and that the MLHSSI and SFRI sequences both have a long right tailing, indicating that the sequence distributions of the four indices are asymmetric around their respective mean, and that the distribution of macro-financial structure risks is consistent with the monetary liquidity hierarchy. The J-B value shows that the four index sequences obey the normal distribution at the 5% significant level. In addition, it can be learnt from the kurtosis that the FLDDI sequence exceeds normal distribution.

Trend features of the macro-financial structure risk index

Based on the results of calculation, the sequence of the macro-financial structure risk index is plotted, as shown in **Figure 1**.

As can be seen from **Figure 1**, from January 2007 to April 2015, China's macro-financial structure risk index can be broadly divided into three stages. The first stage, from January 2007 to December 2008, was the accumulative stage. Despite the impact of the Asian financial crisis of 1997, the macro-financial structure risk index during the stage was relatively stable, but undeniably the risks built up. The second stage, from January 2009 to March 2013, marked rapid expansion of macro-financial structure risks. In the later subprime mortgage crisis, capital flows changed and brought about unbalanced flow of funds between different sectors. The third stage, from April 2013 to the present, marked high and volatile risks. In the background of economic new normal, the focus of economic development was shifted to the structural adjustment, thus alleviating the increase in the risk of macroeconomic structure. Consequently, the risks gradually took on the trend of decline. In terms of overall trend, China's macro-financial structure risk index has assumed an upward trend since then, and is currently in the process of being mitigated from the high and volatile status.

Trend features of the macro-financial structure risk index

The sub-indices of macro-financial structure risk are distinctive. The three indices of FLDDI, MLHSS and ASMAQI have been juxtaposed in a diagram, in order to investigate the differences between them, as seen in **Figure 2**.

It can be seen from **Figure 2** that the impacts of the three sub-indices on the macro-financial structure risks are different. First of all, China's macro-financial structure risks mainly stem from the mismatch structure. The fact of ASMAQI constituting the weight coefficient of SFRI and the consistency in their trend indicate that China's macro-financial structure risks are primarily determined by the degree of mismatch between the financial sector and the corporate sector. Funds from the financial sector are the primary source of finance for the development of the
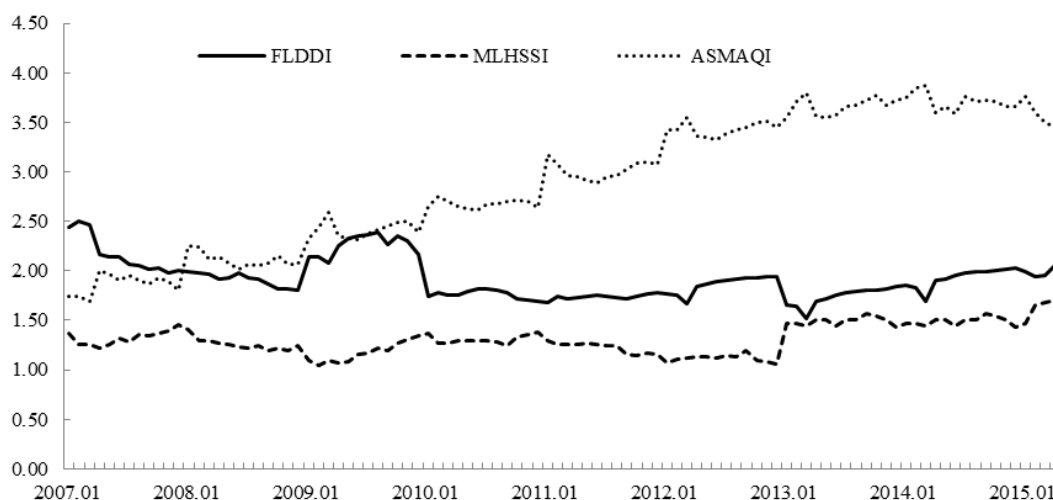
Figure 2. Trends of the Three Sub-Indices of the Macro-Financial Structure Risks

business sector. So their effective flow to the corporate sector is strongly correlated to the mismatch structure. Secondly, the foreign asset structure risk index is the main reason for the phased changes in China's macro-financial structure risks. The trend of FLDDI shows that there were significant structural change points from December 2008 to October 2010 and from December 2012 to April 2013, which included the breakpoints of the three phases of SFRI. In addition, the monetary hierarchy liquidity structure risk has always been a source of risk for China's macro-financial structure risks. During the sampling period, the MLHSSI showed a steady trend, without obvious impact on the trend of SFRI, but it was a fundamental cause for China's macro-financial structure risks.

