Hindawi
Complexity
Volume 2022, Article ID 6331366, 15 pages
https://doi.org/10.1155/2022/6331366

Research Article

Corporate Bond Pricing Model with Interaction between Liquidity and Credit Risk

Zijian Wu, Baochen Yang, and Yunpeng Su

College of Management and Economics, Tianjin University, Tianjin 300072, China

Correspondence should be addressed to Baochen Yang; bchyang@tju.edu.cn

Received 11 December 2021; Revised 26 March 2022; Accepted 13 April 2022; Published 24 May 2022

Academic Editor: Faheem Aslam

This study derives a liquidity and credit risk-adjusted capital asset pricing model and investigates the model using the data set in China's corporate bond market. Our research shows that the channels through which liquidity risk affects corporate bond return are individual bond liquidity risk, the interaction between individual bond liquidity risk and market liquidity risk. The channels through which credit risk affects corporate bond return are individual bond credit risk, the interaction between individual bond credit risk and market credit risk. The main channel through which the interaction between liquidity risk and credit risk affects corporate bond return is the interaction between individual bond liquidity risk and market credit risk. The model reveals the impact mechanism of individual risk and market risk on bond return and explains why the interaction between liquidity risk and credit risk affects bond pricing.

1. Introduction

The equilibrium pricing model and arbitrage pricing model are two main asset pricing models. Scholars mainly use the equilibrium pricing model to study the source of risk premium from macroeconomic variables that affect the structure of market economy, such as capital asset pricing model, but it is difficult to understand due to strict assumptions. In contrast, the arbitrage pricing theory is more widely used. Compared with other pricing models, the stochastic discount factor model has fewer conditions and is easier to apply and understand. Dealing with the relationship between risk and return is the central problem of asset pricing theory. Under the condition that there is no risk-free arbitrage opportunity in the financial market, the price of an asset and its future return can be linked by the stochastic discount factor to obtain the basic pricing equation.

Many scholars study the theory of stochastic discount factor [1–4]. Kan and Zhou [1] find that the capital asset pricing model is superior to the stochastic discount factor model, while Jagannathan and Wang [2] believe that the stochastic discount factor model is more accurate. Cochrane [5] finds that the capital asset pricing model and stochastic discount factor model have similar accuracy and restates the whole asset pricing theory under the theoretical framework of stochastic discount factor. Lou et al. [3] and Zhou et al. [4] also make relevant studies. Lou et al. [3] find that the stochastic discount factor model could price all assets on the premise that the financial market does not allow arbitrage opportunity, and it is more accurate for small sample estimation. Zhou et al. [4] extend the parameter estimation method of the Rosenberg–Engle projection stochastic discount factor and derive a projection stochastic discount factor estimation method. The above studies show that the stochastic discount factor theory is often used in asset pricing and has higher accuracy for data with a small sample of inactive transaction, such as corporate bond pricing.

Some scholars find that corporate bond spreads are related to credit risk and liquidity risk [6, 7]. Huang and Huang [8] find that credit risk affects bond spreads using structural bond pricing models. Some scholars believe that liquidity risk is the determinant of corporate bond spreads [9–11]. The above literature shows that credit risk and liquidity risk are both important factors affecting the pricing of corporate bonds. In addition, several literature studies

discuss the effect of liquidity and credit risk on spreads [12–15]. Ericsson and Renault [12] analyse the interaction between liquidity and credit risk in theory. Duffie and Singleton [13] and Wang et al. [14] find that liquidity risk and credit risk interact. Chen et al. [16] develop a structural credit risk model to examine how the interactions of liquidity and default risk affect corporate bond pricing. Li et al. [17] propose a generalized bond pricing model and account for all the impacts of credit risk, liquidity risk, and their correlation. The above scholars provide evidence that both liquidity risk and credit risk affect corporate bond spreads.

Different from previous literature, this study derives a liquidity and credit risk-adjusted capital asset pricing model based on individual bond risk and market risk. The model derived in this study provides an explanation of why the interaction between liquidity and credit risk affects corporate bond pricing from the individual dimension and market dimension in theory. This study aimed to provide a deeper understanding of the impact factors of corporate bond price.

Our research contributes to the literature in four ways. First, we introduce liquidity risk and credit risk into the traditional capital asset pricing model and obtain a new adjusted corporate bond pricing model. This model reveals the impact mechanism of liquidity risk and credit risk on corporate bond return from individual bond level and market level.

Second, compared with traditional pricing models with strict assumptions, the new adjusted model based on stochastic discount factor theory has relatively few conditions and is easier to apply and understand.

Third, the corporate bond pricing model obtained in this study explains why the interaction between liquidity risk and credit risk affects corporate bond pricing from the mechanism.

Fourth, based on the new adjusted model deduced in this study, empirical research is conducted from the perspective of multidimensional liquidity risk and credit risk. It makes the results more comprehensive and reliable.

Our main findings are as follows. First, the channels through which liquidity risk affects corporate bond return are individual bond liquidity risk, the interaction between individual bond liquidity risk and market liquidity risk. Second, the channels through which credit risk affects corporate bond return are individual bond credit risk, the interaction between individual bond credit risk and market credit risk. Third, the main channel through which the interaction between liquidity risk and credit risk affects corporate bond return is the interaction between individual bond liquidity risk and market credit risk. At last, market factors and the interactions between multiple dimensions of liquidity and credit risk have significant impacts on corporate bond returns, and stock market and bond market have liquidity spillover effects.

The rest of this study is organized as follows: Section 2 gives the literature review. Section 3 derives the liquidity and credit risk-adjusted capital asset pricing model; Section 4 provides the economic significance of the model; Section 5 elaborates on the empirical results; and Section 6 presents our conclusions.

2. Literature Review

Several studies discuss why liquidity affects asset prices [18–21]. The illiquidity is the risk that assets cannot be sold at a reasonable price within a given time [22]. Acharya and Pedersen [18] explain the affecting mechanism of liquidity on asset prices. They establish a theoretical model of liquidity capital asset pricing and identify two channels of risk transmission. Liquidity affects asset pricing from two perspectives of liquidity level and liquidity risk. Dick-Nielsen et al. [23] consider liquidity risk by taking the standard deviation of daily observations of the Amihud measure. Bongaerts et al. [24] use an asset pricing approach to compare the impacts of liquidity level and liquidity risk on expected U.S. corporate bond returns. The above literature shows why liquidity affects asset price.

Lin et al. [25] and Acharya et al. [26] find that liquidity risk is priced. Amihud and Noh [21] show that the illiquidity premium is significantly positive after controlling for mispricing, sentiment, and seasonality. Zou et al. [27] and Yousaf and Hasan [28] also find similar results. The above literature shows that liquidity is an important factor affecting corporate bond price. Corporate bond prices are affected by different dimensions of liquidity [8, 29, 30]. The liquidity of different dimensions has a different impact on corporate bond price. Liu [31] and Bervas [32] find that liquidity has many different dimensions. Houweling et al. [33] consider eight different proxies to measure corporate bond liquidity. Helwege et al. [34] use many liquidity proxies to explain corporate bond spreads, including efficient individual liquidity measures. Ji and Cao [35] find that spreads more reflect market liquidity premium. Díaz and Escribano [29] classify and describe the variety of the existing liquidity measures with the different dimensions of liquidity. These studies provide evidence supporting the impact of individual liquidity and market liquidity on corporate bond price.

