

Research on Comprehensive Financial Crisis Warning Model of Listed Companies Based on Financial Report Big Data and Deep Learning Technology

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Abstract: Against the backdrop of an increasingly complex global economy, corporate financial risks continue to rise, prompting the establishment of an efficient risk warning model to become a focus of academic and practical attention. With the widespread application of artificial intelligence technology, deep learning has opened up a new path in the identification and assessment of financial risks. Based on financial statement big data, this paper applies mainstream deep learning algorithms to construct a comprehensive financial crisis warning model for listed companies. The study selected data from listed manufacturing companies and used the propensity score matching method (PSM) to divide the samples into two groups: financial crisis and stable operation. A multi-level and multi-dimensional warning indicator system was established, and the accuracy of the model was verified by computer simulation and multi-model comparison. The results showed that the prediction accuracy of the model based on deep learning exceeded 90%. This paper uses Logistic regression analysis to identify important factors affecting financial risks. This study not only enriches the financial risk warning framework in theory, but also provides useful tools and references for managers to improve financial security management.

Keywords: Financial risk early warning, Deep learning, Financial crisis prediction, Machine learning algorithm, Financial statement big data

1. Introduction

With the intensification of geopolitical conflicts and the complex and changeable global economic environment, the financial risks faced by enterprises are increasing day by day. How to effectively identify, evaluate and deal with these risks has become a hot issue in the current academic and practical circles. The gradual development of China's capital market and the deepening reform of the delisting system lead to an increase in the number of delisting companies year by year, among which the delisting caused by financial difficulties occupies a dominant position. Therefore, the establishment of an efficient financial risk early warning mechanism is not only the key to the stable development of enterprises, but also a necessary guarantee to ensure the healthy operation of the market.

The traditional financial risk identification method relies on manual data collection and post-analysis, but this method has great lag and limitations, and it is difficult to cope with the rapidly changing market environment. With the development of artificial intelligence, especially machine learning algorithms, new solutions have been provided for the pre-identification and proactive prevention and control of financial risks. As a powerful machine learning algorithm, deep neural network can efficiently process complex nonlinear data and provide accurate financial risk prediction.

This paper uses deep neural network model and computer simulation technology to study and build a comprehensive early-warning model for listed companies' financial crisis. Studies have shown that deep learning-based models have an accuracy of more than 90% in financial risk prediction, significantly improving risk identification capabilities.

This paper also uses Logistic regression model to analyze the main factors affecting the financial risk, and further improves the financial risk assessment system. By combining machine learning algorithm with financial management practice, this paper not only optimizes the existing risk early warning model, but also broadens the application scenario of machine learning in financial risk management, which has important theoretical value and practical significance. This study provides a

more accurate financial risk early warning scheme for listed companies, helps enterprises improve their risk prevention and control capabilities, and provides theoretical support and practical guidance for the stable operation of the capital market.

2. Literature review

In the current economic environment, the impact of trade friction, audit errors and corporate governance structure on corporate financial health has become a hot topic of academic research. In the context of studying the Sino-US trade conflict, Li Bingcheng and other scholars have deeply discussed how trade frictions lead to the financial distress of enterprises through a multi-dimensional path. By selecting Oufeiguang as the research object, the research team found that trade frictions eventually lead to serious financial risks for enterprises by interfering with their import and export business, affecting business performance, restricting financing channels and weakening their innovation ability. This study revealed the multiple impact mechanisms of trade frictions on corporate financial crisis and provided important practical cases for the expansion of relevant theories ^[1].

In the field of audit, the study of Li Bingcheng et al., focusing on the case of Yu Diamond, reveals how audit errors can exacerbate the formation of corporate financial distress by misleading financial reports and influencing the decision-making process. Through empirical analysis, this study points out that audit failure will not only affect the judgment of external investors on the company's financial situation, but also cause the management to make wrong decisions, which leads to the aggravation of financial crisis. This study provides new ideas for the theoretical construction of the impact of audit errors on corporate financial health, and further enriches the academic achievements on the relationship between audit and financial risk management ^[2].