ANALYSIS OF THE MEASURED RESULTS OF THE MACRO-FINANCIAL STRUCTURE RISK INDEX

The results of the macro-financial structure risk index are analyzed from thee perspectives of validity, sensitivity and relevance for further assessment.

The Effectiveness of the Macro-Financial Structure Risk Index

First, its effectiveness is analyzed with the statistical test results. Most of the variables selected in constructing the macro-financial structure risk index in China are capital flow variables, which can be used as leading indicators for maintaining macroeconomic stability and development. In other words, the impact of SFRI on macroscopic economy can be tested to evaluate the effectiveness of the index. The quarterly GDP growth rate was selected as a representative of the macroeconomic performance for establishing the VAR model for the two variables of SFRI and GDP growth rate. Only quarterly data could be acquired for GDP growth rate, so the data of the last month of the corresponding quarter was taken, to reflect SFRI and the GDP growth rate in the VAR model.

According to the principle of minimal AIC and SC, it was initially determined that lag period of the VAR model should be comprised of six stages. The AR root figure shows that the characteristic roots of the entire parameter matrix are located within the unit circle (See **Figure 3**, left), indicating that the VAR (6) model is stable. Then, an impulse response test was carried out for the model. The results show that the GDP growth rate has a negative impulse response to the impact from SFRI and reaches maximum after 6 to 7 quarters (See **Figure 3**). It can be seen that SFRI has a significant negative impact on the macro-economy after a period of time (six quarters, or one and a half years). SFRI can be used as a leading indicator for macroeconomic forecast. It contains information of the future macro-economy and thus can be expected to play a guiding role in the formulation of financial and macroeconomic policies. Therefore, the SFRI results are valid.

Secondly, the effectiveness is analyzed from the perspective of consistency with the securities market. The light signal principle for the economic climate was used, adopting the five stages of red, yellow, green, light blue and blue. Then 1- and 2-times standard deviation was adopted for classification. The calculated results show that the yellow light range for China's macro-financial structure risk is [2.5044, 2.8359]. From this, it can be seen that China's macro-financial structure risk index has been in the yellow light range from February 2013 to the present. However, the statistical test results show that SFRI impact lags behind for 6 quarters. Therefore, from around August 2014 SFRI impact on the macro-economy must have shown gradually. Study of the sensitive securities market finds that
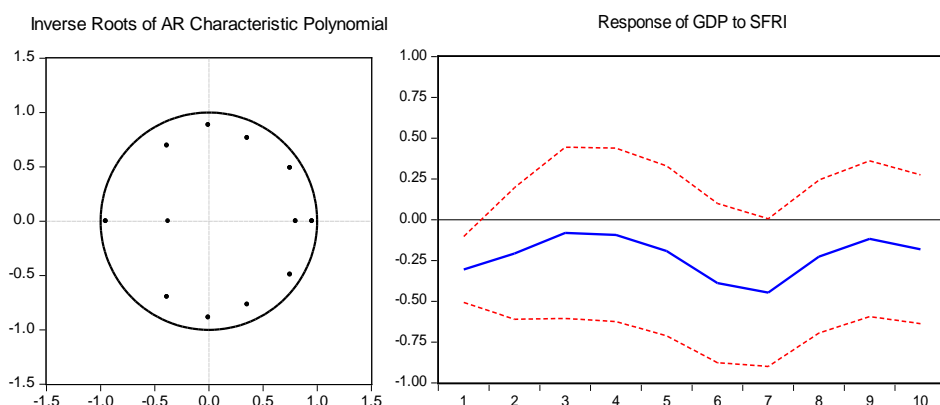
Figure 3. AR Root Figure (Left) and Impulse response of SFRI to GDP Growth Rate (Right)

Table 5. Estimated Parameters of the Two Regression Models and Their Tests

Variable	Model Ⅰ	Model II
C	0.2529***	0.8288***
	(0.0014)	(0.0031)
FLDDI	-0.0993***	-0.2292***
	(0.0003)	(0.0006)
MLHSSI	0.1723***	0.0528
	(0.0000)	(0.3815)
ASMAQI	0.4249***	0.3423***
	(0.0000)	(0.0000)
FLDDI×MLHSSI×ASMAQI		0.0159*
		(0.0309)
Adjusted R^2	0.9843	0.9849
F Value	2070.0540***	1615.2120***
	(0.0000)	(0.0000)

Note: The data in brackets are p values; *, ** and *** indicate that the statistics have passed the test at the 10%, 5% and 1% significance levels, respectively.

