RESEARCH ON RISK MANAGEMENT OF COMMERCIAL BANK CREDIT ASSET SECURITIZATION

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ABSTRACT. As an innovative financial instrument, credit asset securitization (CAS) plays a unique role in improving the structure and quality of commercial banks' assets and liabilities. This paper studies various risk indicators of CAS business by taking one product (HEZHI) of Y commercial bank as an example, and focuses on analyzing the current situation and existing problems of risk management of CAS. According to the research conclusion, the paper puts forward some improvement measures for risk management of Y commercial bank which aims to enrich the research on the risk management theory of commercial bank securitization of assets, diversifies the analysis perspectives, and provides reference for other commercial banks in their subsequent risk management of CAS.

1. INTRODUCTION

Asset securitization was introduced in the US in the 1970s, with the first launched in 1968 by the National Mortgage Backed Credit Association of the Americas. It quickly gained global attention, becoming a significant financial innovation. Asset securitization enhances profitability and liquidity for financial institutions, provides risk management tools, and diversifies financial markets. China officially launched its asset securitization business in 2005, with banks as the main issuers. Credit assets were entrusted to financial organizations (usually trust companies), which issued asset-backed securities to other financial institution investors in the domestic bond market.

Christine pointed out that asset securitization is a financial tool that enables borrowers and lenders to use this financial tool to achieve effective matching of capital [3]. Later, Fabozzi and Kothari defined asset securitization as a process of restructuring illiquid assets like credit, receivables, leases, and consumer loans into tradable securities with investment and exchange features. At the same time, he defined asset securitization as an interest bearing security [6]. Solomon noted that asset securitization is one of the most prominent financial tool in modern economies [13]. Scholars like Dionne and Cebenoyan believe that CAS enhances risk-bearing capacity to some extent.

Based on Canadian data from 1988 to 1998, research showed that commercial banks, under regulatory capital arbitrage, increasingly held high-risk assets while

securitizing lower-risk ones, thus raising their overall risk level [5]. Meanwhile, Cebenoyan and Strahan found that CAS provides banks with liquid funds, enhancing their liquidity and reducing investment and operational risks through diversified investments [1]. Purnanandam found that before the subprime crisis, some commercial banks' excessive participation in the credit and securitization (OTD) market led to lower mortgage credit quality [11]. Later, Nadauld and Sherlund showed that investment banks allowing only high-quality assets into the asset pool effectively transferred low-risk assets out, leaving high-risk assets in banks and increasing their risk exposure [10].

The 2008 US subprime mortgage crisis triggered a global financial crisis and temporarily halted China's CAS experiments. In recent years, as relevant systems have been established and improved, market access barriers have lowered and regulatory policies have eased. China's CAS has evolved from an initial stage to rapid expansion and now high-speed development. Driven by the filing system, the industry has scaled up significantly, with a rapid increase in participating entities, demonstrating strong vitality in the new financial ecosystem. In 2015, the People's Bank of China introduced the registration and issuance system for CAS, marking a qualitative leap from the filing system. The securitization of non-performing assets by commercial banks resumed in 2016. The 2020 Securities Law expanded the definition of securities and established a unified regulatory framework, providing legislative support for asset securitization ([2,4,7–9,12,14]). To help Chinese commercial banks better leverage asset securitization, it is meaningful to explore methods to activate funds and improve operational efficiency through asset securitization.

2. IDENTIFICATION OF CAS RISKS IN Y COMMERCIAL BANK

The asset securitization process of Chinese commercial banks is relatively short, with a lack of theoretical and practical experience. In addition, the complexity of business operations leads to many risks in the product issuance process. It is necessary to systematically analyze the various risks arising from CAS business, and find ways to reduce risks, which is important for the sustainable development of China's banking industry.

(1) Source Analysis of CAS Risk in Y Commercial Bank.

Due to differences in national conditions, regions, and policies, the impact of commercial bank CAS in China is also vastly different, and risks are presented in unique forms. Usually classified by nature, the sources of risk affecting the securitization of commercial bank credit assets can be divided into Table 1.

(2) Risk Identification of CAS in Y Commercial Bank.

Due to the scattered and unsystematic collection of external information, it is impractical to fully identify risks, and not all methods of identifying risks are universally applicable. Therefore, in order to comprehensively and effectively identify the risks faced by commercial banks, it is necessary to combine certain professional methods based on their own characteristics.

For commercial banks, there are many complex sources of risk that affect the CAS. Therefore, before conducting risk management, we conduct qualitative and quantitative identification and analysis of related risks to determine risk management strategies.