Wang Chen's research points out that under the influence of multiple factors such as fluctuations in domestic and foreign economic environment and insufficient internal management, many small and medium-sized enterprises are facing severe financial difficulties, resulting in their survival and development facing huge challenges. Wang Chen analyzed the main manifestations and causes of smes' financial difficulties in detail, and put forward a series of effective coping strategies. These strategies include optimizing capital management, strengthening internal control and improving capital structure, etc., aiming to help smes improve their anti-risk ability and ensure their stable development in a complex market environment ^[3].

Crown Male studied the relationship between CEO replacement in terms of corporate governance structure and the risk of stock price collapse, and found that CEO replacement in enterprises, especially abnormal changes, can effectively alleviate the financing constraints and agency costs faced by enterprises in financial distress, thus reducing the risk of stock price collapse. The study further points out that the impact of CEO replacement on stock price crash risk is significantly different in different types of enterprises. Non-state-owned enterprises, enterprises with dispersed ownership structure and low quality of external audit, CEO replacement is particularly prominent in the inhibition of stock price crash risk. This study provides important theoretical support for how corporate governance and shareholder structure affect corporate risk management ^[4].

At the same time, Zhou Ying analyzed 428 listed companies with special treatment for the first time, combined financial and non-financial indicators to build a financial crisis early warning model, and optimized it by autoencoder and support vector machine (SVM) model. The results show that the F1 value is as high as 0.922 under the condition of 40-dimensional data, which has a strong ability of financial crisis warning. This study not only optimizes the accuracy of the early warning model, but also provides a more scientific and effective risk prediction tool for enterprises ^[5].

Li Bingcheng and others' research on the contagion effect of financial crises in corporate groups shows that there is indeed a mechanism for the spread of financial crises within corporate groups. In particular, when a member company within a group encounters a financial crisis, other member companies may also be affected. The study further pointed out that a good governance structure and capital market efficiency can effectively slow down the spread of crises, while the situation where senior executives hold concurrent positions in multiple companies exacerbates the spread of financial crises. The transmission path of financial crises is mainly achieved through increasing related transactions between companies and raising financing costs. This finding provides a new theoretical perspective on the governance mechanism of crisis transmission within corporate groups and emphasizes the importance of effective control and management^[6].

This study explores the generation and spread mechanism of financial crises from multiple perspectives, and combined with specific cases, reveals the impact of various factors on corporate financial health. These studies provide theoretical support for further understanding the causes, transmission methods and early warning mechanisms of financial crises, and also provide practical guidance for companies to formulate more scientific response strategies when facing a complex and changing economic environment.

3. Theoretical framework and research design

3.1 Research Framework

The goal of this study is to build a financial risk early warning model based on deep neural networks, combining financial and non-financial indicators to provide an effective financial risk prediction tool for manufacturing listed companies. To achieve this goal, this paper first selected a multi-dimensional indicator system based on the financial early warning theory to ensure a comprehensive analysis of the company's financial status from multiple aspects. The financial indicators we selected include debt repayment ability, profitability, cash flow, etc., while non-financial indicators cover information disclosure quality, shareholder structure, etc. The comprehensive analysis of these financial and non-financial indicators helps to accurately identify the potential risks of corporate financial crises and provide support for subsequent early warnings. This study also introduced a deep neural network (DNN) model. Using the powerful learning ability of deep neural networks, a multi-level neural network structure was established. Through training on historical data, it can not only identify current risks, but also predict possible financial problems in the future and issue early warning signals in a timely manner.

The object of this study is listed manufacturing companies, mainly focusing on their financial risk management. In order to ensure the representativeness of the sample, this paper selected 113 companies that were first implemented with ST or *ST from all listed companies, and at the same time matched 226 financially healthy companies with similar asset sizes in the same industry in the same year as the control group. The study adopts a data-driven approach, combines company financial statements and other enterprise characteristic data, and selects samples through the propensity score matching (PSM) method to ensure the rationality of data comparison and the reliability of results. This paper uses a deep neural network model in model construction, including input layer, hidden layer and output layer. The number of nodes in the input layer is equal to the number of selected early warning indicators, the hidden layer uses the ReLU activation function, and the output layer uses the Sigmoid function for binary classification output, aiming to predict whether the company is facing financial risks.

