Research on the Relationship Between Corporate Bond Credit Spreads and Macroeconomic Factors Based on TVP-VAR Model

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Keywords: Corporate Debt, Credit Spread, TVP-VAR Model.

Abstract. There is a significant linkage relationship between corporate bond credit spreads and macroeconomic indicators. Exploring the dynamic and time-varying relationship between the two can better control and adjust market risks at the macro level. Selecting the 2010-2019 quarterly data, and establishing the TVP-VAR model of macro indicators and credit spreads, the following conclusions are drawn: (1) Credit spreads are counter-cyclical. (2) The degree of response of credit spreads and macroeconomic indicators in years with large economic fluctuations is significantly higher than in years when the economy is stable, and tends to be stable for a long time. (3) PMI and risk-free interest rates have a significant negative impact on credit spreads in the long term, and CPI has a relatively low contribution rate to the fluctuation of credit spreads. Based on this, targeted recommendations such as the implementation of prudent macroeconomic policies are provided to provide a basis for corporate bond pricing, regulators to control market risks, and to formulate relevant development strategies, and to promote the healthy development of the corporate bond market.

1. Introduction

Bond financing is the main financing method for enterprises under the background of the credit economy, and one of the main financial instruments in the capital market. How to recognize and measure corporate bond risks has become an important factor affecting the development of China's corporate bond market. The credit spread of corporate bonds is usually expressed as the difference between the bond yield to maturity and the bond yield without credit risk. From a macro perspective, credit spreads are an important indicator that reflects market information and business cycle activities. They often have countercyclical phenomena. Therefore, credit spreads are also regarded as macroeconomic indicators.

General research believes that credit spreads can fully convey bond price risk information, macroeconomic indicators and credit spreads have a dynamic relationship, and the degree of mutual influence between the two is different in different periods of different economic backgrounds. Through the dynamic influence of the two, the macro-regulatory agency can formulate relevant policies in different economic situations to prevent systemic risks; at the same time, it can also conduct special supervision on higher-risk industries or companies to promote the health of my country’s corporate bond market Orderly development.
2. Literature Review

Foreign scholars first began to study quantitative models of credit spreads. Merton \cite{1} first proposed the Merton model in 1974. Singleton and Duffle \cite{2} proposed a simplified model in 1999. The theoretical model assumes that the conditions are too ideal to accurately simulate the real market. Delianedis and Geske \cite{3} found that the structural model cannot explain credit spreads well. After the 2008 international financial crisis, many scholars shifted their research focus to the relationship between macroeconomics and credit spreads. Through calculations, Longstaff and Schwartz\cite{4} found that bond credit spreads are negatively correlated with government bond yields. Tatsuyoshi Okimoto \cite{5} studied the effectiveness of the term structure of credit spreads under the Japanese business cycle in 2017, and the results proved that the increase in credit spreads is related to future economic expansion. It can be seen that the analysis of credit spreads is inseparable from the trend of the economic situation.

According to previous studies, the existing literature cannot explain the differences in credit spreads under different macroeconomic backgrounds. This article innovatively uses the TVP-VAR model to analyze the time-varying characteristics of the impulse response between variables and explain the economics. The influence of macroeconomic indicators and credit spreads under different circumstances, and the study of the difference in the degree of mutual influence between credit spreads during economic ups and downs, has made up for the lack of research.

3. Model Introduction and Variable Selection

3.1. Introduction of TVP-VAR Model

Primiceri considered that the VAR coefficient, the variance of the disturbance term, and the intercept term may change with time, and proposed a new time-varying parameter vector autoregressive model, namely the TVP-VAR model. This model innovates the coefficient and variance-covariance matrix that change with time, and has the nature of time-varying parameters, and can better capture the relationship and characteristics of economic variables under different era backgrounds. Nakajima\cite{6} successively constructed three-variable and four-variable TVP-VAR models to study the economic structure of Japan, further verifying that the introduction of time-varying parameters helps to improve the accuracy of VAR model estimation. The settings of the TVP-VAR model are as follows:

First, the established S-VAR model is:

\[ A y_t = F_1 y_{t-1} + \cdots + F_s y_{t-s} + \mu_t, \quad t = s + 1, \ldots, n \]