Table 1 Classification of Risk Sources Affecting Commercial Bank CAS

Source of Risk	Risk content
credit risks	The debt incurred due to the borrower's own poor management and other reasons, mainly including the loss of principal and interest, as well as the interruption of cash flow, is the most common form of financial risk.
market risk	Some risks caused by the external environment. Early repayment of loan projects in the asset pool by debtors can lead to early repayment risks, as well as the risk of interest rate fluctuations due to loans in the asset pool.
operational risk	The risk of unexpected losses due to deficiencies in information systems or internal controls. Operational risks are often caused by human factors and cannot be completely eliminated. Their risks are mainly caused by internal operational processes, personnel, systems, or external events.

source: analysis of annual reports

Table 2 The risk composition of Y Commercial Bank's CAS

First level indicator	Secondary indicators	Third level indicators
Commercial bank CAS risk	External environmental risks	Political environment risk
		Economic environment risk
		Legal environment risk
	Subject credit risk	Debtor credit risk
		Initiator's credit risk
		Third party credit risk
	Technical operation risk	Risk of asset pool construction
		Bankruptcy isolation risk
		Credit enhancement risk
		Product pricing risk

source: analysis of annual reports

The Analytic Hierarchy Process (AHP) can evaluate various risks and their magnitude in the very process.

(1) Establish a hierarchical structure model. In the process of commercial bank CAS, the main risks can be divided into three categories: subject credit risk, external environmental risk, and technical operation risk. The composition of risks has been further clarified and optimized, presented as a three-level risk system (Table 2).

(2) Construct a comparative judgment matrix. Establish a judgment matrix according to the above method, using W1, W2, W3 to represent external environmental risk, subject credit risk, and technical operation risk in sequence; X1, X2, X3 represent economic environment risks, legal environment risks, and political environment risks; Use Y1, Y2, Y3 to represent the credit risk of the debtor, the credit risk of the initiator, and the credit risk of third-party enterprises; Use Z1, Z2, Z3, Z4 to represent the operational risks of asset pool construction, bankruptcy isolation, credit enhancement, and product pricing. The data in the judgment matrix is a nine level tabular data obtained through a questionnaire survey conducted by relevant research experts and scholars.

Comparative judgment matrix for the risk of commercial bank CAS:

$$W = \begin{bmatrix} 1.000 & 2.8044 & 2.9496 \\ 0.3566 & 1.000 & 1.5619 \\ 0.3390 & 0.6402 & 1.000 \end{bmatrix}.$$

Table 3 Weight of risk assessment indicators

Indicator level risk	Risk weight	Sub indicator risk	Risk weight(%)
External environmental risks(W1)	27.44%	Political environment risk	9.63
		Economic environment risk	8.99
		Legal environment risk	8.82
Subject credit risk (W2)	41.32%	Debtor credit risk	17.08
		Initiator's credit risk	11.75
		Third party credit risk	12.49
Technical operation risk (W3)	31.24%	Risk of asset pool construction	8.43
		Bankruptcy isolation risk	7.84
		Credit enhancement risk	8.07
		Product pricing risk	6.89

source: author's calculation based on analytic hierarchy process

Table 4 Consistency test CR value

P-M (First level indicator judgment judgment matrix and weights)	M1-Ai (Credit risk assessment matrix and weights)	M2-Bi (Technical risk assessment matrix and weights)	M3-Ci (Environmental risk assessment matrix and weights)
0.046	0.081	0.003	0.025

Comparative judgment matrix for environmental risks:

$$X = \begin{bmatrix} 1.000 & 1.2535 & 1.2711 \\ 0.7978 & 1.000 & 1.0765 \\ 0.7867 & 0.9289 & 1.000 \end{bmatrix}.$$

Comparative judgment matrix of credit risk:

$$Y = \begin{bmatrix} 1.000 & 2.8085 & 2.8241 \\ 0.3561 & 1.000 & 0.8055 \\ 0.3541 & 1.2415 & 1.000 \end{bmatrix}.$$

Comparative judgment matrix of technical risks:

$$Z = \begin{bmatrix} 1.0000 & 1.4000 & 1.4911 & 1.9122 \\ 0.7143 & 1.0000 & 0.9709 & 1.6635 \\ 0.6707 & 1.0205 & 1.0000 & 2.1940 \\ 0.5230 & 0.6011 & 0.4580 & 1.0000 \end{bmatrix}.$$

Calculate the geometric mean of all elements in each row of the judgment matrix: $\overline{w}_i = \sqrt[n]{\prod a_{ij}}, i = 1, 2, \ldots, n$, we get $\overline{w} = (w_1, w_2, \ldots, w_n)^T$, it is the weight ratio of each major factor. The weight relationship between the sub indicator layer and the target layer can be calculated from Table 3.

