2022 CSPI Ratings Transition and Default Research

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Summary

This report presents the recent Transition and Default Research for CSPI Credit Ratings Company Limited ("CSPI Ratings"). It is designed to promote a greater understanding of our ratings and to introduce the approaches we use to compute statistics on the rating transition and default rates.

Statistical research on rating transition and default rates is an integral part of credit rating service. It can not only reveal the relationship between credit ratings and default rates, but also test the accuracy, stability, and consistency of credit ratings.

The key findings of our research include:

- In this report, we examine the stability of CSPI Ratings' credit ratings using the rating transition matrix. Up to 87% of CSPI Ratings-rated issuers maintained their ratings through the assessment period. According to the sample statistics, the rating results of CSPI Ratings are stable.
- During the assessment period, no defaults were observed for issuers with outstanding credit ratings from CSPI Ratings.
- CSPI Ratings assigned 69 public issuer ratings and 22 public issuance ratings from 11 April 2018 to 31 December 2022. The effective sample size used in this study is relatively limited. Therefore, it is difficult to reflect the relevant situation comprehensively and to draw any statistically significant conclusions. We will apply the same approach to extend the research with enhanced data.

We also provide the definition and computation methods of transition matrix and default rate in appendices.

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Introduction

This report is the fourth edition of CSPI Ratings' rating transition and default research. It is prepared to help market participants better understand our credit ratings through a study of default events and rating transitions within CSPI Ratings' rating universe. The data used for this research include all CSPI Ratings' global scale long-term issuer credit ratings (LTICR) issued before 31 December 2022. Due to the limited number of ratings published by CSPI Ratings, some of the research results may not be statistically significant and conclusive. As a result, while it is still informative to share the results, some findings based on the limited samples should be interpreted with caution. We will extend the assessment period and update the research results annually in the future. With more data accumulated, the research results will be a more comprehensive reflection of the rating stability and the historical relationship between ratings and default risk.

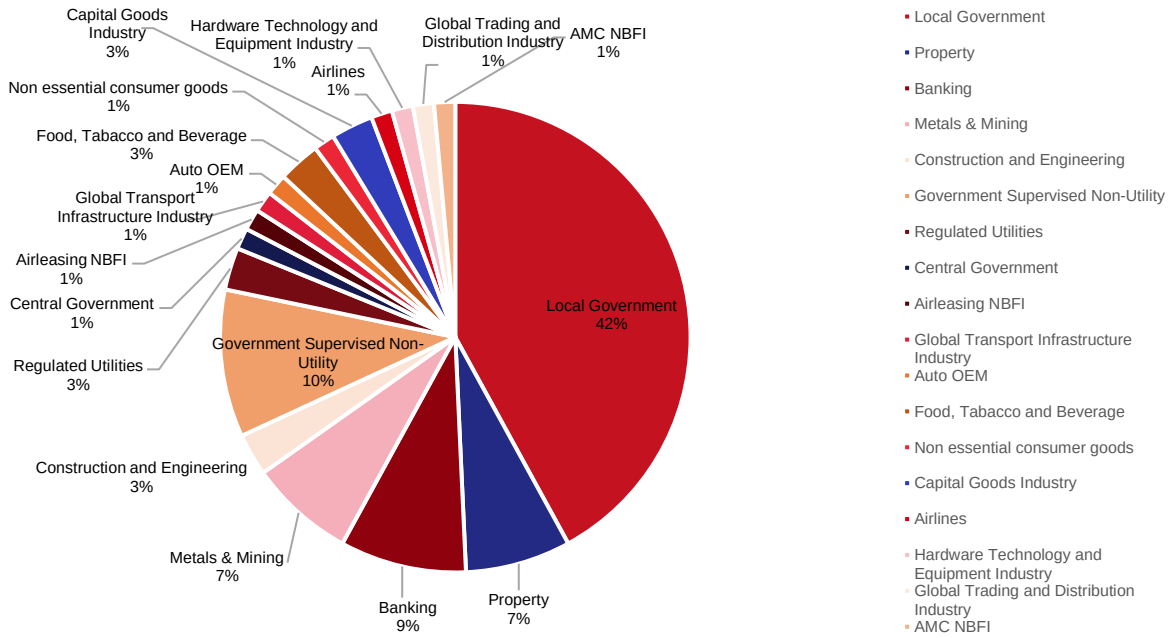
Ratings Issued by CSPI Ratings

CSPI Ratings assigned 69 public issuer ratings and 22 public issuance ratings between 11 April 2018 and 31 December 2022. The issuer ratings are distributed from B+ to AA. While the data collection under the assessment period is relatively small, the rating performance is in line with expectations. During the assessment period, we do not observe any default risk for rated entities.