Investors need some compensation for risk when holding defaultable assets, which is why credit risk affects asset prices [7, 36]. Elton et al. [6] and Friewald et al. [7] find that credit risk is the important determinant of corporate bond spreads. Collin-Dufresne et al. [37] argue that corporate bond spreads are mainly driven by factors that are independent of credit risk. In addition, Longstaff et al. [10] propose a new measure of illiquidity and find that credit risk is the main determinant of corporate bond spreads. Covitz and Downing [38] and Longstaff et al. [10] also reach similar findings by investigating very short-term commercial paper issued by nonfinancial U.S. corporations. Different dimension credit risks have different impacts on corporate bond spreads. Li and Song [39] divide credit risk into dynamic credit risk and static credit risk. Ali et al. [40] estimate the impact of credit rating on capital structure and find a nonlinear relationship. Zeitsch and Davis [41] construct the dynamic correlation of the DCC-GARCH method and find that contingent convertible bond price is most highly correlated with credit default swap spreads. The relevant literature can also refer to King and Mauer [42]. Huang and Shi [43] present a model-based analysis of individual corporate bond returns using the structural approach for credit

risk modeling. The above literature shows that credit risk is the important factor affecting the pricing of corporate bonds.

In addition, several literature studies have discussed the interaction between liquidity and credit risk on corporate bond spreads [12, 16, 44, 45]. Ericsson and Renault [12] analyse the interaction between liquidity and credit risk in theory. Duffie and Singleton [13] and Wang et al. [14] find that liquidity risk and credit risk interact. Chen et al. [11]; Covitz and Downing [38]; Rossi [46]; and Kalimipalli and Nayak [47] provide evidence that liquidity effects are mingled with credit risk effects on bond yield spreads. Ai et al. [48] find that liquidity risk is positively correlated with credit risk, and the interaction between the two types of risk has a significant impact on corporate bond spreads. Sperna Weiland et al. [49] propose a novel way of modeling credit-liquidity interactions through mutually exciting processes. Chen et al. [16] develop a structural credit risk model to examine how the interactions of liquidity and default risk affect corporate bond pricing. Gunay [45] investigates the interaction of credit risk and liquidity risk and that liquidity risk appears to play an important role in credit risk. The above scholars provide evidence of the impact of the interaction between liquidity and credit risk on corporate bond spreads.

In summary, the previous literature provides an important foundation for this study. In this study, we deduce a corporate bond pricing model with interaction between liquidity and credit risk from the individual dimension and market dimension in theory, and we investigate the impact of the interaction between multiple dimensions of liquidity and credit risk on corporate bond price in China's corporate bond market.

3. Model

The capital asset pricing model and multifactor model are special forms of linearization of stochastic discount factor model. The stochastic discount factor model can unify different asset pricing models into one framework [3].

The pricing equation for the stochastic discount factor is as follows:

$$P_{i,t} = E_t\left(M_{t+1}X_{i,t+1}\right), \tag{1}$$

where $M_{t+1} = f$ (parameter) is the stochastic discount factor, $P_{i,t}$ is the price of asset i at period t, $X_{i,t+1}$ is the profit and loss of asset i at period $t+1$, and E_t is the conditional expected return under the current known information.

Assuming that $P_{i,t}$ does not equal 0, let $1 + R_{i,t+1} = X_{i,t+1}/P_{i,t}$, and then, the above equation can be expressed as follows:

$$1 = E_t\left(M_{t+1}\left(1 + R_{i,t+1}\right)\right), \tag{2}$$

where ${}^{i,t+1}_{R}$ represents the return of asset i at period $t+1$.

The stochastic discount factor pricing equation can be understood from two perspectives [3]. First, in a discrete set of states, the asset price is equal to the weighted average sum of return for each state. Second, the expression of asset price can be obtained by solving the first-order optimal conditions to study the optimization of the consumption choice of an economic subject.

Wang and Chen [50] study the liquidity-adjusted conditional capital asset pricing model. Following Wang and Chen [50], we derive a liquidity and credit risk-adjusted capital asset pricing model based on stochastic discount factor theory, and we study the impact mechanism of multiple dimensions of liquidity risk and credit risk on bond return from individual and market perspectives.

Assuming that there are N agents, $n = 1, 2, 3, \ldots, N$, each agent can only survive two periods: t to $t+1$.

Agent n has wealth W_t at period t and wealth W_{t+1} at period $t+1$.

Assuming that there are $I\,(i = 1, 2, 3, \ldots, I)$ risky assets and one risk-free asset, an investor buys ξ shares of asset i at price ${}^{i,t}_{P}$ at period t, and he will sell the asset at price $P_{i,t+1}$ at period $t+1$, where the implied cost of liquidity risk is $C_{l,i,t+1}$ and the implied cost of credit risk is $C_{c,i,t+1}$.where

(i) ${}^{i,t}_{P}$ represents the price of asset i at period t

(ii) ${}^{i,t+1}_{P}$ represents the price of asset i at period $t+1$

(iii) ${}^{i,t+1}_{R}$ represents the gross return of asset i at period $t+1$

(iv) $R^*_{i,t+1}$ represents the net return of asset i at period $t+1$

(v) ${}^{i,t+1}_{L}$ represents the liquidity cost of asset i at period $t+1$

(vi) ${}^{i,t+1}_{C}$ represents the credit risk cost of asset i at period $t+1$

(vii) ${}^{M,t+1}_{R}$ represents the gross market return at period $t+1$

(viii) $R^*_{M,t+1}$ represents the net market return at period $t+1$

(ix) ${}^{M,t+1}_{L}$ represents the market liquidity cost at period $t+1$

(x) ${}^{M,t+1}_{C}$ represents the market credit risk cost at period $t+1$

So, we get the gross return of asset i:

$$R_{i,t+1} = \frac{P_{i,t+1}}{P_{i,t}}. \tag{3}$$

We get the net return of asset i:

$$\begin{aligned} R^*{}_{i,t+1} &= \frac{P_{i,t+1} - C_{l,i,t+1} - C_{c,i,t+1}}{P_{i,t}} \\ &= R_{i,t+1} - L_{i,t+1} - C_{i,t+1}, \end{aligned} \tag{4}$$

where

$$\begin{aligned} L_{i,t+1} &= \frac{C_{l,i,t+1}}{P_{i,t}}, \\ C_{i,t+1} &= \frac{C_{c,i,t+1}}{P_{i,t}}. \end{aligned} \tag{5}$$

