Construction of the China financial pressure index measurement model based under the AHP-EWM-TOPSIS model

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Abstract: With the complexity of the internal structure of the financial market, systemic financial risks occur frequently. The cross cycle of the real economy and the financial system makes the bad problems in the economic development enter into the financial system with the transmission mechanism, thus leading to the reduction of the macroeconomic stability. Therefore, the foundation for preventing systemic financial risks and economic crises in the financial market is the accurate detection of pertinent potential threats. Based on relevant literature, combined with the characteristics of China's financial system, this paper selects indicators from four dominant markets: banking market, stock market, bond market and foreign exchange market. Analytic hierarchy process (AHP) and entropy weight method (EWM) are used to calculate the relevant weights of each index, and the AHP-EWM coupling weight is calculated based on the Lagrange multiplier method. Then, the coupling weight of each index is substituted into the TOPSIS model to measure the comprehensive influence degree of multi-evaluation objects, and the pressure threshold and abnormal risk situation of China's financial market are analyzed accordingly, so as to realize the construction of CFSI measurement model. The results show that: (1) The fluctuation of CFSI over the years is within the controllable range of 0.2~0.5, with few serious outliers; (2) The whole trend has a development trend to the medium and low regions, accompanied by the characteristics of rapid fluctuation and smaller amplitude; (3) The high-risk time zone identified by the model presents a strong inertial effect, with a large fluctuation span and a long duration; (4) The stability of financial pressure in the low-risk area is stronger than in the high risk area, and it can quickly recover to the stable stage and develop towards the trend of low pressure.

Keywords: TOPSIS Model, AHP-EWM, China Financial Stress Index.

1. Introduction

The global economy and financial markets are experiencing varying degrees of systemic financial risks, financial structural issues, and financial pressure due to the rapid spread of the epidemic and ongoing international turbulence, which could result in an extreme financial crisis and economic recession. Therefore, the accurate measurement and identification of the potential threats brought by this is the premise of preventing systemic financial risks and economic crises in the financial market[1]. The majority of current mainstream studies use the market model method of quantitative analysis and the comprehensive index method of index system construction to assess systemic financial risks in the financial market. The market modeling method typically calculates financial market volatility from a large amount of data using time series models like COCVAR, CoVar, and g-Var, capturing the tail correlation of market or institution-generated returns and obtaining a measure of financial risk. To successfully address the category imbalance issue and enhance generalization performance, Huang et al.[2] employed the KFC-SVM model to construct a unique financial extreme risk early warning system (EMS) model. To account for the heterogeneity among financial assets, Barunik et al.[3] employ the Panel Standile regression model to estimate common risks in the tails of the financial regression distribution. Li et al.[4] used a COCVAR model, based on tail-mean losses, to accurately measure regional whole-body financial risk and risk spillovers in the real economy market to prevent regional economic turbulence. The systemic risk measure CoVaR was enhanced by Wang et al.[5] using Copula dependency structure theory to make it more dynamic and capable of accurately capturing common systemic risk events. Models built utilizing econometric techniques, such as time series regression and statistical principles, may require a huge number of parameters and do not intuitively depict the overall trend. Now, the focus of measurement is frequently on a specific market or region's risk, as the risk characteristics for the entire financial
system are still not clear enough to be monitored in real-time for early warning. To quantify the overall amount of stress on a country's or region's financial system and overcome the shortcomings of the market model method, a composite index must be built, mostly using relevant and significant variables in financial markets or major industries. Using volatility data from the stock market, bond market, money market, and banking sector, Duc et al. [6] extended a form of the autoregressive conditional heteroskedasticity (GARCH) model to estimate a significant measure of financial stress using an equal variance weighting scheme. When MacDonald et al. [7] estimated the BEKK model using financial stress indicators to investigate the pathways of volatility transmission among euro area nations and financial markets, they discovered extensive stress transmission in the banking and money markets. Based on stress information such as asset price volatility, financial market liquidity, risk spreads, and valuation levels, Li [8] used a three-step regression filter model and partial quantile regression to construct a systematic financial stress index. He then used the MS-VAR model to identify different risk periods for this index. By building the Financial Stress Index (FSI) of China from the perspective of timeliness and choosing nine significant indicators, such as the Chinese stock market, Dai et al. [9] construct the Economic Development Situation Index (SP-MI), which they then use to both reveal the severity of financial stress experienced and forecast the future state of the economy.