In 2019, the number of issuers and issuance rated by CSPI Ratings and included in the statistical sample of rating were 29 and six, respectively, of which one entity was downgraded during this period, accounting for 3.45%; in 2020, the number of issuers and issuance rated by CSPI Ratings and included in the statistical sample of rating were 44 and 11, respectively, of which one entity was downgraded during this period, accounting for 2.27% of the total; in 2021, the number of issuers and issuance rated by CSPI Ratings and included in the statistical sample of rating were 57 and 22, respectively, of which one entity was downgraded and two were upgraded during this period, accounting for 5.26% of the total; in 2022, the number of issuers and issuance rated by CSPI Ratings and included in the statistical sample of rating were 66 and 23, respectively, of which one entity was downgraded and seven were upgraded during this period, accounting for 12.12% of the total.

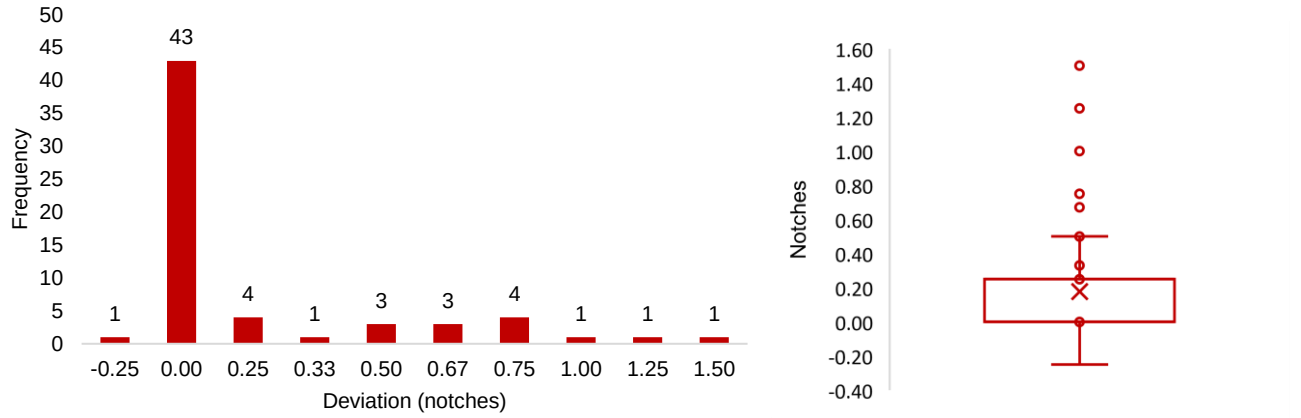
In terms of sector distribution, the issuers rated by CSPI Ratings are mainly distributed in 18 sectors. (Figure 1). Among them, the total number of Local Government, Property, Banking and Metals &Mining issuers accounted for 65%, and the distribution of other sectors was relatively even.

Figure 1: Sector distribution of rated issuers (2018-2022)



In order to compare the ratings issued by CSPI Ratings with market consensus, we assign a numerical value to each rating category, and then compute the deviation of CSPI Ratings' ratings from the market average. Specifically, we use the scale of 19 to 1 to quantify the credit ratings ranging from AAA to C, which means the larger the value, the higher the rating level. Then we can generate the numerical ratings of different issuers from the market average.

Figure 2: Rating (issuer FC LTICR) deviation of CSPI Ratings based on the average of all CRAs as the benchmark



We use the arithmetic mean of the ratings designated by CSPI Ratings and other global CRAs (i.e., S&P, Moody's and Fitch) as a benchmark to calculate the deviation of CSPI Ratings' ratings (Figure 2). Based on our calculation, the mean deviation is 0.18, indicating that CSPI Ratings' ratings are mostly in line with the market consensus.