The net market return at period $t+1$ is as follows:

$$R^*_{M,t+1} = R_{M,t+1} - L_{M,t+1} - C_{M,t+1}. \tag{6}$$

We define the investor's consumption as Ct at period t and consumption as $Ct+1$ at period $t+1$. So, we get the following investor utility function, which contains current and future consumption:

$$U(C_t, C_{t+1}) = U(C_t) + \beta E_t[U(C_{t+1})], \tag{7}$$

where β is the subjective discount factor, which contains investor sentiment and risk aversion. We use the following common utility function:

$$U(C) = \frac{1}{1-\gamma} C^{1-\gamma}, \tag{8}$$

where γ is the parameter, and when $\gamma \longrightarrow 1$,

$$U(C) = \ln(C). \tag{9}$$

Assuming that investors can buy and sell enough risky assets at their own will without transaction costs, they need to choose the optimal risky asset trading strategy to maximize their utility. Thus, an investor's portfolio selection is constructed as follows:

$$\begin{aligned} &\max_{\xi} \quad U(C_t) + E_t \beta U(C_{t+1}), \\ &\text{s.t.} \begin{cases} C_t = W_t - P_{i,t}\xi, \\ C_{t+1} = W_{t+1} + \left(P_{i,t+1} - C_{l,i,t+1} - C_{c,i,t+1}\right)\xi. \end{cases} \end{aligned} \tag{10}$$

We put the constraint into the objective function and take the derivative of ξ, and we set the derivative to zero.

$$U'\left(W_t - P_{i,t}\xi\right)\left(-P_{i,t}\right) + E_t\left[\beta U'\left(W_{t+1} + \left(P_{i,t+1} - C_{l,i,t+1} - C_{c,i,t+1}\right)\xi\right)\left(P_{i,t+1} - C_{l,i,t+1} - C_{c,i,t+1}\right)\right] = 0. \tag{11}$$

Thus, we obtain the optimal consumption and portfolio choice under the first-order condition.

$$\begin{aligned} P_{i,t}U'\left(W_t - P_{i,t}\xi\right) &= E_t\left[\beta\left(P_{i,t+1} - C_{l,i,t+1} - C_{c,i,t+1}\right)U'\left(W_{t+1} + \left(P_{i,t+1} - C_{l,i,t+1} - C_{c,i,t+1}\right)\xi\right)\right], \\ E_t\left[\beta \frac{U'\left(W_{t+1} + \left(P_{i,t+1} - C_{l,i,t+1} - C_{c,i,t+1}\right)\xi\right)}{U'\left(W_t - P_{i,t+1}\xi\right)}\left(\frac{P_{i,t+1} - C_{l,i,t+1} - C_{c,i,t+1}}{P_{i,t}}\right)\right] &= 1, \end{aligned} \tag{12}$$

where we define the following mathematical expression as the marginal substitution rate of investors from period t to period $t+1$. $mt+1$ represents the stochastic discount factor.

$$m_{t+1} = \beta \frac{U'\left(W_{t+1} + \left(P_{i,t+1} - C_{l,i,t+1} - C_{c,i,t+1}\right)\xi\right)}{U'\left(W_t - P_{i,t}\xi\right)}, \tag{13}$$

where

$$\begin{aligned} R^*_{i,t+1} &= \frac{P_{i,t+1} - C_{l,i,t+1} - C_{c,i,t+1}}{P_{i,t}} \\ &= R_{i,t+1} - L_{i,t+1} - C_{i,t+1}. \end{aligned} \tag{14}$$

Thus, the first-order condition can be simply expressed as follows:

$$E_t\left(m_{t+1}R^*_{i,t+1}\right) = 1. \tag{15}$$

So, we get the following mathematical expression:

$$Cov_t\left(m_{t+1}, R^*_{i,t+1}\right) + E_t\left(R^*_{i,t+1}\right)E_t\left(m_{t+1}\right) = 1. \tag{16}$$

The above expression is transformed into the following mathematical expression:

$$E_t\left(R^*_{i,t+1}\right) = \frac{1}{E_t\left(m_{t+1}\right)} - \frac{Cov_t\left(m_{t+1}, R^*_{i,t+1}\right)}{E_t\left(m_{t+1}\right)}. \tag{17}$$

The assumption that the stochastic discount factor is linear does not affect the analysis [50, 51]. So, we make a linear assumption about the stochastic discount factor.

$$m_{t+1} = a_t + b_t R^*_{M,t+1}. \tag{18}$$

Assuming that there is a conditional risk-free asset with a return rate of RF, the following mathematical model is obtained according to the definition of risk-free asset, market portfolio, and $mt+1$:

$$\begin{aligned} E_t\left(R_F m_{t+1}\right) &= R_F E_t\left(m_{t+1}\right) = 1, \\ E_t\left(m_{t+1}\right) &= \frac{1}{R_F}, \\ E_t\left(m_{t+1}R^*_{M,t+1}\right) &= 1. \end{aligned} \tag{19}$$

So, we get the following mathematical expression:

$$E_t\left(R_{M,t+1} - L_{M,t+1} - C_{M,t+1}\right) = \frac{1}{E_t\left(m_{t+1}\right)} - \frac{Cov_t\left(m_{t+1}, R_{M,t+1} - L_{M,t+1} - C_{M,t+1}\right)}{E_t\left(m_{t+1}\right)}, \tag{20}$$

because

$$R_F = \frac{1}{E_t\left(m_{t+1}\right)}. \tag{21}$$

So,

$$E_t\left(R_{M,t+1} - L_{M,t+1} - C_{M,t+1}\right) = R_F - R_F Cov_t\left(m_{t+1}, R_{M,t+1} - L_{M,t+1} - C_{M,t+1}\right). \tag{22}$$

We substitute formula (18) into formula (22), so

$$E_t\left(R_{M,t+1} - L_{M,t+1} - C_{M,t+1}\right) = R_F - R_F Cov_t\left(a_t + b_t\left(R_{M,t+1} - L_{M,t+1} - C_{M,t+1}\right), R_{M,t+1} - L_{M,t+1} - C_{M,t+1}\right), \tag{23}$$

because

$$Cov_t\left(a_t + b_t\left(R_{M,t+1} - L_{M,t+1} - C_{M,t+1}\right), R_{M,t+1} - L_{M,t+1} - C_{M,t+1}\right) = b_t Var_t\left(R_{M,t+1} - L_{M,t+1} - C_{M,t+1}\right). \tag{24}$$

So,

$$b_t = -\frac{E_t\left(R_{M,t+1} - L_{M,t+1} - C_{M,t+1} - R_F\right)}{R_F Var_t\left(R_{M,t+1} - L_{M,t+1} - C_{M,t+1}\right)}, \tag{25}$$

$$R_F = -\frac{E_t\left(R_{M,t+1} - L_{M,t+1} - C_{M,t+1} - R_F\right)}{b_t Var_t\left(R_{M,t+1} - L_{M,t+1} - C_{M,t+1}\right)}, \tag{26}$$

where

$$R_F = \frac{1}{E_t\left(m_{t+1}\right)}. \tag{27}$$

We substitute formula (26) and formula (27) into formula (17), so

$$E_t\left(R_{i,t+1} - L_{i,t+1} - C_{i,t+1} - R_F\right) = \lambda_t \frac{\mathrm{cov}_t\left(R_{M,t+1} - L_{M,t+1} - C_{M,t+1}, R_{i,t+1} - L_{i,t+1} - C_{i,t+1}\right)}{Var_t\left(R_{M,t+1} - L_{M,t+1} - C_{M,t+1}\right)}, \tag{28}$$

where the following expression represents the risk premium:

$$\lambda_t = E_t\left(R_{M,t+1} - L_{M,t+1} - C_{M,t+1} - R_F\right). \tag{29}$$