In formula (1): \(y_t\) is \(n \times 1\) dimensional observation variable; \(A\) is \(n \times n\) dimensional simultaneous coefficient matrix; \(F_1 \ldots F_s\) is the coefficient matrix of observation vector 1 to \(s\) lag, and the disturbance term \(\mu_t\) is \(n \times 1\) dimensional Structural impact, here assume \(\mu_t \sim N(0, \Sigma)\), where:

\[
A = \begin{bmatrix}
1 & 0 & \cdots & 0 \\
a_{21} & \ddots & & \\
\vdots & \ddots & \ddots & \\
a_{k1} & \cdots & a_{kk-1} & 1
\end{bmatrix}, \quad \Sigma = \begin{bmatrix}
\delta_{1} & 0 & \cdots & 0 \\
0 & \ddots & & \\
\vdots & \ddots & \ddots & \\
0 & \cdots & 0 & \delta_{k}
\end{bmatrix}
\]

Secondly, let \(\beta_t = A^{-1}F_1\), \(X_t = I_s \bigotimes (y_{t-1}, \ldots, y_{t-s})\), \(\bigotimes\) is the Kronecker product. Here, time-varying parameters are introduced into \(A\) and \(\Sigma\). The above formula (1) can be simplified as:
\[ y_t = X_t\beta_t + A_t^{-1}\sum_t \varepsilon_t, \quad t = s + 1, \ldots, n \]

Third, referring to Primieri’s setting of the Cholesky coefficient in the model, it is assumed that the time-varying coefficient, variance and covariance of the model follow the following evolution process:

\[
\begin{align*}
\beta_t &= \mu_\beta + \varnothing_\beta (\beta_{t-1} - \mu_\beta) + v_t, \quad t = s + 1, \ldots, n \\
\alpha_t &= \mu_\alpha + \varnothing_\alpha (\alpha_{t-1} - \mu_\alpha) + \zeta_t, \quad t = s + 1, \ldots, n \\
h_t &= \mu_h + \varnothing_h (h_{t-1} - \mu_h) + \xi_t, \quad t = s + 1, \ldots, n
\end{align*}
\]

\[ V = \text{Var} \begin{pmatrix} \varepsilon_t \\ v_t \\ \zeta_t \\ \xi_t \end{pmatrix} = \begin{bmatrix} I_n & 0 & \cdots & 0 \\ 0 & \Omega_\beta & \ddots & \vdots \\ \vdots & \ddots & \Omega_\alpha & 0 \\ 0 & \cdots & 0 & \Omega_h \end{bmatrix} \]

Equations (1) to (5) are typical TVP-VAR models, which are vector autoregressive models with instant variable parameters. Among them, \( \beta_t \) and \( \alpha_t \) are the vectors formed by stacking model parameters; \( h_t \) is the logarithmic form of the variance, that is \( h_t = \log (\delta_t^2) \); \( v_t, \zeta_t, \xi_t \) are the corresponding random disturbances respectively.

### 3.2. Variable Selection and Data Description

In order to better study the credit spreads of corporate bonds, this paper selects the treasury bond spot yield (\( \text{Int} \)), China’s manufacturing logistics and purchasing managers index (\( \text{PMI} \)), consumer price index (\( \text{CPI} \)), and credit spreads (\( X \)). This article selects the quarterly data of various indicators from 2010 to 2019, and the data sources are all Wind database.

### 4. Empirical Analysis of the Impact of Macroeconomics on Credit Spreads

#### 4.1. Unit Root Test

To ensure that the results are true and effective, use Eviews to test the stability of the variables with the ADF method. It can be seen from Table 1 that the variables \( X, \text{Int}, \) and \( \text{CPI} \) are all stable at the 5% significance level, and \( \text{CPI} \) is stable at the 1% significance level.