(3) Model consistency test. When conducting consistency checks, we need to find CI (consistency index), RI (random index), then CR (consistency ratio) values can be obtained. In general, consistency with the current judgment matrix is only confirmed when $CR < 0.1$; If $CR > 0.1$, it means that the determined matrix does not have statistical consistency and the model must be recalibrated. The specific detection steps are as follows:

Firstly, calculate $CI = \frac{\lambda_{max} - n}{n-1}$.

Then, by distinguishing the different orders of the matrix, the corresponding RI (average random consistency index value) is queried using external data.

Again, from $CR = \frac{CI}{RI}$, we get the test coefficient CR. (Table 4)

Table 5 Ranking of CAS Risks in Chinese Commercial Banks

Serial number	Source of Risk	Proportion(%)	Nature of risk	
1	Debtor credit risk	17.08	Subject credit risk	Non systematic risk
2	Third party credit risk	12.49	Subject credit risk	Non systematic risk
3	Initiator's credit risk	11.75	Subject credit risk	Non systematic risk
4	Economic environment risk	9.63	External environmental risks	system risk
5	Legal environment risk	8.99	External environmental risks	system risk
6	Political environment risk	8.82	External environmental risks	system risk
7	Risk of asset pool construction	8.43	External environmental risks	Non systematic risk
8	Credit enhancement risk	8.07	Technical operation risk	Non systematic risk
9	Bankruptcy isolation risk	7.84	Technical operation risk	Non systematic risk
10	Product pricing risk	6.89	Technical operation risk	Non systematic risk
total		100		

source: author's calculation based on analytic hierarchy process

According to the above table, it can be found that if the CR values corresponding to each risk index are all below 0.1, that is, the model passes the consistency test, it indicates that the evaluation matrix is acceptable and feasible.

(4)Hierarchical sorting and analysis. According to the above calculation results, the risk indicators are sorted according to their proportion percentage, as shown in Table 5.

From the results in Table 5, it can be seen that among all the economic risk sources that directly affect CAS, the main credit risk accounts for 41.32% of the overall risk. Among the main credit risk, the debtor credit risk accounts for the largest proportion (17.08%), while third-party credit risk (12.49%) and initiator credit risk (11.75%) account for the same proportion; Then ranked second is technical operational risk, accounting for 31.24%. Among technical risks, asset pool construction risk (8.43%) has the largest proportion, followed closely by credit enhancement risk (8.07%), and product pricing risk (6.89%) has the smallest proportion; Finally, external environmental risk, as a systemic risk, accounts for only 27.44% of the overall risk, with economic environmental risk (9.63%) dominating, while legal environmental risk (8.99%) and political environmental risk (8.82%) are on par. Based on the analysis of its specific risk nature, the top ranked non systematic risk factors indicate that it is entirely possible to reduce these risks through manual intervention. And systemic risk is also a significant proportion of various risk sources that directly affect the asset securitization of commercial banks, and this risk must be macroeconomic regulated at the national level, so its controllability is relatively poor. It is worth noting that there is no significant difference in the risk weights of the four non systematic risks under technical operational risk and the three systematic risks under external environmental risk. This also means that a sound technical risk management system will effectively enhance the effectiveness of commercial bank CAS mechanisms.

3. Measurement and evaluation of CAS risk in Y commercial bank

Based on the results of risk identification in the previous section, this chapter will take Y Bank's HEZHI as an example, use fuzzy clustering and fuzzy comprehensive evaluation models to measure and evaluate the credit risk management and effectively study the risk of Y Commercial Bank's CAS.

This section mainly sets key indicator warnings for the risk influencing factors of Y Commercial Bank's HEZHI, then uses fuzzy clustering to measure the risk

Table 6 The Stage Influencing Factors of Credit Asset Securitization Risk in Y Commercial Bank

Evaluation object	Management phase	Risk category	Influence factor
Commercial bank credit asset securitization risk	Basic assets	Basic asset quality	Outstanding principal balance
			Weighted average remaining term
			Weighted average loan annual interest rate
			Weighted average annual income
			Weighted average income to debt ratio
			Weighted average aging
			Debt default rate
		Early repayment rate of underlying assets	Income level
			interest rate
			Capital market rate of return
	The securitization process	Credit enhancement measures	Internal credit enhancement measures
			External credit enhancement measures
		Securities payment method	Fixed amortization
			Hand over and repay
		Transaction structure risk	Real sales process
			hierarchical design
			Cash flow distribution mechanism
			Loan collateral risk
			Ownership of Mortgage Property
		Selection of service agencies	Own asset size
			Experience in participating in credit asset securitization

of several key indicators of comparable objects, and finally evaluates the risk of Y Commercial Bank's CAS through fuzzy comprehensive evaluation.

