

Financial Crisis Prediction in Chinese Real Estate Industry from Cash Flow Perspective Based on Machine Learning

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ABSTRACT

This paper aims to establish a financial crisis prediction model in real estate industry. The data was acquired from financial statements of 125 listed real estate companies in China from 2013 to 2017 and listed companies marked with ST or ST* are regarded as enterprises in financial crisis. Since the financial crisis of Chinese real estate enterprises is mostly due to the rupture of cash flow chain and inability to repay debts, as a result, 18 features are selected from four dimensions of operational risk, investment risk, financing risk and capital chain risk based on cash flow perspective. This paper imputes the missing values by K-nearest Neighbor (KNN) imputation method and oversampling for imbalanced dataset using Synthetic Minority Oversampling Technique (SMOTE) method. After that, Light Gradient Boosting Machine (LightGBM) algorithm is used to establish financial crisis prediction model, and the accuracy of the model reached 96%. To illustrate the key factors, this paper ranks the importance of each feature by LightGBM classifier, it can be concluded that the financing risk is very important for enterprises into financial crisis and the project investment in the real estate industry should be treated with more caution. This paper innovatively uses method of machine learning to establish financial crisis prediction model for the real estate industry by cash flow features, which is more in line with the actual situation of the real estate industry.

Keywords: Chinese real estate, Financial crisis, Machine learning

1. INTRODUCTION

The real estate industry is a pillar industry in China. According to National Bureau of Statistics of China, residential real estate investment accounted for 10.6% of China's GDP in 2020, that was up 7.06% from a year earlier.

From Figure 1, several key points for the transformation of Chinese real estate industry can be concluded. In 1980, urban land use fees began to be levied, which symbolizes the beginning of China's real estate industry. In 1998, China's commercial housing market supply system was established and the welfare housing distribution system was withdrawn, marking the official start of China's real estate market reform [1]. From 2004 to 2013, the government introduced many preferential policies to effectively promote the development of the real estate industry. These include the most famous "four trillion yuan plan", which made real estate extremely popular during this decade. After 2013,

the government began to implement a series of policies to regulate the real estate industry to restrain the excessively high housing price and reduce the risks brought by the real estate bubble. However, the government's measures have had no obvious effect and the real estate industry has continued to grow [2].

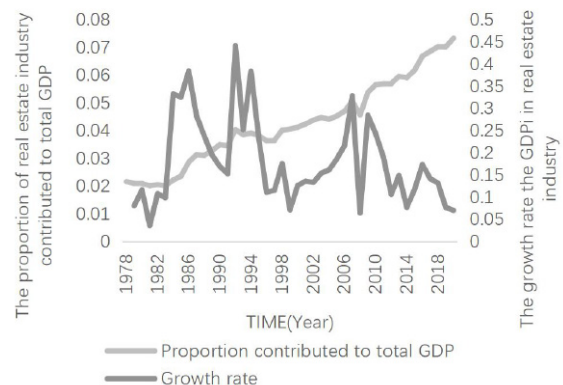


Figure 1. The proportion of real estate industry contributed to GDP and growth rate from 1978 to 2020.

However, due to the characteristics of the real estate industry, such as large investment amount and long capital recovery cycle, the risk of the industry is also high and so its profit margin, leading to more entrants in the industry. Meanwhile, the real estate industry is closely related to dozens of other industries in China, such as construction, chemical industry, finance and service, so the steady development of the real estate industry is crucial [3].

Recently, Hengda has been exposed to a huge amount of debt and has a great risk of default on debt repayment. As a large enterprise with assets of 2.38 trillion yuan, Hengda has witnessed the explosion of financial companies, failure of commercial bills, suspension of real estate and resignation of employees. Meanwhile, Hengda is also burdened with 1.97 trillion yuan of debt [4]. This calls attention to the property sector's long-standing problem of over-financing. The financing channels of the real estate industry are very single, mostly relying on bank loans. According to data from CSMAR, real estate companies have a higher asset-liability ratio generally, which reached to 65.2%. Unreasonable asset structure makes the enterprise management exposed to a crisis, there are some researches indicate that enterprises stuck into operating crisis after financial crisis [5]. Therefore, the prediction of financial crisis in real estate industry is a very important research topic.