At present, domestic and foreign scholars have used different regression models, selected different indicator systems, and used different assignment methods and identification methods for financial stress to measure financial risk, but there are still some research gaps that need to be filled: Firstly, given that the financial markets have been undergoing a period of quick and dynamic development, the indicators used must continually be enhanced following market developments in various industries and product categories; Secondly, due to the degree of freedom restrictions placed on the estimated parameters in earlier studies, the explanatory power of the economic operation was found to be relatively weak, which might result in issues like the removal of useful factors; Finally, the procedure is applied uniformly when determining the weights for each indication, and it appears that the indicator weights are too arbitrary. The findings also seem to vary significantly over time. The first step in this paper's construction of the CFSI indicator system is the selection of representative indicators from the four main dimensions of the financial market—banking, stocks, bonds, and foreign exchange—and the monthly data collection from 2010 to 2021. Subsequently, using spsspro software, the AHP and EWM coefficients of each index were determined and further refined to provide AHP-EWM coupling coefficients. The TOPSIS model is then modified to incorporate the coupling coefficients of each index to measure the overall influence degree of various evaluation items. In order to complete the design of the CFSI measurement model, the weights of each index are finally changed in accordance with the findings.

2. Construction of the CFSI index system

2.1 Bank market

A certain amount of risk stress is being experienced by the banking market as a result of the banking sector's complete integration with the global financial sector. The stability of the financial markets as a whole is correlated with banks' risk stress profile because they are the primary sources of liquidity for the financial system. Five pertinent indicators that measure bank market risk are chosen for this paper: (1) Interbank Spread (X11), a measure of counterparty and liquidity risk in the interbank market. (2) Growth Rate of Short-Term Loans (X22), which is larger, increases bank susceptibility and financial stress. (3) Shanghai Interbank Offered Rate (SHIBOR, X13), which captures the interbank market's premium for short-term liquidity. (4) Banking System Beta (X14), which measures market volatility and reflects the systemic risk of the banking industry. (5) Bank Index Volatility (X15), which represents the percentage of banks' risk exposure that is not attributable to systemic risk [10].

2.2 Stock market

The primary avenue for financial market investments is the stock market. As institutional investing grows in China, the stock market is becoming more volatile and extreme risks are occurring more frequently [11]. Three stock market-related indicators are chosen for this paper: (1) CSI 300 Index Yield (X23), which can depict how stock price swings operate and are generalized in the Chinese stock market. (2) CSI 300 Index Fluctuation Range (X22), the large fluctuation of the stock index tends to cut investors' confidence and cause market panic. (3) Stock Market Value/GDP (securitization rate, X23), if it is close to 1, it means that the securities are seriously overvalued.

2.3 Bond market

As financial markets have grown, emerging nations have started to rely more and more on their domestic debt markets to finance their expenditures. Market bonds have a relatively high average yield, and variations in that yield are a direct reflection of market confidence, which in turn affects how vulnerable the financial system is to risk. Three indicators for the bond market are chosen since the overall activity of the Chinese bond market is not high, the majority of bonds are held to maturity, and they are less susceptible to changes in interest rates: (1) Sovereign Bond Spreads (X31), the larger the sovereign bond spreads, the higher the risk of the market expecting forward interest rates; (2) Negative Term Bond Spreads (X32), the widening of negative maturity bond spreads indicates that at this time The market prefers long maturity treasury bonds and tends to be prudent and risk averse.