Shanghai Composite Index started climbing from about 2000 points to reach the vicinity of 2400 points in October. From September 2013 on, the SFRI value had been above 2.6. After the corresponding lag period, that is, from March 2015 onwards, the Index rose from around 3200 to around 5100 in June. Meanwhile, according to the calculated results, the Chinese economy will be subjected to greater impacts from the micro-financial structure risks until the end of 2016, externally manifested as violent fluctuations in the stock market.

Sensitivity Analysis of Different Types of Structural Risks

In order to analyze the sensitivity of the impact of different structural risks on the macro-financial structure risk, SFRI was used as the explained variable, and FLDDI, MLHSSI and ASMAQI (non-regularized data) as the explanatory variables for regression analysis. Called Model I, it is shown as the following equation:

$$SFRI_t = C + \alpha * FLDDI_t + \beta * MLHSSI_t + \gamma * ASMAQI_t + \varepsilon_t \quad \text{(Model I)}$$

Besides, in order to illustrate the linkage effect among the three aspects, the cross among them was introduced into the general regression model, as seen in model II:

$$SFRI_t = C + \alpha * FLDDI_t + \beta * MLHSSI_t + \gamma * ASMAQI_t$$
$$+ \lambda * FLDDI_t \times MLHSSI_t \times ASMAQI_t + \varepsilon_t \quad \text{(Model II)}$$

The estimate results of the two models are shown in **Table 5**.

It can be seen from **Table 5** that model I and model II have both passed the goodness-of-fit test and are both reflective of the influences of the three sub-indices on the macro-financial structure risk index. In addition, their parameter estimates have all passed the test at 1% significance level. Seen from the direction of parameter estimation, the influence direction of FLDDI and ASMAQI on SFRI is negative and positive respectively, and this is consistent with their nature. From the size of the parameter estimation, ASMAQI has the greatest effect, indicating that mismatch structure risks have a strong sensitivity, and its trend will affect the long-term changes in SFRI. That is decided by the relationship between China's financial sector and its real economy. In the stage of economic transformation, the ability of the financial sector to serve the real economy, that is, the sufficiency of its

Table 6. Correlation Test of Different Types of Macro-Financial Structures Risk Indices

Correlation coefficient	FLDDI	MLHSSI	ASMAQI
FLDDI	1.0000 (----)		
MLHSSI	0.2013** (0.0446)	1.0000 (----)	
ASMAQI	0.4976*** (0.0000)	0.8467*** (0.0000)	1.0000 (----)

Note: The data in brackets are p values; *, ** and *** indicate that the statistics are successfully tested at the 10%, 5% and 1% significance levels respectively.

funds provided to the real sector determines the degree of fund mismatch. Despite its insignificant roles, FLDDI is highly sensitive. Under the joint effect of the three risks, the role of foreign financial asset structure is rapidly increased. This is because under the common mechanism, China's macro-financial structure risks will be subjected to greater influences from its foreign financial asset structure. In monetary policy, greater emphasis should be placed on exchange rate risks. The role of MLHSSI shows that it is less sensitive to macro-financial structure risks. This is because China's monetary policy tends to be active, with relatively stable impacts on macro-financial structure risks.

Moreover, its sensitivity can also be analyzed from the point of structural change. Of the three sub-indices, the mismatch structural risk index is the most sensitive. From staged SFRI analysis, it can be learnt that the three stage points of mismatch structure occurred in December 2008, October 2010 and April 2013 respectively. In reality, "the four trillion" economic-inventive policy was launched in 2008 to deal with the global financial crisis, and due to repeated investment and other circumstances, the financial sector grew steadily more independent of the real economy. As the mutual independence gradually increased, economic stagflation emerged. At the structural change point in 2013, the problem with China's economic structure became more prominent. The mutual independence between the financial sector and the real economy in supporting the pricing system was transformed into aggravated deviation of the financial system from the real economy in structure, exacerbating the mismatch structure.

Relevance Analysis of Different Types of Structural Risks

It is shown in Model II of **Table 5** that the impact of the three sub-indices on the macro-financial structure risk index is 0.0159, which stood the test at 1% of the significant level, indicating that the joint-effect mechanism of the three sub-indices has a significant impact on the total index. Meanwhile, a correlation test was conducted for the three sub-indices in an effort to further illustrate the relevance. The results of the correlation test are shown in **Table 6**.

As can be seen from **Table 6**, there is a correlation between different types of sub-indices, but at different degrees. There is a weak correlation between the risk of foreign financial asset structure and that of monetary liquidity structure, a strong correlation between the risk of mismatch structure and that of monetary liquidity hierarchy, and a strong correction between the risk of foreign financial asset structure and that of mismatch structure.