Rating Transitions

Rating transition matrix shows the rates of a given rating migrating to other rating categories. It illustrates the transition volatility and default risk of each rating category. The rating transition rates are computed via a comparison of the ratings of issuers at the beginning to the end of the assessment period (See Appendix for I for details on constructing the rating transition matrix).

Exhibit 1 provides the average one-year transition matrix of CSPI Ratings' long-term foreign currency issuer credit ratings for the year 2019, 2020, 2021 and 2022; Exhibit 2 provides the average two-year transition matrix of CSPI Ratings' long-term foreign currency issuer credit ratings for the year 2019 to 2020, 2020 to 2021, 2021 to 2022; Exhibit 3 provides the average three-year transition matrix of CSPI Ratings' long-term foreign currency issuer credit ratings for the year 2019 to 2021 and 2020 to 2022. The transition matrices are constructed at the rating modifier level. At the year end of 2022, 87% of CSPI Ratings' rated issuers maintained their long-term foreign currency issuer credit ratings over the assessment period.

Exhibit 1: Average one-year transition matrix (2019-2022): Issuer FC LTICR

From/to Credit Rating	AAA	AA+	AA	AA-	A+	A	A-	BBB+	BBB	BBB-	BB+	BB	BB-	B+	B	B-	CCC to CC	RS	D/SD	WR
AAA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AA+	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AA	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AA-	0.00	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A+	0.00	0.00	0.00	13.33	83.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A	0.00	0.00	0.00	0.00	3.57	96.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A-	0.00	0.00	0.00	0.00	0.00	8.33	83.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.33
BBB+	0.00	0.00	0.00	0.00	0.00	0.00	8.33	91.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BBB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	85.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.29
BBB-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	87.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.50	12.50
BB+	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	50.00	12.50	0.00	0.00	0.00	0.00	0.00	12.50	37.50
BB-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	50.00	0.00	50.00	0.00	0.00	0.00	0.00	0.00	0.00
B+	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.33	33.33	0.00	0.00	0.00	0.00	0.00	33.33
B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CCC to CC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
D/SD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

WR – Withdrawn
Source: CSPI Ratings

Exhibit 2: Average two-year transition matrix (2019-2022): Issuer FC LTICR

From/to Credit Rating	AAA	AA+	AA	AA-	A+	A	A-	BBB+	BBB	BBB-	BB+	BB	BB-	B+	B	B-	CCC to CC	RS	D/SD	WR
AAA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AA+	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AA	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AA-	0.00	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A+	0.00	0.00	0.00	22.22	72.22	5.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A-	0.00	0.00	0.00	0.00	0.00	20.00	60.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.00
BBB+	0.00	0.00	0.00	0.00	0.00	0.00	16.67	83.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BBB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	80.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.00
BBB-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	75.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	25.00	25.00
BB+	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.33	0.00	16.67	0.00	0.00	0.00	0.00	16.67	50.00
BB-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	00.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B+	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	50.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	50.00
B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CCC to CC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
D/SD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

WR – Withdrawn

Source: CSPI Ratings

Exhibit 3: Average three-year transition matrix (2019-2022): Issuer FC LTICR

From/to Credit Rating	AAA	AA+	AA	AA-	A+	A	A-	BBB+	BBB	BBB-	BB+	BB	BB-	B+	B	B-	CCC to CC	RS	D/SD	WR
AAA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AA+	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AA	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AA-	0.00	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A+	0.00	0.00	0.00	28.57	71.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
BBB+	0.00	0.00	0.00	0.00	0.00	0.00	50.00	50.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BBB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	66.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.33
BBB-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	50.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	50.00	50.00
BB+	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	25.00	0.00	0.00	0.00	0.00	0.00	25.00	75.00
BB-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B+	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CCC to CC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
D/SD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

WR – Withdrawn

Source: CSPI Ratings

Theoretically, the rating transition matrices show a good rating stability. However, the current statistical observation period is not long enough and the number of samples is very limited. In the future, with the increase of the observation period and sample number, the rating transition matrices will provide a more informative and conclusive indication of the rating stability and default risk.