2.4 Foreign exchange market

In a globalized economy, a country's economic volatility and risk control are not only related to its macroeconomic
fundamentals, but also subject to the impact of global financial risk diffusion[12], while the abnormal fluctuations in asset prices caused by large fluctuations in exchange rates in the foreign exchange market are the main source of signals for risk release. In this paper, three indicators are selected in the foreign exchange market: (1) USD-RMB Yields (X4i), which generate sharp fluctuations in both exchange rates due to the cyclical difference in economic recovery between the US and China and the Fed's continuous rate hikes. (2) Changes in foreign exchange reserves (X2i), where fluctuations in foreign exchange savings reflect the ability of the exchange rate market to self-regulate and cope with foreign exchange rate risks. (3) Vulnerability of foreign exchange market (X45), used to reflect the strength of foreign exchange reserves to intervene in the exchange rate (4) Growth rate of total foreign debt (X4a), the growth of foreign debt indicates that a country's financial market is more open to the outside world and the market environment is relatively stable. Accordingly, the financial pressure index system is constructed, as shown in Table 1.

Table 1. Indicator construction table

<table>
<thead>
<tr>
<th>Level 1 indicators</th>
<th>Level 2 indicators</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bank market(Xi)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interbank Spread</td>
<td>Is(X11)</td>
<td>[13]</td>
</tr>
<tr>
<td>Growth Rate of Short-Term Loans Rslg(X12)</td>
<td></td>
<td></td>
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<tr>
<td>Shanghai Interbank Offered Rate (SHIBOR) Rsh(X13)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Banking System Beta Bb(X14)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bank Index Volatility Vbi(X15)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stock market(X3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CSI 300 Index Yield Y300(X31)</td>
<td></td>
<td>[14]</td>
</tr>
<tr>
<td>CSI 300 Index Fluctuation Range R300(X32)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stock Market Value/GDP Rs(X32)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bond market(X2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sovereign Bond Spreads Ssb(X21)</td>
<td></td>
<td>[15]</td>
</tr>
<tr>
<td>Negative Term Bond Spreads Sntb(X25)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Foreign exchange market(X4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>USD-RMB Yields Yur(X41)</td>
<td></td>
<td>[16]</td>
</tr>
<tr>
<td>Changes in foreign exchange reserves Cr(X42)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vulnerability of foreign exchange market Vf(X43)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Growth rate of total foreign debt Rtedg(X44)</td>
<td></td>
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</tr>
</tbody>
</table>

3. Optimization of AHP-EWM-TOPSIS model construction

3.1 Technique for Order Preference by Similarity to an Ideal Solution

Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS), is a ranking method for multi-attribute decision analysis of multiple objectives based on multiple indicators and approximation to the optimal solution. It constructs a positive and negative ideal solution space based on the initial data matrix after normalization. Then the gap between each evaluation object and the optimal and inferior solution is calculated separately to obtain the closeness of each evaluation object to the idealized objective, i.e., the ideal posting progress, as a basis for measuring the degree of superiority and inferiority among the evaluation solutions. Then it is ranked and a more realistic tuning strategy is proposed for the ranking level. The TOPSIS method can make full use of the information from the raw data and has no strict restrictions on the index system. The general steps of the method are as follows:[17].Step 1: Build the raw data matrix D:

\[
D = \begin{bmatrix}
A_1 & c_1 & c_2 & \cdots & c_n \\
A_2 & d_{11} & d_{12} & \cdots & d_{1n} \\
& \vdots & \vdots & \ddots & \vdots \\
A_i & d_{i1} & d_{i2} & \cdots & d_{in} \\
& \vdots & \vdots & \ddots & \vdots \\
A_m & d_{m1} & d_{m2} & \cdots & d_{mn}
\end{bmatrix}_{m \times n}
\]  

(1)

Here, \(A(i \in \{1, 2, \ldots, m\})\) and \(c(j \in \{1, 2, \ldots, n\})\) represent alternative schemes and standards, respectively. Step 2: To obtain the standardized decision matrix R:

\[
r_{ij} = \frac{d_{ij}}{\sqrt{\sum_{k=1}^{n} d_{ik}^2}}
\]