3.2 Data Analysis and Model Development

In terms of data processing and model training, this paper divides the training set and the test set from 226 sample data in a ratio of 6:4, of which 10% of the training data is used as a validation set to prevent the model from overfitting. In order to further improve the generalization ability of the model, this study introduced the Dropout regularization technology in the training process, set a 50% dropout probability, selected the cross entropy as the loss function, and used the Adam optimizer to improve the training efficiency and optimization effect. Through these measures, the study ensured the stability and accuracy of the model, and also verified the superiority of the constructed deep neural network model in financial risk early warning by comparing with the traditional prediction model.

Based on financial and non-financial indicators, this study combined with deep neural network technology and proposed a new financial risk early warning method. By comprehensively analyzing the financial data and external characteristics of the enterprise, the study can effectively identify potential financial crises and provide a reliable risk prediction tool for listed manufacturing companies. The model not only improves the accuracy of the prediction, but also provides forward-looking decision support for the management of the enterprise, further promoting the effectiveness of the enterprise's financial risk management.

4. Model construction and empirical analysis

4.1 Model design and training

In this study, deep neural network (DNN) model is designed and trained to accurately identify and predict financial risks. In order to ensure the best performance of the model, the researchers finally determined the optimal structure of the model through multiple rounds of experiments and parameter adjustments, including setting the number of hidden layers to two layers, containing 128 and 64 neurons respectively, while setting the learning rate to 0.001, and the number of training iterations to 800. Through this structure setting, the model can converge stably in the training process, thus improving its ability to predict financial risks. In the training results, it can be observed that the Loss function of the model on the training set gradually approaches zero, and the evaluation indexes such as Precision, Recall and AUC (area under the curve) continue to improve, finally reaching the ideal level of close to 1. On the validation set, the loss value of the model is 3.37, the accuracy is 1, the recall rate is 0.889, and the AUC value is stable at 0.944, indicating that the model also performs well on the validation set. In the prediction of the test data, the trained deep neural network model showed 90% accuracy, of which the prediction accuracy of financial crisis enterprises was 91%, and the prediction accuracy of financial health enterprises was 88%. In addition, the recall rate of both types of enterprises reached 90%, and the F1 score was stable at 0.9, which showed that the model maintained a high level of prediction ability and stability in a number of evaluation indicators.

4.2 Influence assessment of variables

Although the deep neural network model can provide high accuracy financial risk prediction, it cannot reveal the specific role of each financial early warning indicator in the prediction process, so this paper further adopts the Logistic regression model to evaluate the influence of each financial indicator on the financial situation. In this analysis, the researcher takes the financial health state as the dependent variable Y and all financial early warning indicators as the independent variable X, and constructs a Logistic regression model, and determines the direction and degree of its influence on the dependent variable by analyzing the regression coefficients of each indicator. The results show that the regression coefficient of development ability is the largest, reaching 0.9296, which indicates that development ability has the strongest early warning ability for financial risks. The regression coefficient of cash flow is 0.7826, indicating that cash flow plays a crucial role in financial risk identification. In addition, the influence of other indicators such as earnings per share, long-term solvency, profitability and operating efficiency decreases in turn. This result provides a valuable reference for enterprise managers, especially when paying attention to financial health management, it is necessary to pay special attention to key indicators such as development ability, cash flow and earnings per share, so as to identify and deal with possible financial risks in time.

4.3 Model practicability and result analysis

Combining the predictive ability of the deep neural network model with the evaluation of the influence of financial early warning indicators, the model proposed in this study provides a powerful tool for the monitoring and management of corporate financial risk. In practical application, the constructed model can effectively distinguish between financial crisis enterprises and healthy enterprises, and has excellent performance in several evaluation indicators such as accuracy rate and recall rate, which indicates that the model has high practicability and operability. Through detailed analysis of each financial indicator, the study reveals the relative importance of different indicators in the financial early warning process, provides a clear financial monitoring focus for enterprises, and enables enterprises to monitor and manage key financial indicators in a targeted manner, thus reducing potential financial risks. In general, the financial risk prediction model designed in this research not only provides reliable technical support for enterprises, but also provides scientific basis for enterprise managers to make decisions, and helps enterprises to detect risks in advance and take necessary countermeasures in the face of financial crisis, so as to effectively improve the financial security and overall operational stability of enterprises.