<table>
<thead>
<tr>
<th>Variable</th>
<th>ADF inspection value</th>
<th>P value</th>
<th>test results</th>
</tr>
</thead>
<tbody>
<tr>
<td>( X )</td>
<td>-3.424948**</td>
<td>0.0161</td>
<td>steady</td>
</tr>
<tr>
<td>( \text{Int} )</td>
<td>-3.386942**</td>
<td>0.0175</td>
<td>steady</td>
</tr>
<tr>
<td>( \text{PMI} )</td>
<td>-3.084978**</td>
<td>0.0370</td>
<td>steady</td>
</tr>
<tr>
<td>( \text{CPI} )</td>
<td>-4.015590***</td>
<td>0.0040</td>
<td>steady</td>
</tr>
</tbody>
</table>

(Note: *, **, *** indicate significant at the statistical level of 10%, 5%, and 1% respectively)

#### 4.2. Empirical Analysis of TVP-VAR

Using OxMetrics, the Markov Chain Monte Carlo (MCMC) method is used for 10,000 simulations,
the first 1,000 results are eliminated as burn-in, and the last 9,000 samples are used to estimate the parameters. It is generally considered that an invalid factor of less than 100 is acceptable. It can be seen from Table 2 that the standard deviation of the parameters is small, indicating that the estimation result is better; the invalid factors are all low, and less than 100, indicating that the MCMC estimation result is effective.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>95%L</th>
<th>95%U</th>
<th>Convergence Diagnostic Value</th>
<th>Invalid Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Σβ)1</td>
<td>0.0231</td>
<td>0.0028</td>
<td>0.0185</td>
<td>0.0293</td>
<td>0.031</td>
<td>7.05</td>
</tr>
<tr>
<td>(Σβ)2</td>
<td>0.0229</td>
<td>0.0026</td>
<td>0.0184</td>
<td>0.0287</td>
<td>0.009</td>
<td>4.44</td>
</tr>
<tr>
<td>(Σα)1</td>
<td>0.0872</td>
<td>0.0439</td>
<td>0.0417</td>
<td>0.1929</td>
<td>0.055</td>
<td>31.72</td>
</tr>
<tr>
<td>(Σα)2</td>
<td>0.0880</td>
<td>0.0444</td>
<td>0.0429</td>
<td>0.1890</td>
<td>0.651</td>
<td>33.38</td>
</tr>
<tr>
<td>(Σ h )1</td>
<td>0.1415</td>
<td>0.1216</td>
<td>0.0494</td>
<td>0.4848</td>
<td>0.160</td>
<td>83.03</td>
</tr>
<tr>
<td>(Σ h )2</td>
<td>0.1395</td>
<td>0.0947</td>
<td>0.0498</td>
<td>0.4062</td>
<td>0.896</td>
<td>35.89</td>
</tr>
</tbody>
</table>

As can be seen from Figure 1, the first line of sample autocorrelation coefficients, you can see that the sample autocorrelation coefficient quickly drops to near zero, and there is no strong fluctuation, indicating that there is almost no autocorrelation relationship in the sample; the second line of sample path, sample The path display is relatively stable, with a few extreme values acceptable, indicating that the preset 10,000 MCMC sampling can obtain valid relevant samples; the third line is the posterior distribution density function, the function image is approximately close to the normal distribution, which meets the inference requirements.

4.3. Time Point Impulse Response Analysis

Compared with the traditional VAR model, the advantage of the TVP-VAR model is that it can explore the difference in impulse response at different points in the cycle. The following selects the second quarter of 2012, the first quarter of 2015 and the second quarter of 2017 for research. We can obtain the time-point impulse response function graph to explore the dynamic mechanism of
various factors. In the following, the cross line is 2012, the * line is 2015, and the ▲ line is 2017. The image trends are generally consistent, indicating that the model is robust.

First, analyze the impulse response of credit spreads to macro variables. The first graph in Figure 2 shows that PMI has a positive impact on credit spreads at three points and then has a negative impact first, and then gradually becomes smaller after two periods; Figure 2 shows that the impact on credit spreads first has a negative impact. The risk interest rate causes a negative impact, and after a short-term positive impact, it returns to the negative impact and shows a state of convergence. Figure 3 shows that the positive impact has a negative impact on CPI, and after the second phase, it becomes a positive impact. In Figure 2, the last three lines are the graphs of impulse response between macroscopic variable factors. It can be seen that variable fluctuations will be affected by itself but the degree of influence is relatively small; the mutual influence between various variables is not near 0, but relatively large, Which shows that the linkage of various indicators in China's macro economy is greater, and the possibility of resonance in the financial market is greater.