(2)

\[
R = \begin{bmatrix}
(r_{11} & r_{12} & \cdots & r_{1n} \\
r_{21} & r_{22} & \cdots & r_{2n} \\
& \vdots & \vdots & \ddots \\
r_{i1} & r_{i2} & \cdots & r_{in} \\
& \vdots & \vdots & \ddots \\
r_{m1} & r_{m2} & \cdots & r_{mn}
\end{bmatrix}_{m \times n}
\]

(3)

This step is skipped if the matrix D has been normalized. Step 3: Get the weighted and normalized decision matrix V:

\[
V = [v_{ij}]_{m \times n} = [w_j r_{ij}]_{m \times n}
\]

(4)

At this point, \(w_j = \frac{\sum_{j=1}^{n} W_j}{\sum_{j=1}^{n} W_j}\). Thus \(\sum_{j=1}^{n} W_j = 1\) and \(W_j\) is the original weight given the standard \(c_j\).

\[
V = \begin{bmatrix}
v_{11} & v_{12} & \cdots & v_{1n} \\
v_{21} & v_{22} & \cdots & v_{2n} \\
& \vdots & \vdots & \ddots \\
v_{i1} & v_{i2} & \cdots & v_{in} \\
& \vdots & \vdots & \ddots \\
v_{m1} & v_{m2} & \cdots & v_{mn}
\end{bmatrix}_{m \times n}
\]

(5)
Step 4: Use the TOPSIS method to determine the positive and negative ideal solution of each index in the normalized matrix respectively. The maximum value of each indicator is positive ideal solution (PIS) $A^+$, and the minimum value is negative ideal solution (NIS) $A^-$:

$$A^+ = \{v_1^+, \ldots, v_j^+, \ldots, v_n^+\}$$

$$A^- = \{v_1^-, \ldots, v_j^-, \ldots, v_n^-\}$$

Where, $J_1$ and $J_2$ are associated with the benefit set and the cost attribute set, respectively. Step 5: Calculate the Euclidean distance between each sample index and the positive and negative ideal solution. The formula is as follows:

$$S_i^+ = \sqrt{\frac{1}{n} \sum_{j=1}^{n} (v_{ij} - v_1^+)^2}$$

$$S_i^- = \sqrt{\frac{1}{n} \sum_{j=1}^{n} (v_{ij} - v_1^-)^2}$$

Step 6: Calculate the relative proximity $C_i$, and rank the advantages and disadvantages according to the relative proximity. The value of $C_i$ is between 0 and 1, and the closer it is to 1, the higher the ideal paste progress is, and the better the ideal solution can be evaluated.

### 3.2 AHP-EWM coupling weight calculation based on the Lagrange multiplier method

#### 3.2.1 Analytic Hierarchy Process

The Analytic Hierarchy Process (AHP) is a systematic, multi-criteria, quantitative and qualitative decision-making approach. It can transform numerical weights into irrational, non-quantifiable criteria and is mostly used to handle subjective, unstructured decision management problems that are challenging to measure. To mathematically represent the process of generating decisions, hierarchical analysis transforms complex decision problems with many objectives, criteria, or unstructured characteristics into straightforward hierarchical steps, creating a multilevel analytical structural model[18]. In the end, the issue comes down to comparing the relative qualities of the lowest level to the highest level.

When constructing the system model using hierarchical analysis, it can be divided into the following steps: Step 1: Define objectives and build a hierarchical framework. The decision objectives, decision criteria and decision objects are divided into the top level, middle level and bottom level according to the degree of association, and an "objective level-criteria level" and "criteria level-indicator level" are established. "A two-level hierarchical model is established."