Default Rates

Issuers with CSPI Ratings' outstanding credit rating experienced no defaults over the assessment period, while two issuers whose ratings had been withdrawn defaulted in July 2022. CSPI Ratings withdrew Shimao Property Holdings Limited's rating in March 2022 and Ronshine China Holdings Limited's rating in April 2022.

Conclusions

In this report, we compute statistics on the rating transitions and defaults of the issuers rated by CSPI Ratings from 2018 to 2022. During the assessment period, no defaults were observed for issuers with outstanding credit ratings from CSPI Ratings. Due to the relatively short assessment period and small sample size, it is difficult to reflect the relevant situation comprehensively and make statistically significant conclusion. We will take the same method for further research next year with extended rating samples.

Appendix I

Definition of Credit Rating Transition Matrix

The credit rating transition matrix is one of the test criteria for the stability of rating results. Rating stability refers to the degree to which credit ratings remain unchanged over a particular period. The credit rating transition matrix is the statistics of credit rating transition paths of the rating agency's rating objects within a particular time period, calculating transition rates of each rating category to form a transition matrix. It can measure the stability of the rating results by observing the transition of credit ratings from the beginning to the end of a time period.

The credit rating transition matrix is briefly described as follows: assume the credit rating of the rating object at the beginning of the period is i, and its credit rating at the end of the period is adjusted to j, then the credit rating transition rate of the rating object is P_{ij} and the following matrix is called the transition matrix.

$$P = \begin{pmatrix} P_{11} & P_{12} & P_{13} & \cdots \\ \vdots & \vdots & \vdots & \vdots \\ P_{i1} & P_{i2} & P_{i3} & \cdots \\ \vdots & \vdots & \vdots & \vdots \end{pmatrix} \quad P_{ij} \geq 0, \quad i, j = 1, 2, 3, \cdots$$

Obviously, $\sum_{j=1}^{\infty} P_{ij} = 1$, $i = 1, 2, 3, \ldots$

The Statistical Sample of the Credit Rating Transition Matrix

CSPI Ratings adopts the internationally prevailing static pool approach to estimate the transition matrix. The static pool approach can be understood from two aspects. Firstly, in terms of sample selection, it only examines the rating objects whose ratings are active and outstanding from the beginning to the end of the observation period. Secondly, when counting the ratings for each rating category, this approach only considers the ratings of the rating objects at the beginning and end of the period, and the trajectory of the ratings within the period are not considered.

Measurement and Estimation of Credit Rating Transition Matrix

Different measurements of credit rating transition matrix illustrate the properties and characteristics of the "rating transition" using different methods and from different perspectives. CSPI Ratings employs three different statistical methods to estimate three different measurements of credit rating transition matrix.

1. One-year transition matrix

The statistical method of the one-year transition matrix is called the cohort method, which is the most commonly used and basic method to calculate the credit rating transition matrix. The cohort method is to record credit ratings of all qualified obligors or obligations at the beginning of the year. For example, let $\mathrm{n_i}$ indicate that there are $\mathrm{n_i}$ rating objects with credit rating i at the beginning of year y and it will be compared with the credit records at the end of the year. If there are $\mathrm{n_{ij}}$ rating objects that are transited from rating i to rating j at the end of the year, the formula $\mathrm{P_{ij}} = \frac{\mathrm{n_{ij}}}{\mathrm{n_i}}$ calculates the transition rate from rating i to rating j during that period. The matrix created after the complete calculation of the transition rates of all migration paths with all rating levels at the beginning of the period is the one-year credit rating transition matrix, which is called the one-year transition matrix of year y. In this way, the transition matrix of other time spans can be obtained, such as the two-year transition matrix of year y and the five-year transition matrix of year y.