3.1. **Key indicator warning.** The most important aspect of risk management, especially credit risk management, is the design of the risk indicator system and the reasonable quantification process of the indicators. Thus, this section collects and summarizes the relevant information of Y Commercial Bank's HEZHI, and uses qualitative analysis methods to select the influencing factors of CAS risk from credit risk, market risk, and operational risk.

As shown in Table 6, the risk of Y Commercial Bank's CAS is divided into two management stages: basic assets and asset securitization process. Among them, the risk in the basic asset management stage is mainly affected by the quality of the basic assets and the early repayment rate of the basic assets, involving a total of 10 influencing factors; The risks in the management stage of asset securitization process are mainly influenced by credit enhancement measures, securities payment methods, transaction structure risks, and the choice of service institutions, involving 11 types of risk factors.

Based on the existing risk factors and the specific situation of Y Commercial Bank's CAS, we can set the normal range values for each risk influencing factor.

Due to the differences in actual situations among commercial banks, the level value range for identifying CAS risks in commercial banks is also different. If fixed standards or risk interval measures are used to identify securitization risks, the objectivity of the identification results can easily be questioned. Therefore, the risk range for setting specific risk warning factors for commercial bank CAS must be combined with the actual situation of the local economy and society.

In order to better identify, evaluate, and control risks, this paper uses factor analysis to analyze the risk indicator system of Y Commercial Bank's CAS.

Factor analysis is the main analytical method of multivariate statistical analysis, which has been widely used in disciplines such as society, management, geology, and economics. It extracts a few comprehensive variable indicators from a large number of variable indicators on the premise of integrating multiple indicators, and refers to the transformed comprehensive indicators as principal components. Among them, all the main comprehensive indicators are linear combinations of the original variables, and there is no correlation between each element, thus highlighting the superior function of the main comprehensive indicators. Factor analysis is a commonly used empirical analysis method that explains the most observed facts with the least number of factors. Variables have obvious interpretability and can maximize the role of professional analysis.

Based on the analysis results of principal components, the weights of each principal component will be generated. The advantage of this is that on the one hand, it reduces the workload, and on the other hand, it reduces the interference of human factors in the evaluation process, achieving the goal of dimensionality reduction and revealing the essence of things. It is a method with the least information loss.

This paper analyzes through the steps of factor analysis:

(1) Obtain initial data and standardize it to eliminate the influence of dimensionality;

(2) Calculate the standardized correlation matrix of each indicator factor;

(3) Calculate the eigenvalues and cumulative contribution rate, and determine the principal components;

(4) Calculate the variance contribution rate of principal components;

(5) Perform comprehensive evaluation based on the variance contribution rate of each principal component as weights.

Credit risk is the most common risk in the field of financial markets. Based on the previous results, credit risk is currently the main risk for commercial investment banks in China. The management and effectiveness of credit risk will directly affect the operational performance of Chinese commercial banks and seriously affect the stability of the overall financial service system in China. Credit risk is often associated with losses, or in other words, credit risk may lead to losses. Credit risk can be understood from two aspects: firstly, for an event in credit activities, there is both the possibility of loss and the possibility of gain. Secondly, credit risk refers only to a potential possibility or an uncertain future transaction. The CAS business of commercial banks has begun to take off. As an emerging business direction, it is not well understood in the market, and its own product characteristics further increase the difficulty of credit risk identification for its CAS products. This is also a common and urgent problem faced by numerous financial entities, investors, and consumers, which affects the macro decision-making of national governments, the development of the economy and society, and even the stability of the world economy. Being able to effectively identify credit risks has a significant positive effect on rapid and effective risk warning.