4. Economic Significance of the Model

4.1. An Asset Pricing Model with Interaction of Return, Liquidity, and Credit Risk. When $Cov(R, L) \neq 0$, $Cov(R, C) \neq 0$, $Cov(C, L) \neq 0$

$$
\begin{aligned}
E_t\left(R_{i,t+1}\right) - R_F = {} & E_t\left(L_{i,t+1}\right) + E_t\left(C_{i,t+1}\right) \\
& + \lambda_t \frac{\operatorname{cov}_t\left(R_{M,t+1}, R_{i,t+1}\right)}{Var_t\left(R_{M,t+1} - L_{M,t+1} - C_{M,t+1}\right)} + \lambda_t \frac{\operatorname{cov}_t\left(\left(L_{M,t+1}, L_{i,t+1}\right)\right)}{Var_t\left(R_{M,t+1} - L_{M,t+1} - C_{M,t+1}\right)} + \lambda_t \frac{\operatorname{cov}_t\left(C_{M,t+1}, L_{i,t+1}\right)}{Var_t\left(R_{M,t+1} - L_{M,t+1} - C_{M,t+1}\right)} \\
& - \lambda_t \frac{\operatorname{cov}_t\left(R_{M,t+1}, L_{i,t+1}\right)}{Var_t\left(R_{M,t+1} - L_{M,t+1} - C_{M,t+1}\right)} - \lambda_t \frac{\operatorname{cov}_t\left(L_{M,t+1}, R_{i,t+1}\right)}{Var_t\left(R_{M,t+1} - L_{M,t+1} - C_{M,t+1}\right)} + \lambda_t \frac{\operatorname{cov}_t\left(C_{M,t+1}, C_{i,t+1}\right)}{Var_t\left(R_{M,t+1} - L_{M,t+1} - C_{M,t+1}\right)} \\
& + \lambda_t \frac{\operatorname{cov}_t\left(L_{M,t+1}, C_{i,t+1}\right)}{Var_t\left(R_{M,t+1} - L_{M,t+1} - C_{M,t+1}\right)} - \lambda_t \frac{\operatorname{cov}_t\left(R_{M,t+1}, C_{i,t+1}\right)}{Var_t\left(R_{M,t+1} - L_{M,t+1} - C_{M,t+1}\right)} - \lambda_t \frac{\operatorname{cov}_t\left(C_{M,t+1}, R_{i,t+1}\right)}{Var_t\left(R_{M,t+1} - L_{M,t+1} - C_{M,t+1}\right)},
\end{aligned}
\tag{30}
$$

where the following expression represents the risk premium:

$$\lambda_t = E_t\left(R_{M,t+1} - L_{M,t+1} - C_{M,t+1} - R_F\right). \tag{31}$$

The above expression is transformed into the following mathematical expression:

$$
\begin{aligned}
E_t\left(R_{i,t+1} - R_F\right) = {} & E_t\left(L_{i,t+1}\right) + E_t\left(C_{i,t+1}\right) \\
& + \lambda_t\beta + \lambda_t\beta_{LL} + \lambda_t\beta_{CL} - \lambda_t\beta_{RL} - \lambda_t\beta_{LR} \\
& + \lambda_t\beta_{CC} + \lambda_t\beta_{LC} - \lambda_t\beta_{RC} - \lambda_t\beta_{CR},
\end{aligned}
\tag{32}
$$

where the following expression represents the risk premium:

$$\lambda_t = E_t\left(R_{M,t+1} - L_{M,t+1} - C_{M,t+1} - R_F\right). \tag{33}$$

The variables and corresponding expressions of the nine beta for the model with the interaction of return, liquidity, and credit risk are shown in Table 1, where the economic significance of variables is as follows.

β represents the covariance between market return rate and asset return rate, and its economic significance is the market risk of assets in the traditional capital asset pricing model.

β_{LL} represents the covariance between market liquidity and asset liquidity, and its economic significance is liquidity risk to which asset is subjected to. It shows that the channels through which liquidity risk affects corporate bond return are individual bond liquidity risk, the interaction between individual bond liquidity risk and market liquidity risk.

β_{CL} represents the covariance between market credit risk cost and asset liquidity risk, and its economic significance is the interaction between market credit risk and asset liquidity risk. It is the interaction caused by liquidity risk of asset itself and is a part of the interaction between liquidity risk and credit risk.

β_{RL} represents the covariance between market return rate and asset liquidity risk. Its economic significance is the interaction between market risk and asset liquidity risk. It is the interaction caused by liquidity risk of asset itself.

β_{LR} represents the covariance between market liquidity risk and asset return rate. Its economic significance is the interaction between market liquidity risk and asset return rate risk. It is the interaction caused by market liquidity risk.

β_{CC} represents the covariance between market credit risk cost and asset credit risk cost, and its economic significance is credit risk to which asset is subjected to. It shows that the channels through which credit risk affects corporate bond return are individual bond credit risk, the interaction between individual bond credit risk and market credit risk.

β_{LC} represents the covariance between market liquidity risk cost and asset credit risk cost, and its economic significance is the interaction between market liquidity risk and asset credit risk. This is the interaction caused by default risk of asset itself and is a part of interaction between liquidity risk and credit risk.

β_{RC} represents the covariance between market return rate and asset credit risk cost. Its economic significance is the interaction between market risk and asset credit risk. It is the interaction caused by default risk of asset itself.

β_{CR} represents the covariance between market credit risk cost and asset return rate. Its economic significance is the interaction between market credit risk and asset return rate risk. It is the interaction caused by market default risk.

The above expression is transformed into the following mathematical expression:

$$E_t\left(R_{i,t+1} - R_F\right) = E_t\left(L_{i,t+1}\right) + E_t\left(C_{i,t+1}\right) + \lambda_t\beta + \lambda_t\beta_L + \lambda_t\beta_C, \tag{34}$$

where βL represents liquidity risk, βC represents credit risk, and λt represents risk premium.

$$
\begin{aligned}
\beta_L &= \beta_{LL} + \beta_{CL} - \beta_{RL} - \beta_{LR}, \\
\beta_c &= \beta_{CC} + \beta_{LC} - \beta_{RC} - \beta_{CR}, \\
\lambda_t &= E_t\left(R_{M,t+1} - L_{M,t+1} - C_{M,t+1} - R_F\right).
\end{aligned}
\tag{35}
$$

Now, we give the economic significance of the nine beta in the model. First, β is the risk in the traditional capital asset pricing model. Second, there are four sources of liquidity risk to asset. β_{LL} is the covariance between market liquidity and asset liquidity. β_{CL} is the covariance between market credit risk cost and asset liquidity risk. β_{LR} is the covariance between market liquidity risk and asset return rate. β_{RL} is the covariance between market return rate and asset liquidity risk. Finally, there are four sources of credit risk to asset. β_{CC} is the covariance between market credit risk cost and asset credit risk cost. β_{LC} is the covariance between market liquidity risk cost and asset credit risk cost. β_{CR} is the covariance between market credit risk cost and asset return rate. β_{RC} is the covariance between market return rate and asset credit risk cost.

Table 1: Variables and expressions of the nine beta for the model with the interaction of return, liquidity, and credit risk.