**Step 2: Determine the quantitative scale.** To measure the degree of association between indicators, we generally use the significance 1-9 scale table for paired comparison. For quasi-side $C$, compare the relative importance of $n$ elements and construct a pairwise element comparison judgment matrix:

$$A = (a_{ij})_{n \times n}$$

Where $a_{ij}$ is the importance scale of the elements $u_i$ and $u_j$ under the quasi-side $C$, judging the matrix properties as follows:

$$a_{ij} > 0, a_{ji} = \frac{1}{a_{ij}}, a_{ii} = 1$$

Step 3: Construct the judgment matrix and calculate the weights. Starting from the second time of the hierarchical model, we use the pairwise comparison method and the scale table, we can construct the judgment matrix for the elements belonging to the upper layer and calculate the feature root $\lambda$ and feature vector $i$ of $BW=\lambda_{\text{max}}W$. The component of $W$ is the single ranking weight of the corresponding index, which is obtained by the approximate solution method of hierarchical analysis. Step 4: Check the consistency of the judgment matrix. The consistency ratio (CR) of each judgment matrix is calculated, and if the ratio is less than 0.1, the test is passed; if not, the judgment matrix needs to be reconstructed. To judge the matrix consistency, first introduce the one-time indicator $CI$, there is complete consistency when $CI=0$; the larger the $CI$, the more serious the inconsistency. The $CI$ calculation formula is as follows:

$$CI = \frac{\lambda_{\text{max}} - n}{n - 1}$$

The $CI$ was compared with the mean random consistency index $RI$ to obtain the agreement ratio (CR):

$$CR = \frac{CI}{RI}$$

#### 3.2.2 Entropy Weight Method

Entropy Weight Method (EWM) is an objective weighting method that relies only on the data itself to measure the progress of a system as a whole out of order. Its objective feature can compensate for the subjectivity of AHP which relies on expert judgment. The basic principle is that the smaller the degree of variation of an indicator, the less information it reflects, and the lower the corresponding weight[19]. The overall degree of dispersion is judged by determining the entropy value of the indicators, which is inversely proportional to the entropy value and positively proportional to the pairwise composite weights. The steps are generally as follows:

**Step 1:** Calculate the information entropy $S(d)$ and the output entropy $C(d)$ of the $j$ th index:

$$S(d_j) = -\sum_{i=1}^{m} y_{ij} \ln y_{ij}$$

$$C(d_j) = \frac{S(d_j)}{\ln m}$$

**Step 2:** Calculate the difference index $H(d)$ of the $j$ th index:

$$H(d_j) = 1 - C(d_j)$$

The weight $W_j$ of the $j$ th index is:
3.2.3 AHP-EWM coupling empowerment based on the Lagrange multiplier method

The hierarchical analysis method (AHP) is mainly influenced by expert judgment, while the entropy weighting method (EWM) depends only on the relationship between indicators and the amount of information. The combined AHP-EWM assignment method is used to determine the weights of each index, which can avoid the defects of a single assignment bringing too much, and correct the subjectivity with objectivity to get a more reasonable index weight. The specific method steps are as follows.

Step 1: Suppose the same level contains $m$ criterion-level factors, and $n$ scheme-level factors are included under each criterion-level factor, and the AHP judgment matrix can find the weight of $m$ criterion-level factors as $W=\{\omega_1,\omega_2,\omega_3,...,\omega_m\}$, and the weight of $n$ scheme-level factors as $A=\{\alpha_1,\alpha_2,\alpha_3,...,\alpha_n\}$, and the weights of the $n$ scheme-level factors are $A=\{\alpha_1,\alpha_2,\alpha_3,...,\alpha_m\}$; the $n$ factor weights found by using EWM are $B=\{b_1,b_2,b_3,...,b_n\}$.

Step 2: By coupling AHP weight $A$ and EWM weight $B$, the scheme layer factor coupling weight $U=\{u_1,u_2,u_3,...,u_m\}$:

$$
\mu_i = \frac{\sum_{j=1}^{m} (\alpha_j b_j)^{0.5}}{\sum_{j=1}^{m} (\alpha_j)^{0.5}}
$$

(17)

4. CFSI Measurements Empirical

4.1 Data compilation

In order to reflect the overall situation of stress in China's financial market more comprehensively, this paper selects 14 financial indicators from four dimensions of China's financial market: banking market, stock market, bond market and foreign exchange market to construct the index system of China's financial stress index. The financial indicators try to cover all aspects of financial market stress information, while the financial stress characteristics reflected by different indicators show certain complementarity and timeliness. Therefore, monthly data are taken for each indicator, and the sample period of data is from January 2010 to December 2021, from the Wind database, CSMAR database, and EPS database. In view of the availability of statistical data and the consistency of statistical caliber, some data are processed by compound calculation for the construction of relevant indicators. The descriptive statistics of the indicators were obtained as shown in Table 2.