However, most researchers just focus on financial crisis prediction of all listed companies, while the researches concentrate on real estate industry are scarce [6]. And papers establish prediction model in the real estate industry dealt with unbalanced data sets too simply and adopted the method of manual one-by-one matching [7], which did not have randomness and the obtained results were not ergodic.

To establish the prediction model, this paper chooses cash flow indicators instead of traditional ones. Traditional financial indicators, such as operating capacity, profitability and solvency, are not enough to truly and effectively reflect the situation of an enterprise. Some enterprises take advantage of the accrual basis and the ambiguity and uncertainty of some policies, and use the ways of early or late recognition of expenses to manipulate profits [8]. Therefore, this paper chooses features represent cash flow to build models, which are difficult to behave affectedly. Besides, cash flow features can more reliably reflect the solvency of real estate enterprises. Instead of loan payable, this paper uses cash ratio to describe the ratio between available cash assets and short-term debts that need to be paid by cash assets, which is more persuasive [9].

The data was obtained from financial statements of all A-share listing companies in China's real estate industry from 2013 to 2017 from CSMAR. There are 125 companies were chosen, which include 114 companies that are not in financial crisis and 11 that have. Due to the

special situation of real estate enterprises, this paper selects 18 features represent the situation of cash flow and also take other effective features from preview researches into consideration. This paper uses LightGBM algorithm to train the model. For data preprocessing, K-nearest Neighbors imputation was used to impute the missing values and to deal with the problem of imbalanced dataset, this paper uses the classical and effective method named SMOTE, which avoid error caused by manual sample matching. At last, the financial crisis prediction model is established and the conclusion that the financing risk indicators and the investment risk indicators are crucial factors to whether an enterprise will fall into financial crisis is drawn.

This paper makes contribution in both theoretical level and practical level. In theoretical level, first of all, this paper establishes the financial crisis prediction in real estate industry, which makes up the lack of in this industry. Secondly, this paper uses cash flow features to establish the model. Compared with the traditional financial features used by other financial crisis prediction models, this paper is more reliable, forward-looking and predictive from the perspective of cash flow instead of profit, which is easy to be manipulated. Therefore, the generalization accuracy of the model established is higher. Finally, other scholars seldom take imbalanced dataset into account when researching financial crisis prediction. While this paper uses the SMOTE to solve this problem. In practical level, this paper aims to establish a financial crisis prediction model to warn enterprises and help investors reduce investment risks. What's more, from the point of view of business operators, the establishment of financial crisis prediction model enables business operators to predict the coming financial crisis in the next few years, it's a good way to strengthen their caution for debt financing and avoid their blind investment for expansion.

In section 2, this paper introduces the concept of financial crisis and reviews previous scholars' opinions on the causes of financial crisis. In section 3, the source of data and features are introduced. In section 4, this paper introduces the method used for modeling, which is LightGBM. The fifth section introduces method of data preprocessing and describe the experimental result. In sixth section, conclusions of the whole paper are given.

2.LITERATURE REVIEW OF FINANCIAL CRISIS

2.1 The definition of financial crisis

At present, some scholars equate financial risk with debt risk. That financial risk is entirely caused by improper financing. Whether it will cause financial crisis mainly depends on whether the enterprise can fulfill the contract to repay the debt when it is due. If the debt is due, the enterprise is unable to repay, which will break the

loan contract. [10].

According to the definition of financial crisis of listed companies by the Stock Exchange, companies with abnormal financial conditions or other abnormal conditions will be marked with special expressions. Companies that have lost in China for two consecutive years add the character ST to the name of their stock. Stocks that have lost for three consecutive years are tagged with an ST*. This paper considers stock with ST or ST* tag is in financial crisis.