Variable	Expression	Variable	Expression	Variable	Expression
β	$\mathrm{cov}(R_{M,T+1}, R_{i,t+1})/Var_t(R_{M,T+1} - L_{M,t+1} - C_{M,t+1})$	β_{LL}	$\mathrm{cov}(L_{M,T+1}, L_{i,t+1})/Var_t(R_{M,T+1} - L_{M,t+1} - C_{M,t+1})$	β_{CC}	$\mathrm{cov}(C_{M,T+1}, C_{i,t+1})/Var_t(R_{M,T+1} - L_{M,t+1} - C_{M,t+1})$
		β_{CL}	$\mathrm{cov}(C_{M,T+1}, L_{i,t+1})/Var_t(R_{M,T+1} - L_{M,t+1} - C_{M,t+1})$	β_{LC}	$\mathrm{cov}(L_{M,T+1}, C_{i,t+1})/Var_t(R_{M,T+1} - L_{M,t+1} - C_{M,t+1})$
		β_{RL}	$\mathrm{cov}(R_{M,T+1}, L_{i,t+1})/Var_t(R_{M,T+1} - L_{M,t+1} - C_{M,t+1})$	β_{RC}	$\mathrm{cov}(R_{M,T+1}, C_{i,t+1})/Var_t(R_{M,T+1} - L_{M,t+1} - C_{M,t+1})$
		β_{LR}	$\mathrm{cov}(L_{M,T+1}, R_{i,t+1})/Var_t(R_{M,T+1} - L_{M,t+1} - C_{M,t+1})$	β_{CR}	$\mathrm{cov}(C_{M,T+1}, R_{i,t+1})/Var_t(R_{M,T+1} - L_{M,t+1} - C_{M,t+1})$

4.2. An Asset Pricing Model without Interaction of Return, Liquidity, and Credit Risk. When $Cov(R,L)=0$, $Cov(R,C)=0, Cov(C,L)=0$,

$$\begin{aligned} E_t\left(R_{i,t+1}-R_F\right) &= E_t\left(L_{i,t+1}\right)+E_t\left(C_{i,t+1}\right) \\ &+\lambda_t\frac{\operatorname{cov}_t\left(R_{M,t+1},R_{i,t+1}\right)}{Var_t\left(R_{M,t+1}-L_{M,t+1}-C_{M,t+1}\right)} \\ &+\lambda_t\frac{\operatorname{cov}_t\left(L_{M,t+1},L_{i,t+1}\right)}{Var_t\left(R_{M,t+1}-L_{M,t+1}-C_{M,t+1}\right)} \\ &+\lambda_t\frac{\operatorname{cov}_t\left(C_{M,t+1},C_{i,t+1}\right)}{Var_t\left(R_{M,t+1}-L_{M,t+1}-C_{M,t+1}\right)}, \end{aligned} \tag{36}$$

where the following expression represents the risk premium:

$$\lambda_t = E_t\left(R_{M,t+1}-L_{M,t+1}-C_{M,t+1}-R_F\right). \tag{37}$$

So,

$$\begin{aligned} E_t\left(R_{i,t+1}-R_F\right) &= E_t\left(L_{i,t+1}\right)+E_t\left(C_{i,t+1}\right)+\lambda_t\beta+\lambda_t\beta_{LL} \\ &+\lambda_t\beta_{CC}. \end{aligned} \tag{38}$$

The above analysis shows that when the correlation among market risk, liquidity risk, and credit risk is not considered, the common corporate bond spread model can be obtained. Many scholars study the determinants of corporate bond spreads and divide corporate bond spreads into liquidity risk premium and credit risk premium. This is actually a special case of the model; that is, the correlation of return, liquidity, and credit risk is not considered.

4.3. A Liquidity and Credit Risk-Adjusted Capital Asset Pricing Model and Its Economic Significance. In particular, when only considering the correlation between liquidity risk and credit risk, we obtain a liquidity and credit risk-adjusted capital asset pricing model.

$$\begin{aligned} E_t\left(R_{i,t+1}\right)-R_F &= E_t\left(L_{i,t+1}\right)+E_t\left(C_{i,t+1}\right)+\lambda_t\frac{\operatorname{cov}_t\left(R_{M,t+1},R_{i,t+1}\right)}{Var_t\left(R_{M,t+1}-L_{M,t+1}-C_{M,t+1}\right)}+\lambda_t\frac{\operatorname{cov}_t\left(L_{M,t+1},L_{i,t+1}\right)}{Var_t\left(R_{M,t+1}-L_{M,t+1}-C_{M,t+1}\right)} \\ &+\lambda_t\frac{\operatorname{cov}_t\left(C_{M,t+1},C_{i,t+1}\right)}{Var_t\left(R_{M,t+1}-L_{M,t+1}-C_{M,t+1}\right)}+\lambda_t\frac{\operatorname{cov}_t\left(C_{M,t+1},L_{i,t+1}\right)}{Var_t\left(R_{M,t+1}-L_{M,t+1}-C_{M,t+1}\right)}+\lambda_t\frac{\operatorname{cov}_t\left(L_{M,t+1},C_{i,t+1}\right)}{Var_t\left(R_{M,t+1}-L_{M,t+1}-C_{M,t+1}\right)}, \end{aligned} \tag{39}$$

where the following expression represents the risk premium:

$$\lambda_t = E_t\left(R_{M,t+1}-L_{M,t+1}-C_{M,t+1}-R_F\right). \tag{40}$$

The above expression is transformed into the following mathematical expression:

$$\begin{aligned} E_t\left(R_{i,t+1}-R_F\right) &= E_t\left(L_{i,t+1}\right)+E_t\left(C_{i,t+1}\right)+\lambda_t\beta+\lambda_t\beta_{LL} \\ &+\lambda_t\beta_{CC}+\lambda_t\beta_{CL}+\lambda_t\beta_{LC}. \end{aligned} \tag{41}$$

β_{LC} and β_{CL} are the interaction between liquidity risk and credit risk, and their mathematical expressions are as follows:

$$\begin{aligned} \beta_{LC} &= \frac{\operatorname{cov}_t\left(L_{M,t+1},C_{i,t+1}\right)}{Var_t\left(R_{M,t+1}-L_{M,t+1}-C_{M,t+1}\right)}, \\ \beta_{CL} &= \frac{\operatorname{cov}_t\left(C_{M,t+1},L_{i,t+1}\right)}{Var_t\left(R_{M,t+1}-L_{M,t+1}-C_{M,t+1}\right)}. \end{aligned} \tag{42}$$

The economic significance of β_{LC} is the interaction between market liquidity risk and asset credit risk and is a part of interaction between liquidity and credit risk. It is caused by the default risk of asset itself. The economic significance of β_{CL} is the interaction between market credit risk and asset liquidity risk and is also a part of interaction between liquidity and credit risk. It is caused by the liquidity risk of asset itself.

The model not only provides the pricing mechanism and risk composition of the interaction between liquidity risk and credit risk but also provides the sources and channels of liquidity risk and credit risk. It reveals the impact mechanism of individual risk and market risk on bond return and explains why the interaction between liquidity risk and credit risk affects bond pricing.