<table>
<thead>
<tr>
<th>Indicator code/Unit</th>
<th>Max</th>
<th>Min</th>
<th>Mean</th>
<th>Median</th>
<th>Std.dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\text{X}_{i/100}\text{ million}$</td>
<td>49309.0</td>
<td>4814.0</td>
<td>17272.4</td>
<td>12703.0</td>
<td>4654.1</td>
</tr>
<tr>
<td>$\text{X}_{i/%}$</td>
<td>0.23</td>
<td>0.03</td>
<td>0.11</td>
<td>0.09</td>
<td>0.05</td>
</tr>
</tbody>
</table>

4.2 Coupling weight measurement

The AHP method was first used to calculate the subjective weights. This expert review panel invites university professors, financial researchers and relevant industry experts in total of 5 people. Based on section 4.2.1 of this paper, each expert, according to the classification of financial markets, first evaluates the weights of secondary indicators contained in each market separately and scores the data of each indicator within the specified value range. The local subjective weights of each indicator are obtained based on the results of the experts' evaluation of the weights of each indicator. The evaluation matrices of the secondary indicators are shown in Tables 3 to 6.

Table 3. Bank market index evaluation matrix

<table>
<thead>
<tr>
<th>Index</th>
<th>$I_{s}$</th>
<th>$R_{slg}$</th>
<th>$R_{sh}$</th>
<th>$B_{b}$</th>
<th>$V_{hs}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$I_{s}$</td>
<td>1</td>
<td>2.5</td>
<td>0.667</td>
<td>0.333</td>
<td>0.333</td>
</tr>
<tr>
<td>$R_{slg}$</td>
<td>0.4</td>
<td>1</td>
<td>0.25</td>
<td>0.167</td>
<td>0.833</td>
</tr>
<tr>
<td>$R_{sh}$</td>
<td>1.5</td>
<td>4</td>
<td>1</td>
<td>0.5</td>
<td>3.333</td>
</tr>
<tr>
<td>$B_{b}$</td>
<td>3</td>
<td>6</td>
<td>2</td>
<td>1</td>
<td>6.667</td>
</tr>
<tr>
<td>$V_{hs}$</td>
<td>0.5</td>
<td>1.2</td>
<td>0.3</td>
<td>0.15</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 4. Stock market index evaluation matrix

<table>
<thead>
<tr>
<th>Index</th>
<th>$Y_{300}$</th>
<th>$R_{300}$</th>
<th>$R_{c}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Y_{300}$</td>
<td>1</td>
<td>0.25</td>
<td>0.4</td>
</tr>
<tr>
<td>$R_{300}$</td>
<td>4</td>
<td>1</td>
<td>1.25</td>
</tr>
<tr>
<td>$R_{c}$</td>
<td>2.5</td>
<td>0.8</td>
<td>1</td>
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</tbody>
</table>

Table 5. Bond market index evaluation matrix

<table>
<thead>
<tr>
<th>Index</th>
<th>$S_{sl}$</th>
<th>$S_{sb}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$S_{sl}$</td>
<td>1</td>
<td>0.6</td>
</tr>
<tr>
<td>$S_{sb}$</td>
<td>1.667</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 6. Foreign exchange market index evaluation matrix