Based on this understanding, in order to better identify risks, especially credit risk, which plays a key role, this paper extracts common factors through factor

Table 7 Credit Rating Comparison Table

Product Name		Sales amount (Ten thousand yuan)	Proportion of Amount(%)	Coupon rate	Credit rating
SuYuan	Priority A	150,500.00	70.3	Floating interest rate	AAA
	Priority B	34,200.00	15.97	Floating interest rate	A
	Next level	29,390.00	13.73		Not rated
HEZHI	Priority A1	300,000.00	31.01	Fixed interest rate	AAA
	Priority A2	433,000.00	44.76	Fixed interest rate	AAA
	Priority B	54,500.00	5.63	Fixed interest rate	AA
	Priority C	48,600.00	5.02	Fixed interest rate	A
	Next level	131,320.00	13.57	No coupon rate	Not rated
Yang Guang	Priority A	258,000.00	85.78	Fixed interest rate	AAA
	Priority B	13,500.00	4.49	Fixed interest rate	AA
	Next level	29,278.31	9.73		Not rated

moderation test and factor extraction effect analysis, extracts evaluation indicators, and constructs a credit risk indicator system. The final results show that the main factors affecting credit risk include weighted average aging, weighted average remaining years, current year non-performing loan ratio, outstanding principal balance, and single outstanding principal balance. Therefore, this paper selected the five key indicators that can reflect the credit risk of Y Commercial Bank's CAS, and through literature research, expert interviews, and existing data research, while referring to existing warning standards, set the values of each risk interval of the identification indicators within the range of 20% of the upper and lower limits of the safe interval.

Based on the problems and corresponding data of risk management in Y Commercial Bank's CAS, we have found that some key data have exceeded this risk range and reached the warning level.

3.2. **Fuzzy clustering risk measurement.** Credit risk, as one of the most important risks in credit securitization, has such a significant impact to measure risk more accurately, this section applies a mathematical model of fuzzy clustering. Several comparable objects will be selected to establish a model library, and cluster analysis will be conducted on key risk indicators relative to other typical comparison objects in the model library. Finally, the measurement conclusion of Y Commercial Bank's HEZHI credit risk will be effectively obtained.

1. Determine the comparison object

For the convenience of comparison, this paper selects risk assessments made by the same risk rating agency to establish a model library. Based on the risk rating of China Bond Credit Rating, this paper selected the SuYuan series with lower credit ratings, as well as the YangGuang Building Model Library and HEZHI with higher credit ratings for clustering measurement.

From Table 7, it can be seen that SuYuan's coupon rate adopts a floating rate. Compared to fixed rates, floating rates are more affected by market uncertainties, so the risk is relatively high; Suyuan's credit rating for Priority A is AAA, while its credit rating for B is only A, and its credit rating for Secondary A is not rated. Therefore, from the perspective of credit rating, Suyuan's credit rating is relatively low; In terms of the proportion of the amount, the sum of the sales amount of the priority B tier and the secondary tier accounts for as high as 30%, and the proportion of the sales amount of the secondary tier exceeds 10%. From the above indicators,

Table 8 Comparison Table of Key Indicators

Related indicators \Product name	HEZHI	YangGuang	SuYuan
Weighted average aging(month)	5.86	3.7	6.37
Weighted average remaining years(month)	11	8.3	18.23
The non-performing loan ratio at that time(%)	1.07	1.59	1.43
Outstanding principal balance(RMB100mn)	88.37	30.08	21.41
Single outstanding principal balance(RMB100mn)	1.54	1.29	0.76

it can be seen that SuYuan's overall risk is relatively high. The total sales scale of YangGuang is only 3007.78 million yuan, while the total sales scale of HEZHI is as high as 9674.2 million yuan. Although the total sales scale of YangGuang is less than one-third of HEZHI, the proportion of YangGuang's priority A amount is as high as 85.78%, higher than HEZHI's 75.76%. At the same time, its secondary amount proportion is only 9.73%, lower than HEZHI's 13.57%. From the perspective of priority and secondary proportion, YangGuang has a certain comparative advantage over HEZHI. From the perspective of risk retention ratio, general credit ABS issuing institutions only require the lowest level of self holding scale to be 5% of their own scale. Therefore, SuYuan's self holding scale is 40.3525 million yuan, HEZHI's self holding scale is 65.66 million yuan, and YangGuang's self holding scale is 28.4878 million yuan. From the perspective of self holding scale, HEZHI has the largest self holding scale and higher self retention risk, while YangGuang's self holding scale is the smallest and lower risk.

After determining the key risk identification indicators, cluster analysis can be conducted on these three comparison objects from these five aspects(See Table 8).