5. Empirical Analysis

5.1. Variables, Data, and Sample

5.1.1. Data and Sample. Shin and Kim [52] investigate liquidity and credit risk in the corporate bond market. Following Shin and Kim [52], we conduct the following data processing on the research object to comprehensively include the data and information on China's corporate bond market. First, we select corporate bonds from the interbank market and exchange market in China as research samples. We collect the data from the Wind database. We delete the

bonds that are not traded and exclude bonds with a maturity of less than a year. Second, we select the data on corporate bonds and market from March 2006 to December 2021 in China. We download the basic data from the Wind database. Third, we collect relevant data and calculate liquidity risk variables and credit risk variables based on the data.

5.1.2. Variables. Many scholars study liquidity and credit risk [52–54]. Amihud [53] constructs a proxy of illiquidity measure based on the theoretical model of Kyle [55]. Following the Amihud [53], this study constructs Amihud, monthly illiquidity measures to describe liquidity. Referring to Downing et al. [56], we construct range, a monthly illiquidity measure. Amihud and range describe price shock liquidity measure. *BAUMI* is the Amihud liquidity variable based on the corporate bond market, and it represents bond market liquidity. *BRANGE* is a range liquidity variable based on the corporate bond market, and it represents bond market liquidity. *SAUMI* is the Amihud liquidity variable based on the stock market, and it represents stock market liquidity.

Fama and French [57] find that two bond market factors affect bond returns. Following Fama and French [57], we construct the market risk factor and the market default factor, *TYEAR*301 and *CREDIT*, respectively. TYEAR301 is the difference between treasury rate of the 30-year long-term and treasury rate of the 1-year short-term, and it represents market risk. *CREDIT* is the difference between corporate bond rate of the 30-year long-term and treasury rate of the 30-year long-term, and it represents market credit risk. We investigate the impacts of market factors and the interaction between multiple dimensions of liquidity and credit risk on corporate bond returns. We select the data on corporate bond market and stock market from March 2006 to December 2021 in China. We collect the data from the Wind database and calculate the measures required in this study.

5.2. The Description of Spreads, Liquidity, and Credit Risk

5.2.1. Corporate Bond Spreads and the European Debt Crisis. Figure 1 shows the description of corporate bond spreads and the European debt crisis. Standard & Poor's lowers the long-term sovereign credit rating of Greece from "A-" to "BBB+" on December 16, 2009, which intensifies the Greek crisis. However, the financial community believes that the Greek economy is small and the impact of the debt crisis will not be extended. At this time, the Greek crisis has little impact on China's corporate bond market and corporate bond spreads.

The Greek crisis begins to spread to the rest of Europe, and the rest of Europe begins to fall into crisis in the first half of 2010. Spain's finance ministry says on February 4, 2010, that the country's overall public budget deficit will be 9.8% of GDP in 2010 and predicts that the budget deficit will remain high for the next three years. With the escalation of the European debt crisis, Greece formally applies for assistance from the EU and IMF on April 23, 2010.

Due to the impact of the European debt crisis, bond spreads of all rated enterprises in China begin to increase

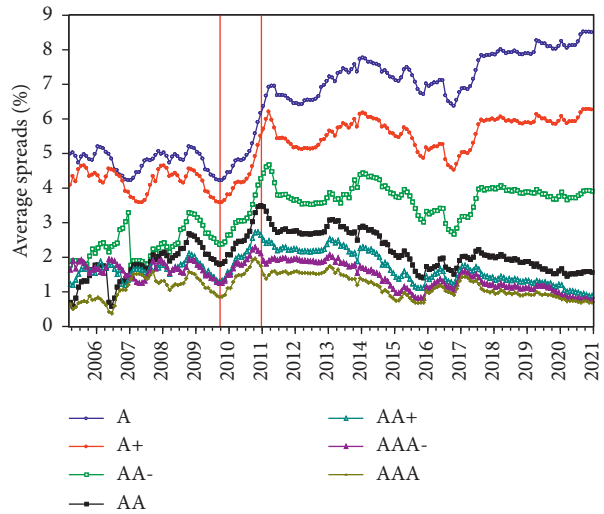

Figure 1: Corporate bond spreads and European debt crisis.

gradually from the second half of 2010, indicating that liquidity risk and credit risk in China's corporate bond market begin to increase. Subsequently, the World Financial Organization begins to rescue Greece. Eurozone member states and the International Monetary Fund provide Greece with a bailout plan of up to 750 billion euros. The European Summit is held, and all countries reach a consensus on the bailout of Greece on July 22, 2011.

With the help of the world, the Greek crisis has been effectively contained. As can be seen from the figure, with the escalation of the Greek crisis, the spreads of Chinese investment-grade (AA level and above) corporate bonds gradually increase and reach the maximum value at the end of 2011. With the bailout of the Greek crisis, the spreads of investment-grade (AA level and above) corporate bonds begin to decline steadily and gradually return to the normal level. As can be seen from the chart, speculative-grade (AA- and below) corporate bond spreads in China do not decline slowly after reaching their peak at the end of 2011, but increase year by year after minor adjustments. This shows that after the European debt crisis, investors begin to demand more risk compensation for speculative grade (AA- and below) corporate bonds with high credit risk.

5.2.2. The Description of Liquidity, Credit Risk, and Their Interaction. Figure 2 shows market risk, credit risk, liquidity, and the interaction between liquidity and credit risk. *TYEAR*301 represents market risk. *CREDIT* represents market credit risk. *BAUMI* represents bond market liquidity. *BIRC* × *CREDIT* represents the interaction between liquidity of bond market price shock dimension and credit risk. *BRANGE* × *CREDIT* represents the interaction between liquidity of bond market volume-price shock dimension and credit risk. *SAUMI* × *CREDIT* represents the interaction between liquidity of stock market volume-price shock dimension and credit risk.

As shown in Figure 2, bond market liquidity risk and credit risk rise in the second half of 2007, during which the