<table>
<thead>
<tr>
<th>Index</th>
<th>$Y_{ur}$</th>
<th>$C_{f}$</th>
<th>$V_{f}$</th>
<th>$R_{redg}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Y_{ur}$</td>
<td>1</td>
<td>2.222</td>
<td>3.333</td>
<td>1.25</td>
</tr>
<tr>
<td>$C_{f}$</td>
<td>0.45</td>
<td>1</td>
<td>1.111</td>
<td>0.4</td>
</tr>
<tr>
<td>$V_{f}$</td>
<td>0.3</td>
<td>0.9</td>
<td>1</td>
<td>0.286</td>
</tr>
<tr>
<td>$R_{redg}$</td>
<td>0.8</td>
<td>2.5</td>
<td>3.5</td>
<td>1</td>
</tr>
</tbody>
</table>

Then the first-level index of the financial market is scored, and the subjective weight of each index is obtained. The evaluation matrix of financial market indicators is shown in Table 7.
Combining the results of Table 7 with the results of Tables 3 to 6, the overall AHP weights of each secondary indicator can be calculated. The EWM weights were calculated using the data collected in Section 5.1 to obtain the entropy weights for each secondary indicator. Under the principle of minimum information entropy, the resulting AHP weights and EWM weights were processed using the Lagrange multiplier method to calculate the AHP-EWM coupling assignment as the final weights of each indicator. The obtained results are shown in Table 8.

As can be seen from Table 8, according to the judgment of AHP, most of the experts believe that the beta coefficient of the banking system β occupies a higher weight in financial market stress, and the volatility range of CSI 300 index is the next most important, with its weight of 14.788% and 10.509%, respectively, while other indicators do not exceed 10%. Overall, the weight distribution of each indicator is relatively even, which may lead to the underestimation of the importance of some indicators. The analysis of EWM's calculation results reveals that the weight of each indicator is widely disparate, with USD-RMB return (20.275%), bank index volatility (12.076%) and foreign exchange market vulnerability (11.716%) exceeding 10%, while the weight of less influential indicators is only 1% to 2%. Among them, the Y300 weighting of CSI 300 index return is 0%, probably because the actual data show that the indicator has not changed significantly in the last decade. By comparing the two methods, it is found that the indicators with higher weights differ between them, so the AHP-EWM coupled weights are used to consider both subjective and objective factors to reduce the error. Table 8 shows that only the USD-RMB yield (16.565%) and the Shanghai Interbank Offered Rate (10.863%) are weighted more than 10%, while the remaining indicators are more evenly distributed, basically fluctuating from 4% to 8%. The coupled weights not only highlight the weight of important indicators, but also do not underestimate the weight of smaller indicators, which shows the unique advantage of the AHP-EWM method in taking into account the subjective and objective factors.

### 4.3 CFSI measure

Based on the TOPSIS model, the monthly data of each indicator from 2010 to 2021 were included, and the AHP-EWM coupling coefficient obtained in Section 5.2 was calculated as the custom weight. During the analysis, the index IS, Rds, Rs, Bps, Ybi, Y300s, R300s, Sts, Yurt, Cr, Vt
were positive, $R_s$ and $R_{nedg}$ were negative, and the results are shown in Figure 1.

As can be seen from Figure 1, the CFSI fluctuations in all years show large differences, but are basically in the range of 0.2 to 0.5, with few serious abnormal values. The overall has a tendency to develop towards the moderately low region, with rapid fluctuations and becoming smaller in magnitude. The high-risk time zones identified by the model show strong inertia effects, with fluctuations showing characteristics such as large spans and long durations. The stability of financial stress in the low-risk region is stronger than that in the high-risk region, and it can quickly recover to a stable phase and develop toward the low-stress trend.

5. Conclusions

(1) The CFSI fluctuations in all years are basically in the range of 0.2 to 0.5, with few serious abnormal values. The overall has a tendency to develop towards the moderately low region, with rapid fluctuations and becoming smaller in magnitude. (3) The high-risk time zones identified by the model show strong inertia effects, with fluctuations showing characteristics such as large spans and long durations. The stability of financial stress in the low-risk region is stronger than that in the high-risk region, and it can quickly recover to a stable phase and develop toward the low-stress trend.

References

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