Among them, these five key indicators are all related to the underlying assets of the asset pool, and the credit risk of the underlying assets is directly related to the borrower. Specifically, weighted average aging refers to the weighted average period from the value date to the initial date of each loan. Generally, the longer the weighted average aging, the lower the overall default rate of the asset pool, because the loan has a certain normal credit performance, and the borrower's default probability will also decrease as the final repayment period approaches; The weighted residual term represents the overall risk exposure time, and the higher the weighted average term, the higher the default rate; The non-performing loan ratio represents the proportion of non-performing loans in the current year, and the higher the non-performing loan ratio, the greater the risk of default; The outstanding principal balance, as the name suggests, refers to the remaining principal in the loan principal except for the repaid principal. The larger the outstanding principal balance, the greater the uncertainty and risk; The outstanding principal balance of a single transaction is calculated by averaging the outstanding principal balance over each transaction. If there are more transactions, the average outstanding principal balance per transaction will be smaller, and the uncertainty will be relatively smaller. As a result, the risk of a single outstanding debt will be smaller. Conversely, if there are more transactions, the risk of a single outstanding debt will be higher. It is not difficult to see that these five key indicators can reflect the magnitude of risk to a certain extent.

2. Fuzzy clustering

After establishing a comparison table of key indicators related to SuYuan, Yang-Guang, and HEZHI, a data matrix was created as follows:

(1) Data matrix (where the rows represent HEZHI, YangGuang, and SuYuan respectively, and the columns represent the corresponding weighted average aging (months), weighted average remaining years (months), non-performing loan ratio (%), outstanding principal balance (RMB 100 million), and single outstanding principal balance (RMB 100 million) of the three objects.)

$$\begin{bmatrix} 5.86 & 11 & 1.07 & 88.37 & 1.54 \\ 3.7 & 8.3 & 1.59 & 30.08 & 1.29 \\ 6.37 & 18.23 & 1.43 & 21.41 & 0.76 \end{bmatrix}.$$

(2) Data standardization

In data matrix problems, different data generally have different quantities of steel. In order to compare quantities with different quantities of steel, it is usually necessary to perform appropriate transformations on the data. However, even so, the obtained data may not necessarily fall within the interval [0,1]. Therefore, the data standardization referred to here is to compress the data into the interval [0,1] according to the requirements of the fuzzy matrix. This paper uses the following commonly used translation standard deviation transformation formula for transformation:

$$\chi'_{ik} = \frac{\chi_{ik} - \overline{\chi_k}}{S_k}, i = 1, \ldots, n, k = 1, \ldots, m, \text{ Here } \overline{\chi_k} = \frac{1}{n} \sum \chi_{ik},$$

$$S_k = \sqrt{\frac{1}{n} \sum (\chi_{ik} - \overline{\chi_k})^2},$$

we obtain $\overline{\chi_1} = 5.31, \overline{\chi_2} = 12.51, \overline{\chi_3} = 1.36, \overline{\chi_4} = 46.62, \overline{\chi_5} = 1.2,$

$$S_1 = 1.16, S_2 = 4.19, S_3 = 0.21, S_4 = 29.73, S_5 = 0.33.$$

After transformation, the mean of each variable is 0, the standard deviation is 1, and the influence of dimensionality is eliminated. However, what is obtained in this way may not necessarily fall within the interval [0,1].

For transformation matrices:

$$\begin{bmatrix} 0.47 & -0.36 & -1.38 & 1.40 & 1.03 \\ -1.39 & -1.00 & 1.10 & -0.56 & 0.27 \\ 0.91 & 1.37 & 0.33 & -0.85 & -1.33 \end{bmatrix}.$$

Using translation range transformation:

$$\chi''_{ik} = \frac{\chi'_{ik} - min\chi'_{ik}}{max\chi'_{ik} - min\chi'_{ik}}, 1 \leq i \leq n.$$

Further compress χ''_{ik} to interval [0,1] and eliminate the influence of quantity. The modified data matrix obtained from this is as follows:

$$\begin{bmatrix} 0.81 & 0.57 & 0 & 1 & 1 \\ 0 & 0 & 1 & 0.13 & 0.68 \\ 1 & 1 & 0.69 & 0 & 0 \end{bmatrix}.$$

(3) Calibration: Furthermore, establish a fuzzy similarity matrix. According to the maximum minimum method, the following results are obtained:

$$r_{11} = r_{22} = r_{33} = 1, r_{12} = r_{21} = 0.18, r_{13} = r_{31} = 0.29, r_{23} = r_{32} = 0.18.$$

(4) By using the transitive closure method, the following fuzzy equivalent matrix is obtained:

$$\begin{bmatrix} 1 & 0.18 & 0.29 \\ 0.18 & 1 & 0.18 \\ 0.29 & 0.18 & 1 \end{bmatrix}.$$

(5) Set different thresholds for clustering:

a. When $\lambda = 1$, three products are each in the same category, no recognition result can be obtained;

b. When $\lambda = 0.29$, the corresponding clustering matrix is

$$\begin{bmatrix} 1 & 0 & 1 \\ 0 & 1 & 0 \\ 1 & 0 & 1 \end{bmatrix}.$$

The risk quantification level of HEZHI is $\lambda = 0.18$, and it belongs to the same category as SuYuan.