2.2 Causes of financial crisis

As for the causes of the financial crisis, this paper reviews the earlier financial crisis theory and the analysis of the crisis causes of China's real estate industry by Chinese scholars in recent years.

TABLE 1. Review of causes of financial crisis

Author(s)	Main Reason	Summarized Highlights
Li [11]	Systematic risk	Systematic risk includes policies and social environment.
	Unsystematic risk	Unsystematic risk depends on the operation of the enterprise
Acharya et al. [12]	Banks evaded regulatory capital requirements	Banks can hold smaller capital buffers by putting assets in off-balance-sheet entities. The capital regulations allow banks to hold less amount of capital if they have AAA-rated tranches of securitized mortgages.
	Operational risk exposure	Financial crisis was caused by four key players which are mortgage brokers and banks, credit rating agencies, insurance companies and investment banks.
Shi & Fu [14]	Corporate Governance	There are insufficient cash flow to make up for the capital invested by the company's rapid expansion and debt owed by financing.
	Weak solvency and high debt level	An individual cannot centralize all power, it needs to be supervised by independent directors.

	The policies have an impact on the financing and sales of real estate enterprises	The "three red lines" of national policies have a great negative impact on corporate financing.
Han [15]	The investment of real estate enterprises is not reasonable and cannot reach the expected income effect	There are some problems such as market research deviation in real estate investment and blindly excessive expansion of enterprises.
Jiang [16]	The rupture of capital chain	When the capital chain is in danger, the solvency of the enterprise is not good, which affects the refinancing ability. Due to policy restrictions, non-bank loans account for a high proportion of financing costs

Acharya and Andersen were discussing the financial crisis of the whole country following the financial crisis of many companies in the real estate industry. Shi, Han and Jiang expressed their opinions on the financial crisis of real estate enterprises before the national financial crisis. Han mentioned that policies have a great impact on the real estate industry. The fact that government restricted the two main sources of funds for real estate enterprises (house sales and financing) may lead to financial crisis of enterprises. Shi and Jiang believed that the financial crisis was caused by problems in enterprise management. Shi believed that excessive investment by the management makes the enterprise expand too fast, and the recovery cycle of funds is very long, which led to the inability of the enterprise to repay debts. Therefore, Shi also proposed that power cannot be concentrated in one person, it needed to be supervised by independent directors to avoid failing investment decisions. Jiang shared the same view, believing that the break in the capital chain is a nightmare for enterprises, which will lead to a series of refinancing difficulties later.

Based on their viewpoints, this paper believes that the financial crisis of real estate enterprises is caused by both external environment and internal enterprise management. In many cases, the restrictions imposed by the external environment on the operation of enterprises will disrupt the long-term decisions of radical enterprises.

Since they have carried more debts, their fault tolerance rate is lower and any changes could put them at a risky situation. Therefore, in order to comprehensively evaluate the causes of financial crisis, this paper will adopt features from four dimensions to measure whether an enterprise will fall into financial crisis. They are operating risk indicators [14], capital chain risk indicators [16], investment risk indicators [15] and financing risk indicators [15], respectively.

3.DATA AND VARIABLES

The data comes from the quarterly reports, semi-annual reports and annual financial reports of all A-share listing companies in China's real estate industry from 2013 to 2017 from CSMAR. Since an enterprise marked as an ST or ST* because they have lost for two or three consecutive years, it is meaningless to use the financial data of the enterprise within three years to predict whether it will fall into financial crisis. Therefore, this paper selects data from 5 years to 1 year before the loss. There are 125 companies were chosen, which include 114 companies that are not in financial crisis and 11 that have. Due to the special situation of real estate enterprises, this paper selects most of features represent the situation of cash flow and also took other important features into consideration. Because some companies take advantage of the accrual basis and the ambiguity and uncertainty of some policies to manipulate profits by recognizing expenses early or late, which makes statement of profit or loss unreliable. In contrast, cash flow indicator fraud is difficult and easy to identify [15]. In order for features to reflect the overall characteristics of the companies, the cash flow perspective, features are selected in four dimensions which are operating risk indicators, capital chain risk indicators, investment risk indicators and financing risk indicators respectively.