It can be seen in the strong correlations that the mismatch structure risk has become the core factor. From realistic investigation, after the subprime mortgage crisis in 2008, the global economy began the transition the from virtual economy to the real economy, as it dawned on countries around the world also that "industrial hollow" had an impact on the overall economy. Likewise, the mismatch structure risk gradually accumulated and surfaced in China's macro-financial structure in the beginning of 2008. It has assumed a rising trend, until reaching the current state of high and volatile situation. Observation concluded that it maintained the trend until November 2014, before taking a downward trend, only after the implementation of a series of structural adjustment policies.

Another aspect of strong correlation studied is the correlation between monetary liquidity hierarchy and mismatch structure risk, which is also manifested in China's monetary policy in recent years. Its monetary policy for 2008-2009 was mainly aimed at fighting the global financial crisis, and the tools used were primarily quantitative, including increased bank loans. For the 2010-2011 period, changes were gradually made to its monetary policy tools, with consideration for structural problems. A dominant manifest consisted in window guidance of monetary policy tools and practices were adopted for improving the lending structure. After 2013, its monetary policy presented the tendency of comprehensive structural adjustment, including targeted RRR cuts. Those monetary policy adjustment methods are in essence meant to amend the mismatch structure. Therefore, it can be seen from the perspective of the objectives of monetary policies that there is a greater correlation between monetary liquidity hierarchy and mismatch structure risks.

CONCLUSION

The macro-financial structure risks are reflective of a country's structural risks in the flow of funds, and capable of accurately predicting the potential risks in its capital flows. Based on the causes of macro-financial structure risks, this paper constructed the macro-financial structure risk index and subjected it to applied research. The basic conclusion is as follows:

First, macro-financial structure risks are generally on the rising, with the trend characteristics. Since 2007, China's macro-financial structure risks have been accumulating, and assumed the staged features of accumulation, expansion and high and volatile fluctuation in the three periods from January 2007 to January 2008, January 2009 to March 2013 and April 2013 to the present respectively. Although there might have been a downward after April 2013, it is in the process of wide shock, with relatively strong sensitivity. So, the progressive development and reform in the current stage is critical. In particular, against the backdrop of new normal in economic development and the superposition of the "three stages", micro adjustments should be exercised to prompt a downward trend.

Second, the trend characteristics of sub-indices and their impact on macro-financial structure risks are different. From the perspective of trend characteristics, the risks of foreign financial asset structure and the fluctuation of the monetary liquidity hierarchy tend to be stable, and within a stable and controllable range. However, the mismatch risk index tends to rise, starting to deviate from the other two sub-indices in 2010. Therefore, greater emphasis should be placed on mismatch structural risks in regulating macro-financial structure risks, while the risk of mismatch structure depends more on internal circulation of funds in the financial system. The three sub-indices are reflective of the influence of macro-financial structure risks. The influence of FLDDI and ASMAQI on SFRI is negative and positive respectively. In terms of the size of the parameter estimate structure, ASMAQI plays the greatest role and is the most sensitive. FLDDI is also highly sensitive despite its relatively less significant roles, and MLHSSI is relatively insignificant in sensitivity.

Third, the macro-financial structure risk index has a leading role to play for the macro-economy. Analysis of the validity of macro-financial risk index, GDP and other related data has found that the impact of macro-financial structure risk index on macroeconomic operation tend to lag behind for about 6 to 7 quarters. Meanwhile, the sensitivity analysis has found that the impact of macro-financial structure risk on macroeconomic operation lasts for more than one year. In other words, for the year 2016, China's economy remained in the high-risk shock period. It can be seen from the sub-indices that foreign financial asset structure risks are in the sensitive period of the rising channel. Therefore, greater emphasis must be placed on the superposition effects of the sensitive period and shock period for the total index in adjusting economic policies. In formulating specific strategies for free convertibility of RMB and other core issues, more attention should be paid to structural risks.

Fourthly, the correlation of the sub-indices of macro-financial structure risks is different and features common effect. The correlations between those sub-indices are inconsistent; some are strongly correlated, while others are weakly related. However, the core of strong correlations is reflected in mismatch structure risks, that is, the effectiveness of the financial sector serving the real sector urgently necessitates improvement and its competence for allocation of financial resources needs to be further strengthened. In terms of the common effect, the mismatch structure risks are strongly related to the monetary policy targets, which are being changed from quantity-based to price-based. The changed targets are conducive to the control of macro-financial structure risks once they are applied for improving the match between the financial system structure and the real economy structure.

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