2. Average transition matrix

Taking the one-year average transition matrix as an example, the average transition matrix is obtained by the weighted average of one-year transition matrix for multiple years. For instance, let $\mathrm{P_1(i,j)}$ denote the transition rate from rating i to rating j of year $\mathrm{y_1}$ and $\mathrm{P_2(i,j)}$ denote the transition rate from rating i to rating j of year $\mathrm{y_2}$. $\mathrm{P_3(i,j)}, \mathrm{P_4(i,j)}, \ldots, \mathrm{P_k(i,j)}$ are the transition rates for year $\mathrm{y_3}$, $\mathrm{y_4}$, …, $\mathrm{y_k}$. $\overline{\mathrm{P}}_{\mathrm{ij}}$ denotes the average one-year transition rate from year $\mathrm{y_1}$ to year $\mathrm{y_k}$, which is calculated as

$$\overline{\mathrm{P}}_{\mathrm{ij}} = \mathrm{P_1(i,j)w_1(i)} + \mathrm{P_2(i,j)w_2(i)} + \cdots + \mathrm{P_k(i,j)w_k(i)},$$

where $w_1(i)$ is the weight of $p_1(i,j)$ and is calculated as follows:

$$w_1(i) = \frac{n_1(i)}{n_1(i) + n_2(i) + \cdots + n_k(i)}$$

where $n_1(i)$ denotes the number of rating objects with rating i at the beginning of the year y_1, $n_2(i)$ denotes the number of rating objects with rating i at the beginning of the year y_2 and so on.

Appendix II

Default rate indicators

The default rate indicators are built by various methods or defined from different perspectives, with an aim to describe the nature and characteristics of the number of defaults. We will start from introducing three rank-classified indicators that are of the most concerned in default studies.

1. Annual default rate

Annual default rate is usually associated with a specific sample and a time horizon, which refers to the annual default rate of different rating entities within the time horizon of the sample (usually 1 year).

Normally, the credit rating of a defaulting entity is its rating level at the beginning of the default year, i.e., as of January 1. For instance, the default rate of an AA rated entity in 2001 is the default rate of the rated entity whose rating is AA at the beginning of 2001.

2. Cumulative default rate

Cumulative default rate refers to the cumulative default rate of a sample over multiple years, which equals the total number of defaults during the period divided by the total number of the sample at the beginning of the time period. The rate is the accumulation of annual default rate in a particular time horizon (usually 2 years and above), and it is also targeted at a specific sample.

3. Average cumulative default rate

Average cumulative default rate refers to the average of the cumulative default rates of various time horizons and multiple sample groups. The time horizon of this indicator is usually 2 years and above, and it has a concept of multiple samples.

Appendix III

Default rate calculation

1. Cohorts

The calculation of most indicators is based on the concept of cohorts. Specifically, a cohort is formed on the basis of the rating held by the rated entity at the beginning of a certain year. Normally, a n(R, Y) denotes the size of the cohort composed of rating entities holding rating R at the beginning of Y year. For instance, a n(AA, 2001) denotes the size of the cohort of companies holding AA rating at the beginning of 2001.

2. Annual default rate

Annual default rate equals to the number of defaults from the cohort that occur in the cohort formation year divided by the total number of entities in the cohort. For a cohort holding rating R at the beginning of year Y, let d(R, Y) be the number of defaults of the cohort over the year Y, n(R, Y) denotes the size of the cohort, and D(R, Y) denotes the annual default rate of the cohort. Then D(R, Y) = d(R, Y) / n(R, Y).

3. Marginal default rate

Denote d(R, Y, t) as the number of defaults in the t-th year of the cohort formed at the beginning of year Y, n(R, Y, t) as the number of non-defaults of the cohort until the start of the t-th year, and the marginal default rate MD(R, Y, t) as the probability of a default in the t-th year of an entity that has no default record before the t-th year. Then the marginal default rate equals the number of defaults in the t-th year divided by the number of remaining non-defaults at the beginning of the t-th year, that is MD(R, Y, t) = d(R, Y, t) / n(R, Y, t).

4. Cumulative default rate

Denote $d(R,Y,t)$ as the number of defaults of the cohort in the t-th year after being rated. Then T-year cumulative default rate $CD(R,Y,T)$ equals the total number of defaults from the year of cohort formation up to the T-th year divided by the total number of rated entities of the cohort at the start of the period, that is:

$$CD(R,Y,T) = \sum_{t=1}^{T} d(R,Y,t)/n(R,Y)$$

which is

$$\mathrm{CD(R,Y,T)} = 1 - \prod_{t=1}^{T} [1 - MD(R,Y,t)]$$

Where $1 - MD(R,Y,t)$ denotes the marginal survival rate of the t-th year.