Based on the above results, it can be concluded that HEZHI and SuYuan are at the same risk level, with a credit risk of 0.18, which is relatively high.

3.3. **Fuzzy comprehensive risk assessment.** Based on the previous AHP risk warning identification and fuzzy clustering credit risk measurement quantification model results, in order to comprehensively evaluate the risk of HEZHI, this section further selects the fuzzy comprehensive evaluation method for corresponding risk assessment.

(1) Select factor set and evaluation set. Construct factor set U=u1, u2, u3, u4, u5, u6, u7, u8, u9, u10. Among them, u1: the credit risk of the debtor; u2: Third party credit risk; u3: Credit risk of the initiator; u4: Economic and environmental risks; u5: Legal environment risk; u6: Political environment risk; u7: Risk of asset pool construction; u8: Credit enhancement risk; u9: Bankruptcy isolation business risk; u10: Pricing risk of company products. Simultaneously construct the evaluation set V=v1, v2, v3. Among them, v1: high risk, v2: medium risk, v3: low risk.

(2) Construct an evaluation matrix. Single factor evaluation, based on expert scoring method to evaluate various risks, if only the credit risk of the debtor, if 10% of experts think that this risk has a significant impact on asset securitization risk, 10% of experts think that the risk is average, and 90% of experts think that the risk is small, then we can obtain $u1 \rightarrow (0.1, 0.1, 0.9)$.

Similarly, by evaluating other factors as a single factor, a fuzzy mapping from U to V is obtained, that is $u1 \rightarrow (0.8, 0.1, 0.1)$, $u2 \rightarrow (0.4, 0.4, 0.2)$, $u3 \rightarrow (0.4, 0.3, 0.3)$, $u4 \rightarrow (0.5, 0.3, 0.2)$, $u5 \rightarrow (0.3, 0.3, 0.4)$, $u6 \rightarrow (0.5, 0.3, 0.2)$, $u7 \rightarrow (0.6, 0.2, 0.2)$, $u8 \rightarrow (0.7, 0.2, 0.1)$, $u9 \rightarrow (0.6, 0.3, 0.1)$, $u10 \rightarrow (0.5, 0.3, 0.2)$.

From the above single factor evaluation relationship, the fuzzy relationship Rf=R can be induced, and the evaluation matrix can be obtained

$$R = \begin{bmatrix} 0.8 & 0.1 & 0.1 \\ 0.4 & 0.4 & 0.2 \\ 0.4 & 0.3 & 0.3 \\ 0.5 & 0.3 & 0.2 \\ 0.3 & 0.3 & 0.4 \\ 0.5 & 0.3 & 0.2 \\ 0.6 & 0.2 & 0.2 \\ 0.7 & 0.2 & 0.1 \\ 0.6 & 0.3 & 0.1 \\ 0.5 & 0.3 & 0.2 \end{bmatrix}.$$

(3)Comprehensive evaluation. Construct a weight vector based on the risk of each factor in AHP, multiply it with the single factor evaluation matrix, and obtain the following result.

$$A = \begin{bmatrix} 0.1708 & 0.1249 & 0.1175 & 0.0963 & 0.0899 & 0.0888 & 0.0843 & 0.0807 & 0.0784 & 0.0689 \end{bmatrix}.$$

Then $B = A \circ R = (0.1708, 0.1249, 0.1249)$.

According to the principle of maximum membership degree, the comprehensive risk evaluation value of HEZHI is v1: high risk level.

Based on comprehensive analysis, the overall risk of HEZHI is relatively high. Considering the weighted average remaining years, the overall risk exposure time of HEZHI is relatively long, and the risk uncertainty, the borrower default rate, and the overall default rate of the asset pool are high. The default rate of borrowers and the overall default rate of asset pools should not be underestimated, and it is necessary to continue to strengthen credit management of borrowers and enhance control over default rates. Especially with a lower weighted average income ratio, it exposes the borrower's low credit level, which may not guarantee timely repayment. Although asset securitization has great potential for development in China, the various risk issues faced by HEZHI cannot be ignored due to the impact of the pandemic in recent years. From the analysis of key indicators, it can be seen that only with the intervention of measures related to HEZHI can risks be controlled.