TABLE 2. Introduction of features

Features	Illustration	Category
y	Whether in financial crisis, 1 is yes, 0 is no	Target of prediction
Cash content of operating income	Cash/operating income received from selling goods or providing labor services	
Cash flow ratio	Net cash flow from operating activities/average current liabilities	Indicators of cash chain risk
Cash recovery rate of all assets	Net cash flow from operating activities/total assets at the end of the period	

Surplus cash coverage ratio	Operating net cash flow/net profit	
Cash dividend coverage ratio	Net cash flow from operating activities/average current liabilities	
Cash reinvestment ratio	Operating cash flow/capital expenditure	
Long-term equity investment ratio	The initial cost of external long-term equity investment/the most recent audited net assets	
Cash return on net assets	Cash runoff from operating activities/average net assets	Indicators of investment risk
Growth rate of net traffic generated by operating activities	Increase in net cash flow from empirical activities in the current period/base period net operating cash flow	
Growth rate of total assets	Growth in total assets this year/total assets at the beginning of the year	
Net cash flow from operating activities per share	Net cash flow from operating activities/total equity	Indicators of operating risk
Inventory turnover	Operating cost/average inventory balance	
Long-term asset suitability ratio	(Shareholders' equity + long-term liabilities) / (net fixed assets + net long-term investment)	
Cash ratio	Cash and cash equivalents/current liabilities	
Current ratio	Current assets/current liabilities	Indicators of financing risk
Cash flow maturing debt coverage ratio	Net operating cash flow/average total liabilities	
Cash flow interest coverage ratio	Net cash flow from operating activities/financial expenses	

4.METHODOLOGY

This paper uses LightGBM algorithm to establish financial crisis prediction model. LightGBM is a popular algorithm that was open sourced in 2017 by Microsoft. Like eXtreme Gradient Boost (XGboost), it is an efficient implementation of Gradient Boosting Decision Tree (GBDT). In mechanism, it is similar to GBDT and XGBoost in that the negative gradient of loss function is used as the residual approximation of the current decision tree to fit the new decision tree. But LightGBM has more advantages. For example, LightGBM runs 10 times faster than XGBoost while taking only 1/6 memory usage of compared to XGBoost with better accuracy [17].

LightGBM uses the histogram algorithm (See Figure3), which occupies lower memory and has lower data separation complexity [18]. The idea is to discretize continuous floating features into k discrete values, and construct a Histogram with a width of k. Then traverse the training data and count the cumulative statistics of each discrete value in the histogram. When performing feature selection, it is only necessary to traverse to find the optimal segmentation point according to the discrete value of the histogram.

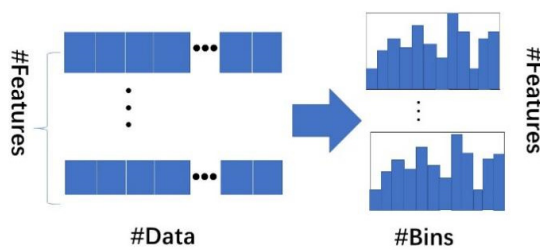


Figure 2. Process of histogram algorithm.

5.EXPERIMENTAL RESULTS

5.1 Data processing

5.1.1 Impute missing value

Due to the different accounting policies selected by the enterprise and the change of accounting policies from 2013 to 2017, there are some missing values in the CSMAR database, so KNN imputation method is used to impute these missing values. In KNN approach, the goal is to find k samples in the dataset that are comparable or close in space. The value of the missing data points is then estimated using these k samples. The mean value of the 'k'-neighbors found in the dataset is used to impute each sample's missing values. The Euclidean distance is generally used for the definition of distance. Assuming two points x and y in n dimension, i refers to the ith dimension of x and y, it is between 1 and n. the Euclidean distance of two points is expressed by formula 1.

$$D(x,y)=\sqrt{\{(x_1-y_1)^2+(x_2-y_2)^2+\dots+(x_n-y_n)^2\}}=\sqrt{\sum_{i=1}^n(x_i-y_i)^2} \quad (1)$$

With KNN imputation, the missing values in the dataset can be imputed.