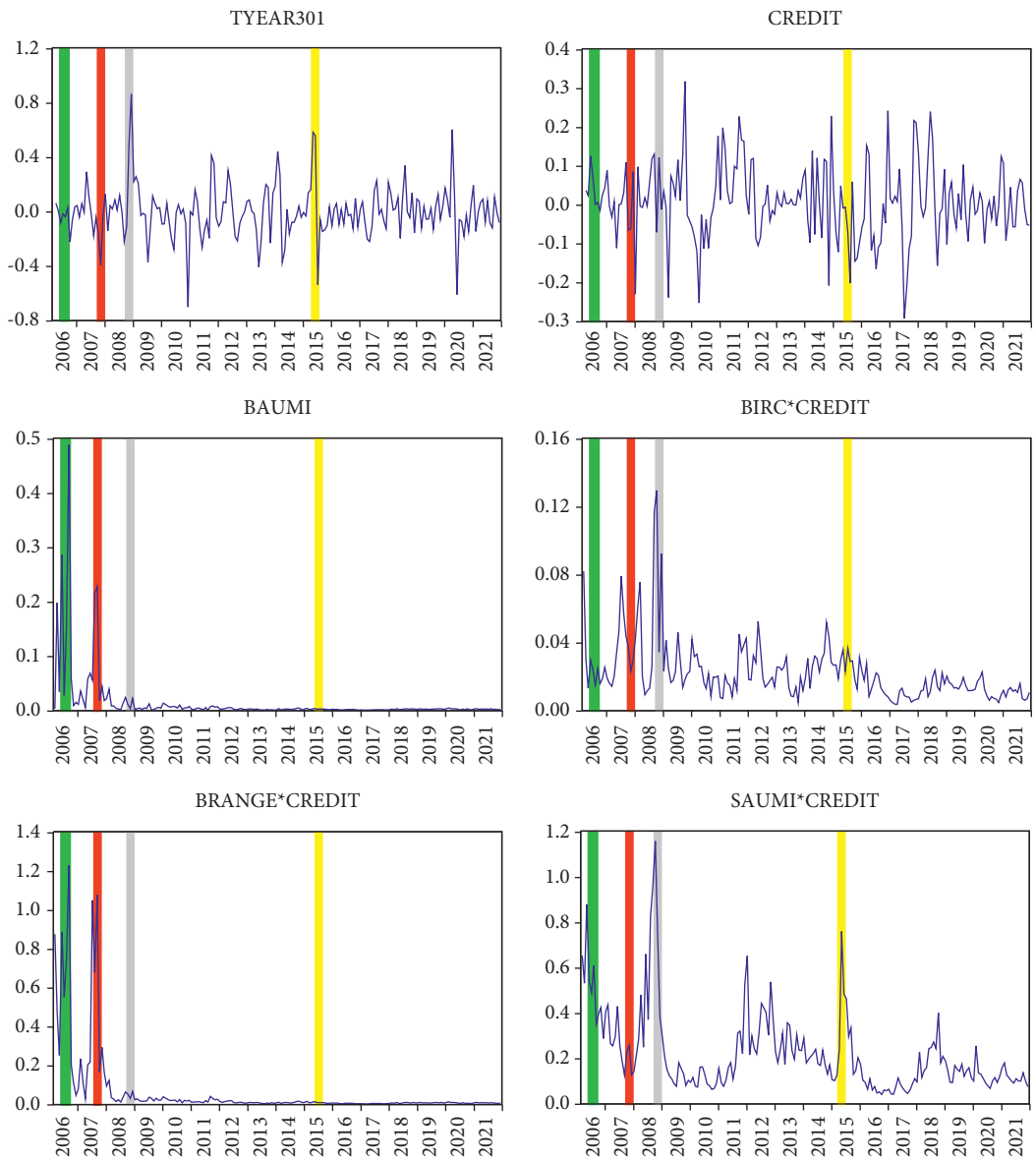

Figure 2: Description of liquidity, credit risk, and their interaction.

interaction between liquidity and credit risk also increases. In the later stage of the subprime crisis, there is a strong increase in the interaction between liquidity of bond market price shock dimension and credit risk. Meanwhile, the interaction between liquidity of stock market volume-price shock dimension and credit risk reaches its peak. Market risk and credit risk also begin to increase significantly. The logic behind this is that in the early stage of the financial crisis in 2008, liquidity risk begins to increase, followed by credit risk, which leads to the increase in the interaction between liquidity risk and credit risk. In the late stage of the financial crisis, the risk of bond market spreads to the stock market, resulting in co-movement and spillover effects between bond market and stock market. This has led to spiraling interactions between liquidity and credit risk in both equity and bond markets.

Similar to the global financial crisis in 2008, during the Chinese stock market crisis in 2015, the interaction between liquidity of stock market volume-price shock dimension and credit risk also begins to increase, indicating that the co-movement between stock market and bond market and liquidity spillover effects cannot be ignored.

5.3. Market Factors and the Interaction between Multiple Dimensions of Liquidity and Credit Risk. Chordia et al. [58] find that bond and stock market liquidity are significantly correlated. Dimic et al. [59] find that time-varying stock-bond correlation patterns vary significantly between the time horizons. Broadstock and Cheng [60] provide evidence that the green and black bond prices are sensitive to changes in financial market volatility. Umar et al. [61] document a strong connection between the components of the sovereign yield curve and sectorial equity indices. Therefore, we examine the interaction between stock market liquidity and bond market credit risk. Following Amhud [53], we

Table 2: Empirical result φs of market factors and the interaction between multiple dimensions of liquidity and credit risk.

	C	*TYEAR301*	*CREDIT*	*BIRC*	*BRANGE*	*SAUMI*	*SAUMI* × *CREDIT*	*BAUMI* × *CREDIT*	*BIRC* × *CREDIT*	Adj-R2
1	−0.0005	−0.1836∗∗∗								0.0373
	(−0.0417)	(−2.8789)								
2	−0.0038	−0.1547∗∗∗	0.5752∗∗∗							0.1422
	(−0.3276)	(−2.5577)	(4.8849)							
3	0.0466∗∗∗	−0.1359∗∗	0.5778∗∗∗	6.8718∗∗∗						0.2115
	(2.8529)	(−2.3372)	(5.1182)	(4.1652)						
4	0.0503∗∗∗	−0.1195∗∗	0.5458∗∗∗	9.3746∗∗∗	0.6436∗∗∗					0.2786
	(3.2147)	(−2.1427)	(5.0428)	(5.5685)	(4.2676)					
5	0.0684∗∗∗	−0.1100∗∗	0.5795∗∗∗	7.0461∗∗∗	0.7286∗∗∗	0.5054∗∗∗				0.3054
	(4.1151)	(−2.0063)	(5.4228)	(3.8222)	(4.8260)	(2.8458)				
6	0.0936∗∗∗	−0.0943∗	0.6018∗∗∗	7.2481∗∗∗	0.5762∗∗∗	−1.2457∗	0.6817∗∗∗			0.3342
	(5.1059)	(−1.7496)	(5.7373)	(4.0131)	(3.6853)	(−2.0363)	(2.9857)			
7	0.0734∗∗∗	−0.1022∗	0.5803∗∗∗	7.6997∗∗∗	1.6856∗∗∗	0.5002∗∗∗		0.6679∗∗∗		0.3502
	(4.5497)	(−1.9253)	(5.6143)	(4.2972)	(5.6630)	(2.9116)		(3.6899)		
8	0.1209∗∗∗	−0.0727	0.6334∗∗∗	−30.4927∗∗∗	0.4460∗∗∗	0.6027∗∗∗			14.3891∗∗∗	0.4083
	(6.7644)	(−1.4259)	(6.3919)	(−4.5036)	(3.0172)	(3.6570)			(5.7281)	
9	0.1198∗∗∗	−0.0690	0.6300∗∗∗	−33.2753∗∗∗	1.2918∗∗∗	1.2921∗	−0.2668	0.5658∗∗∗	15.6377∗∗∗	0.4398
	(6.8291)	(−1.3896)	(6.5337)	(−3.7118)	(4.5108)	(1.6861)	(−0.9339)	(3.3460)	(4.6701)	

The table shows the empirical results of market factors and the interaction between multiple dimensions of liquidity and credit risk. *TYEAR301* is the difference between treasury rate of the 30-year long-term and treasury rate of the 1-year short-term, and it represents market risk. *CREDIT* is the difference between corporate bond rate of the 30-year long-term and treasury rate of the 30-year long-term, and it represents market credit risk. Following Amhud (2002), we construct stock market and bond market liquidity measures, *SAUMI* and *BAUMI*. The range is a liquidity measure used by Han and Zhou (2016), and it represents the liquidity of price shock dimension. We follow Han and Zhou (2016) and construct a bond market liquidity measure, *SRANGE*. Dick-Nielsen et al. (2012) analyse the liquidity components of corporate bond spreads using liquidity measure, IRC, and we follow them and construct a bond market liquidity measure, *BIRC*. The interaction between liquidity and credit risk is represented by the cross-term. The sample period is March 2006 to December 2021. The t-statistics are given in parentheses, and ∗, ∗∗, and ∗∗∗ represent significance at the 10%, 5%, and 1% levels, respectively.