For instance, $d(AA,2001,1)$ denotes the number of defaults of the cohort in 2001 (same with $d(AA,2001)$), $d(AA,2001,2)$) denotes the number of defaults of the cohort in 2002, …, then $\sum_{t=1}^{5} d(AA,2001,t)$ is the cumulative number of defaults of the rated entities holding AA rating between 2001 and 2005. $CD(AA,2001,5)$ represents the cumulative default rate of the cohort from 2001 and 2005, which is a 5-year indicator.

When T = 1, the cumulative default rate equals the annual default rate.

5. Average marginal default rate

The indicators above all use the concept of a single cohort, that is, only one sample cohort is concerned. However, the average marginal default rate and the following average cumulative default rate use the concept of multiple cohorts and examine a set of cohorts. Those are weighted averages, which are weighted by the relative size of the cohort. The average marginal default rate aims at computing average cumulative default rate.

Denote $d(R,Y_0,t)$ as the number of defaults of the cohort formed at the beginning of year Y_0 in the t-th year, $d(R,Y_i,t)$ as the number defaults of the cohort formed at the beginning of year Y_i in the t-th year; denote $n(R,Y_0,t)$ as the number of non-defaults of the cohort formed at the beginning of Y_0 until the start of the t-th year, $n(R,Y_i,t)$ as the number of non-defaults of the cohort formed at the beginning of year Y_i until the start of the t-th year. The average marginal default rate $\overline{MD}(R,T,t)$ represents the weighted average default rates of the rated entities in i_t cohorts in the t-th year that have no default records before the t-th year, which can be calculated by

$$\overline{MD}(R,Y,t) = \frac{d(R,Y_0,t) + d(R,Y_1,t) + \cdots + d(R,Y_i,t)}{n(R,Y_0,t) + n(R,Y_1,t) + \cdots + n(R,Y_i,t)} = \sum_{Y=Y_0}^{Y_i} d(R,Y,t) \Big/ \sum_{Y=Y_0}^{Y_i} n(R,Y,t)$$

where the time span of samples is between the beginning of Y_0 and the beginning of Y_{i+t}, and there are total (i + t) years.

For instance, in order to calculate the average marginal default rate of the AA-level entities in the third year, the time span should be from the beginning of 2001 to the beginning of 2005 (or the end of 2004). The formula is as follows:

$$\overline{MD}(AA, 2001, 3) = \sum_{Y=2001}^{2003} d(AA, Y, 3) \,/\, \sum_{Y=2001}^{2003} n(AA, Y, 3)$$

The numerator of the RHS of the equation is a sum of three numbers, which are 1) the number of AA-level defaulting entities that are rated at the start of 2001 and default in 2003, 2) the number of AA-level defaulting entities that are rated at the start of 2002 and default in 2004 and 3) the number of AA-level defaulting entities that are rated in 2003 and default in 2005; the denominator is also a sum of three numbers, which are 1) the number of AA-level non-defaulting entities that are rated at the start of 2001 and have no default record until 2003, 2) the number of AA-level non-defaulting entities that are rated at the start of 2002 and have no default record until 2004 and 3) the number of AA-level non-defaulting entities that are rated in 2003 and have no default record until 2005.

6. Average cumulative default rate

Denote $\overline{CD}(R, Y, T)$as the T-year weighted average cumulative default rate. Then

$$\overline{CD}(R, Y, T) = 1 - \prod_{t=1}^{T} [1 - \overline{MD}(R, Y, t)]$$

Obviously, $\overline{CD}(R, Y, 1) = \overline{MD}(R, Y, 1)$, i.e., 1-year average cumulative default rate equals to 1-year average marginal default rate.

In this case, the sample time horizon is $(i_T + T)$ years, hence it also represents the T-year average cumulative default rate in $(i_T + T)$ years, where i_T denotes the number of cohorts used for computing the average marginal default rate of the T-th year.

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