5.1.2 To deal with imbalanced dataset

One issue with imbalanced classification is that there are too few examples of the minority class for a model to learn the decision boundary effectively. Oversampling examples from the minority class is one solution to this problem. Before fitting a model, simply duplicate examples from the minority class in the training dataset. This can balance the class distribution but adds no new information to the model.

SMOTE selects samples in the feature space that are close together and draws a line between them, then creates a new sample at a position along that line. A representative from the minority class is picked at random first. Then, for that example, k of the closest neighbors (usually k=5) is found. A neighbor is picked at random, and a synthetic example is constructed between the two instances in feature space at a random position.

5.2 Main results

5.2.1 Model performance

This paper uses LightGBM algorithm to establish the financial crisis prediction model and being evaluated by three indicators, which are F1 Scores, Area under Curve (AUC) and Accuracy. The F1 Scores is a measure of a test's accuracy in binary classification statistical analysis. It is calculated using the test's precision and recall. ROC curve can reflect the trend of sensitivity (FPR) and specificity (TPR) of a model in selecting different thresholds. AUC is the area under Receiver Operating Characteristic (ROC) Curve, it is a measurement of whether the classifier doing a great job in binary classification.

Table 3 shows the performance of the model. Its F1 Scores reach to 0.846, AUC scores reach to 0.849, accuracy of this model reaches 0.96, which means the rate of correct classification by the classifier reached 96%. These indicators are well enough to indicate this model can be used for real prediction compared with traditional indicators of 74.3% accuracy [19].

TABLE 3. The performance of model

Classifiers	LightGBM
F1 Scores	0.846
Auc Scores	0.849
Accuracy	0.963

Notes: F1 Scores is the mean number of accuracy and recall. Auc scores is the sum of the areas under the ROC curve. Accuracy indicates the classification accuracy rate in the test group.

5.2.2 Key factors

Next, through the importance score of each feature obtained by LightGBM algorithm in the process of training model, this paper analyzes the influenced features lead to financial crisis.

TABLE 4. THE SYMBOL OF EACH FEATURE

Features	Symbols
Cash content of operating income	x1
Cash reinvestment ratio	x2
Net cash flow from operating activities per share	x3
Inventory turnover	x4
Long-term equity investment ratio	x5
Cash return on net assets	x6
Growth rate of net traffic generated by operating activities	x7
Growth rate of total assets	x8
Long-term asset suitability ratio	x9
Cash ratio	x10
Current ratio	x11
Cash flow maturing debt coverage ratio	x12
Cash flow interest coverage ratio	x13
Cash flow ratio	x14
Cash recovery rate of all assets	x15
Surplus cash coverage ratio	x16
Cash dividend coverage ratio	x17

As it can be seen from the figure 3, the financing risk indicators is the most important of the four dimensions.

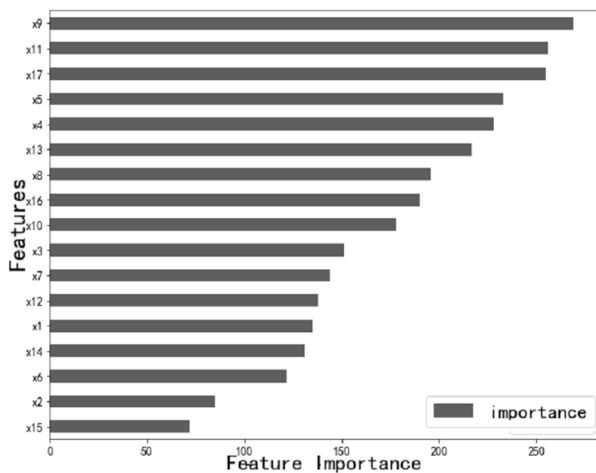


Figure 3. Feature importance ranking. Notes: importance is scored by the number of times the feature

is used and the information divergence of the feature.