construct stock market and bond market liquidity measures, SAUMI and BAUMI, respectively. The range is a liquidity measure used by Han and Zhou [54], and it represents the liquidity of price shock dimension. We follow Han and Zhou [54] and construct bond market liquidity measure, SRANGE. Dick-Nielsen et al. [23] analyse the liquidity components of corporate bond spreads using liquidity measure, IRC, and we follow them and construct bond market liquidity measure, BIRC. The interaction between liquidity and credit risk is represented by the cross-terms. The t-statistics are given in parentheses, and $*$, $**$, and $***$ represent significance at the 10%, 5%, and 1% levels, respectively. Table 2 shows the estimated results.

In Table 2, Model 1 gives the regression results that include market risk, and Model 2 gives the regression results including market risk and market credit risk. In Model 1 and Model 2, the regression coefficients of *TYEAR*301 are -0.1836 and -0.1547, respectively, and they are significant at the level of 1%. It shows that the market risk is bigger, and the bond yields are smaller, consistent with Yang et al. [62]. In Model 2, the regression coefficient of *CREDIT* is 0.5752 and is significant at the level of 1%. The results of Model 2 show that when the market credit risk rises, investors need more credit risk compensation, consistent with Li et al. [17].

Model 3 and Model 4 give the regression results including bond market liquidity measures. In Model 3 and Model 4, the regression coefficients of *BIRC* are 6.8718 and 9.3746, respectively, and they are significant at the level of 1%. It shows that the liquidity of price shock dimension is priced in China's corporate bond market, consistent with Dick-Nielsen et al. [23]. In Model 4, the regression coefficient of *BRANGE* is 0.6436 and is significant at the level of 1%. The results of Model 4 show that the liquidity of volume-price shock dimension has a significant impact on returns of corporate bonds, and corporate bond pricing should consider multiple dimensions of liquidity, consistent with Shin and Kim [52].

Model 5 gives the regression results including stock market liquidity measure. In Model 5, the regression coefficient of *SAUMI* is 0.5054 and is significant at the level of 1%. In addition, Adj-R^2 of Model 5 is 0.3054 and is significantly improved than that of Model 4. The liquidity risk of stock market increases, leading to greater risk of stock volatility. Many companies will carry out repurchase transactions, reducing cash holdings and increasing bond default risk. The stock market liquidity risk and bond market credit risk interact with each other, thus affecting investor returns, consistent with Yang et al. [62].

Models 6–9 give the regression results including the interaction between liquidity and credit risk. In Model 6, the regression coefficient of $SAUMI \times CREDIT$ is 0.6817 and is significant at the level of 1%. Adj-R^2 of Model 6 is 0.3342 and is significantly improved than that of Model 5. It shows that the interaction between liquidity of stock market volume-price shock dimension and credit risk is positively correlated with returns of corporate bonds, consistent with Gunay [45]. The logic behind this is that the liquidity risk of stock market spreads to bond markets through a common liquidity risk factor, resulting in co-movement and spillover effects between bond market and stock market. Model 7 and Model 8 give the regression results that include bond market liquidity. In Model 7, the regression coefficient of $BAUMI \times CREDIT$ is 0.6679 and is significant at the level of 1%. It shows that the interaction between liquidity of bond market volume-price shock dimension and credit risk increases by 1 unit, and the return of corporate bond increases by 0.6679 units on average. In Model 8, the regression coefficient of $BIRC \times CREDIT$ is 14.3891 and is significant at the level of 1%. In addition, Adj-R^2 of Model 8 is 0.4083 and is significantly improved than 0.3054 of Model 5. It shows that the interaction between liquidity of bond market price shock dimension and credit risk has a significant impact on corporate bond price, consistent with Li et al. [17]. Model 9 gives the regression results including multiple dimensions of liquidity. The regression coefficients of $BAUMI \times CREDIT$ and $BIRC \times CREDIT$ are 0.5658 and 15.6377, respectively, and they are significant at the level of 1%. Adj-R^2 of Model 9 is significantly improved than that of Model 8. It shows that the interaction between liquidity and credit risk is priced and multiple dimension liquidity premiums cannot be ignored.

Stock market liquidity and bond market liquidity are linked by a common liquidity factor, resulting in co-movement and spillover effects between bond market and stock market [34]. Liquidity has multiple dimensions and interacts spirally with credit risk, which jointly affects asset prices.

6. Conclusion

We introduce liquidity risk and credit risk into the traditional capital asset pricing model and derive a liquidity and credit risk-adjusted capital asset pricing model. We investigate the new model using the data set in China's corporate bond market. The model not only provides the pricing mechanism and risk composition of the interaction between liquidity risk and credit risk but also provides the sources and channels of liquidity risk and credit risk. It also reveals the impact mechanism of individual risk and market risk on bond return and explains why the interaction between liquidity risk and credit risk affects bond pricing. Our main conclusions are as follows.

First, the channels through which liquidity risk affects corporate bond return are individual bond liquidity risk, the interaction between individual bond liquidity risk and market liquidity risk. The interaction between individual bond liquidity risk and market liquidity risk has a positive impact on corporate bond spread.

Second, the channels through which credit risk affects corporate bond return are individual bond credit risk, the interaction between individual bond credit risk and market credit risk. The interaction between individual bond credit risk and market credit risk has a positive impact on corporate bond spread.

Third, the main channel through which the interaction between liquidity risk and credit risk affects corporate bond return is the interaction between individual bond liquidity

risk and market credit risk. The economic reason is that liquidity risk and credit risk transform and affect each other in the trading of new and old bonds in the secondary market. Relevant studies can be referred to as He and Xiong [44] and He and Milbradt [63].

Finally, market factors and the interactions between multiple dimensions of liquidity and credit risk have significant impacts on corporate bond returns, and the stock market and bond market have liquidity spillover effects.

This study provides new interpretation channels for corporate bond pricing considering the correlation between risks, and the research results can be used as a reference for investors and policymakers. For example, our results show that the stock market and bond market have liquidity spillover effects and the interaction between liquidity of stock market volume-price shock dimension and credit risk has a significant impact on corporate bond price. When stock market liquidity risk increases, risk-averse investors should sell stocks and buy corporate bonds with high credit ratings to avoid liquidity risk. During the financial crisis, policymakers should take some measures to prevent a large amount of trading or insider trading in a short period of time, which reduces the impact on asset prices and avoids market panic because of price shock. This study does not consider the effect of investor structure difference, which may be a direction for further research.

Data Availability

This study uses the data from the Wind database.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

This work was supported by the National Natural Science Foundation of China (Grant Nos. 71471129 and 71501140) and Tianjin Philosophy and Social Science Planning Project (Grant no. TJGL19-018). For their helpful comments, we thank the editor and anonymous referees. All mistakes are our own.

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