5. Conclusions and Suggestions

5.1 Research Conclusions

In the current complex and changeable economic environment, financial risk management has become an important issue that enterprises, especially listed companies, need to solve urgently. An effective financial risk early warning system can give timely warning before the outbreak of potential risks, prompting the enterprise management to review the operation of the enterprise in advance and take corresponding risk prevention measures, so as to avoid the occurrence of financial crisis. In this paper, deep neural network (DNN) is used to construct financial risk early warning model, and a lot of experiments and optimization are carried out on it. According to the analysis of the experimental results, the prediction accuracy of the model reaches more than 90%, and it is highly consistent with the actual financial situation of listed companies, which indicates that the model not only has strong effectiveness and practicability, but also provides a reliable decision support tool for enterprise management, investors and creditors in practical application, helping them in the face of uncertainty. Be able to make decisions scientifically and rationally and take effective measures to deal with financial risks.

However, although the accuracy of deep neural network model in financial risk prediction is high, it can not directly measure the specific impact of each financial index on the financial risk of enterprises. Therefore, the Logistic regression model is further adopted in this paper, and each financial early warning index and financial risk status are put into the model for regression analysis. According to the results of regression analysis, indicators such as development ability, cash flow, earnings per share and long-term solvency rank first in order of importance, indicating that these financial dimensions have the greatest impact on the financial health of enterprises. Through this analysis, enterprises can more clearly understand which financial indicators have a greater impact on the risk early warning system, and then pay more attention to these core financial indicators in daily operations to help enterprises realize early risk identification and effective response.

5.2 Policy Recommendations

In order to help enterprises effectively reduce financial risks, improve financial stability and enhance market competitiveness in the future operation process,. Whether an enterprise can continue to develop in the fierce market competition depends on continuous innovation and sound management capabilities. In order to enhance sustainable development capabilities, enterprises should increase investment in technological innovation and promote product and service upgrades to adapt to changes in market demand. Enterprises need to pay attention to the optimization of management processes, and ensure efficient coordination of various businesses by improving resource allocation efficiency and operational management level, thereby improving overall operational efficiency. Enterprises should strengthen the construction of core teams, focus on talent training and introduction, and improve the professional quality and innovation ability of the management team, so as to enhance the market adaptability and competitiveness of enterprises.

Cash flow management occupies a vital position in corporate financial management. Reasonable control of cash flow can effectively reduce the financial risks faced by enterprises. Therefore, enterprises should establish a sound cash flow forecasting and monitoring mechanism, continuously track and analyze changes in cash flow, and identify potential risks in a timely manner. By optimizing the capital structure, enterprises can not only ensure the stable operation of cash flow, but also better cope with the challenges brought by market fluctuations. In terms of capital use, enterprises should reasonably allocate internal funds and external financing resources, use diversified financing channels such as money market and securities market to ensure efficient operation of funds, improve capital utilization and risk resistance, so as to better cope with external risks and ensure the long-term stable operation of enterprises.

The long-term debt repayment ability of enterprises directly affects their financial health, and improving long-term debt repayment ability is the key to maintaining financial stability. Enterprises should focus on accumulating their own capital, enhancing endogenous development capabilities, and improving risk resistance, so as to provide guarantees for the long-term stable development of enterprises. Optimizing capital structure and reducing debt ratio are also important means to improve debt repayment ability. Enterprises can also reasonably use financial instruments to improve capital structure and enhance debt repayment ability. In order to effectively diversify financial risks, enterprises should implement diversified business strategies, avoid excessive reliance on a single

business, thereby reducing the impact of financial fluctuations on the overall business operations, and improving the overall debt repayment ability and capital structure of enterprises.

5.3 Research limitations and prospects

Although the financial risk warning model proposed in this paper has performed well in terms of prediction accuracy and application effectiveness, it still has certain limitations. Although deep neural network models can capture complex patterns in financial data, they lack the ability to warn of financial shocks caused by sudden external events (such as economic crises, natural disasters, etc.). When using such models, enterprises need to flexibly adjust risk response strategies in light of changes in the external environment. Future research can consider incorporating more external economic variables, policy changes, market trends and other factors into the model to further improve the adaptability and accuracy of the model, so as to better predict and respond to complex financial risks.

The financial risk early warning system proposed in this paper provides an effective risk monitoring and management tool for enterprises. Although it cannot cope with all potential risks, it can help enterprises achieve early warning and take timely response measures to a certain extent, thereby reducing the probability of financial crises and ensuring the sustainable development and stable growth of enterprises.

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