Three of the first five indicators in order of importance are on behalf of the financing risk indicators, one is the investment risk indicators, one is the capital chain risk indicators. It can be seen that when real estate enterprises encounter difficulties or risks in financing, they are most likely to fall into financial crisis. Hou explained that Chinese real estate industry has a strong financial attribute. After obtaining the right to use the land for development and construction, real estate enterprises will also fail in subsequent investment due to lack of funds. The huge investment before cannot be recovered [20]. The project can be profitable only by continuing to rely on financing. Zhang believes that although Chinese real estate enterprises have diversified financing channels, most financing channels cannot play a good role in the financing practice of real estate enterprises, resulting in Chinese real estate enterprises overly rely on bank loans and self-financing financing channels [21]. Therefore, when the policy limits the financing channels of bank loans, it is difficult for enterprises to raise funds through other channels, which leads to the failure of projects to continue to follow up and the weakening of profitability, leading to their financial crisis. Wang’s empirical paper also indicate that here is a positive correlation between enterprise financing ability and profitability [22].

From the dimension of financing risk, the most important feature is long-term suitability asset ratio, and the second is current ratio. They both are indicators of the solvency of assets allocation. Long-term assets suitability rate is calculated by the formula of “shareholders' equity + long-term investment/net fixed assets + net long-term investment”. This represents the allocation among equity financing, equity capital, long-term liability financing, fixed assets and long-term investment. Current ratio is the ratio of current assets to current liabilities, which represents the allocation of the asset structure of the part with strong liquidity. In fact, these two features warn real estate enterprises not to make blind investment expansion, but to carefully choose investment projects under the existing capacity and make adequate market research. Huang and Huang mentioned free cash flow and over-investment theory, which illustrates the reason of over-investment. Since managers aim to maximize their own interests, managers tend to invest corporate cash flow in negative NPV projects instead of distributing dividends to shareholders when there is no good investment opportunity [23].

6.CONCLUSION

This paper intends to establish the financial crisis prediction model of real estate industry from the perspective of cash flow. By selecting representative indicators of cash flow and other important factors from four dimensions, which are operating risk indicators,

capital chain risk indicators, investment risk indicators and financing risk indicators respectively. After imputing the missing values using method of KNN Imputation, SMOTE is used to deal with imbalanced dataset. At last, the LightGBM algorithm is used to build financial crisis prediction model because of its better performance in prediction.

The financial prediction model reaches 96% accuracy in categorising companies that are in financial danger, which can be applied in practice to identify the financial crisis of real estate enterprises compared with other papers using traditional features only reached the accuracy of 76.7% [20]. From features importance ranking, this paper concludes that the financing risk and the investment risk of assets are crucial factors to whether an enterprise will fall into financial crisis.

Through the construction of this model, the government can find the enterprises that may fall into financial crisis as soon as possible and supervise them in time. So as to avoid a series of problems arising from the bankruptcy of large real estate enterprises. For example, the increase of unemployment, the decline of national GDP and so on. Furthermore, from the perspective of business operators, the establishment of a financial crisis prediction model enables business operators to predict the coming financial crisis in the coming years, which is a good way to strengthen their caution when it comes to debt financing and avoid making rash expansionary investments. In terms of supervision, the creation of a financial crisis prediction model allows regulators to focus on major firms and restrict their excessive funding through relevant legislation, as well as supervise their strategic actions, in order to avoid a crisis.

Since the financial statements of Chinese Small and Medium-sized Enterprises (SMEs) are not made public, the model established in this paper is only applicable to listed large enterprises. In this paper, enterprises with ST and ST* are not distinguished, and future studies can distinguish enterprises with different types of financial crisis.

AUTHOR CONTRIBUTIONS

Yuchen Han has completed all the work of this paper.

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