From Figure 3, it can be seen from Figure 1 that an impact of PMI first has a positive impact on credit spreads, and then continues to decrease. Figure 2 shows that a positive impact of the risk-free interest rate first had a positive impact on credit spreads, and then began to weaken and become a negative impact after two periods, showing a trend of convergence. In 2012, the response level was slightly higher than that of the stable economy. It can be seen from Figure 3 that a positive impact from CPI has a positive impact on credit spreads, which gradually stabilized after weakening in the later period. From the perspective of response, PMI and risk-free interest rates have a stronger response to credit spreads, while CPI is weak.
4.4. Further Analysis

1) PMI has a long-term negative correlation with credit spreads, and it explains the fluctuation of credit spreads to a high degree. The greater the volatility of the macroeconomic development level, the greater the macro system risk, the greater the probability of default faced by enterprises, and the greater the credit spread. The macro-economy affects the difficulty of corporate investment and financing to a certain extent, and the degree of impact is more obvious in the process of economic downturn. In the process of the European debt crisis in 2012, the economic downturn made corporate financing more difficult, and high market risks affected the leverage ratio and default loss of companies. The expected growth rate of corporate cash flow was low, which increased the default rate and default risk of companies. Large, investors need higher risk premiums to compensate for high risks, which will increase credit spreads. The PMI indicator reflects the overall economic situation and the general trend of change. Therefore, PMI has a strong impact on credit spreads and has a negative impact on credit spreads in the long run.

2) There is a long-term negative correlation between the risk-free interest rate and the credit spread, and the interpretation of the fluctuation of the credit spread is relatively large. As far as my country’s corporate bond market is concerned, corporate bond investment entities are mainly institutional investors, such as commercial banks. It can be seen from empirical evidence that the response level in the second quarter of 2012 was higher than that of the other two years. It is expected that due to the European debt crisis in 2012, my country’s economic growth will be slow and there will be a downward economic trend. People lack confidence in the market, and the response level will fluctuate. Years are higher than years when the economy is stable. The risk-free interest rate has a strong impact on credit spreads and has a significant negative correlation; in the long run, the response level tends to be stable, indicating that the mutual influence mechanism between the two has gradually stabilized.

3) The relationship between CPI and credit spread, whether it is a positive or a reverse relationship, has a positive effect in the long run. In the period of rising CPI, people's consumption expenditures increase, along with the decrease of investment expenditures, the degree of investor risk aversion increases, making investors demand higher rates of return under the same conditions, which increases credit spreads. In the long run, the impact of CPI on credit spreads is relatively weak, so its contribution to the fluctuation of credit spreads is relatively low.

5. Conclusions and Recommendations

5.1. Conclusions

This article uses the TVP-VAR model to explore the time-varying shock relationship between CPI, PMI, risk-free interest rates and corporate bond credit spreads. Based on the above empirical results, the conclusions are as follows:
1) Credit spreads reflect changes in the business cycle to a certain extent, and there is a phenomenon of counter-economic cycles.

2) From a time-varying perspective, the degree of response of credit spreads and macroeconomic indicators in years with large economic fluctuations is significantly higher than in years when the economy is stable. Under the economy, the possibility of resonance in the financial market increases; in the long run, the response degree of the two tends to stabilize.

3) PMI and risk-free interest rates have a significant negative impact on credit spreads in the long-term, and explain the fluctuations of credit spreads to a high degree; the impact of CPI on credit spreads has a positive effect in the long-term, which cannot be well Explain the reasons for fluctuations in credit spreads.

5.2. Suggestions
1) Implement prudent macroeconomic policies. Based on the impact of the macro economy on credit spreads, relatively sound economic policies should be implemented to help maintain the stability of the capital market, make the corporate bond market relatively stable, and protect the interests of investors.

2) Improve the bond market structure and optimize the corporate bond issuance mechanism. At present, my country’s corporate bond issuers have relatively high qualification requirements, generally state-owned holding companies. This strict access mechanism will result in a single hierarchical structure of corporate bonds in my country. Many large non-listed companies cannot obtain financing through this channel and cannot perform well. The role of its financing tools. Therefore, it is necessary to continuously optimize the corporate bond issuance mechanism, enrich the market level, and give full play to the role of corporate bonds in serving the real economy.

References