This section mainly conducts an in-depth analysis of the impact and risk factors of asset securitization, and uses the Analytic Hierarchy Process to conduct detailed calculations of various refined risk indicators. By using fuzzy clustering method and fuzzy comprehensive evaluation method to effectively measure and evaluate the credit risk of entities in the process of asset securitization, reasonable conclusions are obtained based on reasoning and evidence. In summary, given that China is still in the early stages of CAS development and commercial banks generally lack theoretical knowledge and practical experience, it is necessary to use appropriate modeling methods to measure and analyze risk indicators, and strive to minimize operational risks. Based on the characteristics of risks and considering both systemic and non systemic factors, further refine the potential risks in CAS and control them in a targeted manner.

4. Risk control measures for CAS of Y commercial bank

The securitization of credit assets is a double-edged sword. Its innovation brings liquidity as well as many unpredictable risks. With the impact of the COVID-19, the risks arising from the securitization of credit assets cannot be ignored. Therefore, we should take this as a warning and strengthen the management of CAS risks.

Risk control measures mainly come from two aspects. The first aspect mainly proposes risk control measures from the perspective of Y commercial bank's underlying assets. The aspect mainly proposes risk control measures during the securitization process of Y commercial bank. Based on the previous results in last chapter, we can propose targeted improvement measures from the sources and weights of risks.

For the Risk Control Measures for Basic Assets of Y Commercial Bank, we can take the following measures:

1. Enrich the types of underlying assets. From the details of the securitization products provided by Y Commercial Bank, the underlying assets mainly involve housing mortgage loans, vehicle loans, loans, personal unsecured loans, and non-performing loans.

2. Strengthen the management of credit risk in basic assets. To manage the credit risk of the underlying assets, Y Commercial Bank can build a sound risk management system within the bank and establish a comprehensive credit risk control system to promptly mitigate any incurred credit risks, and asset-backed securities can adopt a structured product design, which specifically includes both senior asset-backed securities subordinated asset-backed securities. To some extent, this internal enhancement measure reduces the overall credit risk of the asset-backed securities.

3. Strengthen the response to transaction structure risks and continuous purchase structure risks. The HEZHI of Y Commercial Bank can set up some early termination management mechanisms for continued purchases in the transaction structure Meanwhile, in order to limit the operational risks in the continuous purchasing process, the relevant transaction documents should also specify in detail the operational procedures of continuous purchasing, as the responsibilities of each participant, to ensure that all parties involved in the continued purchase and hold can strictly adhere to the agreement.

For the Risk Control Measures in the Securitization Process of Y Commercial Bank, we can take the following measures:

1. Appropriately change the risk retention method. In HEZHI, Commercial Bank Y plans to hold no less than 5% of the total issuance size of asset-backed securities, and its holdings of each tranche of asset-backed securities cannot be less than 5% of the total issuance size, with a total issuance size of 96.42 million yuan, and a total self-retained risk amount of 483.8 million yuan, bearing a large risk. If the vertical mode is chosen, only 5% of the lowest tranche needs to be held. The holding amount of the subordinated tranche of HEZHI is 131.32 million yuan, which means only 6.566 million yuan needs to be reserved. Compared to the previously retained amount of483.8 million yuan, this is a reduction of nearly 90%. This not only reduces the risk but also greatly releases the capital.

2. Establish strict auditing principles for entrusted and cooperative institutions. For Y commercial banks, they can participate in transactions with securities companies according to simplified approval procedures and efficient approval efficiency. Therefore, Y commercial banks to set up two types of institutions: one is a cooperative institution, and the other is a trustee institution.

3. Strengthen the CAS system and supporting system construction of Y Commercial Bank. In order to promote the healthy development of CAS and control the operating risks in the process of credit asset securit, Y commercial bank must do a good job in the following areas: First, improve the system, second, enrich financial tools, third, standardized operations, and, institutional arrangements can be made in terms of product design, transaction business structure design, basic asset risk management, and risk retention.

5. Conclusion

This paper takes Y Commercial Bank's CAS business as the research object, with asset restructuring, risk isolation, and credit enhancement as the theoretical basis. Through a review of relevant research, it analyzes the current situation and existing problems of the bank's CAS risk management, identifies, measures, and evaluates its CAS risks, and proposes risk control measures for Y Commercial Bank's CAS.

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