Construction and Optimization of a Financial Early Warning System Based on Big Data and Deep Learning Technology

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Abstract: New technologies such as big data, artificial intelligence, mobile internet, cloud computing, Internet of Things, and blockchain have brought about significant changes and development in the financial industry. Predicting the financial situation of enterprises, reducing the probability of uncertainty risks, and reducing the likelihood of financial crises have become important issues in enterprise financial crisis warning. In view of the issues in enterprise financial early warning systems such as lag, low accuracy, and high warning costs in data analysis, a financial early warning system based on big data and deep learning technology has been established, taking into account the different situations of listed and non-listed companies. This carries significance in improving the accuracy of enterprise financial early warning and promoting timely and effective decision-making.

Keywords: Financial crisis; Big data; Deep learning; Financial early warning system

1. Introduction

The 14th Five Year Plan for National Economic and Social Development of the People's Republic of China and the Outline of Vision and Objectives for 2035 (draft) put forward a proposal to accelerate the construction of a digital economy, a digital society, and a digital government, as well as to expedite the overall transformation of the production mode, lifestyle, and governance mode with digital transformation. As a result of the pandemic, enterprises are facing increasing uncertainties; the lag of internal financial data in a company leads to the inability to control its financial situation in advance. Predicting the financial situation of companies, reducing the probability of uncertainty risks, and reducing the likelihood of financial crises have become important issues in enterprise financial crisis warning. The overall crisis triggered by enterprise financial crisis is mainly manifested in three aspects.

1.1. Enterprise financial crises hinder normal production

Insufficient idle funds and poor cash flow turnover increase the financial burden of enterprises, resulting in the depletion of funds and difficulty in maintaining normal production and operation. Once a company encounters difficulties in normal production and operation, its production and operation will fall into a vicious cycle, making it even more difficult to achieve sustained and stable development.

1.2. Enterprise financial crises suppress competitiveness and growth potential

When an enterprise is faced with financial crisis, the accuracy of managers in predicting the economic benefits of the enterprise is affected. This causes the enterprise to lose its market competitiveness and makes it difficult to predict the future losses and profits of the enterprise, leading to issues in forming capital accumulation, which is another factor that gives rise to enterprise financial crisis.

1.3. Enterprise financial crises lead to a setback in production driven by employee enthusiasm

Without ensuring normal production and operation, heavily indebted enterprises find it difficult to protect the interests of their employees. This greatly dampens the enthusiasm of employees to participate in enterprise production and even leads to a significant loss of talent, which would further exacerbate the financial crisis.

The emergence of big data has made it possible to obtain multi-dimensional non-financial data, providing new opportunities for studying financial warning from the perspective of non-financial indicators. Supported by big data, we view netizens as sensors for enterprises, establish the connection between online signal fluctuations and financial risks in the business process, mine massive information related to enterprises, and use big data indicators and deep learning technology to create an effective enterprise financial crisis warning model.

The financial early warning system falls under the category of microeconomics early warning and has gained significant economic research value. Wu *et al*. [1] were the first to introduce the financial early warning model in China through which they analyzed foreign models that use financial indicators for financial early warning. Chen [2] used 27 non-special treatment (ST) and ST companies in the Shanghai and Shenzhen stock markets as comparative samples to test the applicability of foreign univariate early warning models to domestic listed companies. Zhang [3] used the financial data of 60 companies to study the second-class linear discriminant model and found that the model has strong forecasting ability. Wu *et al*. [4] selected 21 financial ratios from 70 non-ST and ST companies to conduct research on enterprise financial risk warning models. Fu *et al*. [5] predicted the financial deterioration of listed companies in China and found that using artificial neural network analysis models in financial early warning research has higher accuracy and applicability. Wang *et al*. [6] used non-financial indicators (such as corporate governance and external guarantees) to construct an early warning model, which expanded the selection of variables in the model and also led the research on financial systems to a more comprehensive and deeper level.

At present, financial early-warning services provided by financial companies are based on financial indicators for analysis and prediction. Since financial indicators are lagging, incomplete, and subjective, some enterprise financial early warning models are not complete enough to effectively and timely warn business indicators. The financial early warning system based on big data and deep learning can, on the one hand, utilize big data to improve the shortcomings of previous financial early warning models for enterprises and, on the other hand, relate the characteristics of big data to the actual development situation of enterprises to grasp the overall direction of economic development, thus promoting financial risk warning and further improving its effectiveness. Song [7] found through a comprehensive analysis of 60 enterprises that the introduction of big data indicators in the financial warning model can significantly improve the prediction effect in the long run.

In China, the research on financial early warning started relatively late, and the capital market environment is still immature and incomplete. The methods and models used in research were mostly based on foreign literature research, lacking creativity and practical guidance for companies as well as a financial early warning model that combines the capital market environment, company characteristics, and big data analysis in China.

2. Problems in establishing a financial early warning system

2.1. Lagging analysis of financial early warning system data

According to the evaluation of the financial situation of enterprises based on completed data, some crises are inevitable. The existing financial warning analysis of enterprises is aimed at understanding and adapting to the market, mainly using quantitative analysis and often only considering financial factors. However, financial indicators are often just a form of financial crisis, and they are characterized by delayed responsiveness, incompleteness, and subjectivity. Basically, all enterprises have subjectivity when formulating financial risk warning models. Most enterprises have incomplete financial risk warning models and incomplete financial indicators, which do not cover all aspects or fully express their current situation. Moreover, financial indicators themselves have lag reactivity, which contradicts the original intention of enterprises to use and analyze financial indicators for early warning. The financial warning model established based on financial indicators as the main prediction basis has significant drawbacks, as it cannot truly predict the financial risks of enterprises in practical applications.

2.2. Low accuracy of financial early warning system

Early models were based on a limited number of enterprises for empirical research, and the data lacked support and had low accuracy. Financial warning can be divided into two types based on the selected indicators: financial indicators and non-financial indicators. The effectiveness of financial warning based on financial indicators has always been limited by the distortion and lag of accounting information. On the other hand, the financial warning model based on non-financial indicators has been criticized for its subjectivity in obtaining indicators. The survival and development of enterprises largely depend on the personal qualities and abilities of their owners. Due to the lack of awareness and professional training in management, small and medium-sized enterprise owners often tend to prioritize production and operation, while neglecting sales and financial management. This leads to these enterprises being at a disadvantage in early warning and response to financial crises [8].

2.3. Non-listed companies have high financial warning costs and incomplete or absent financial warning systems, leading to greater financial risks

The market demand for non-listed companies is high, but the financial crisis warning system has not segmented the industry. Due to limited financial resources and a lack of specialized financial management personnel, the financial decision-making work has been halted due to high fee thresholds. Due to the unclear source of financial data, there are limited research and practice on its financial early warning system externally. If the financial information of a company is neglected over a period of time or there is no timely warning system for financial crisis, it may be easily affected by macroeconomic factors, low capital and technology composition, and other factors, leading to varying degrees of financial crisis for most non-listed companies.

3. Implementation path of building a financial early warning system based on big data and deep learning technology

There are two main contents in the financial early warning system based on big data and deep learning technology. The first is building a financial early warning model used by enterprises. The model can be divided into two major modules: listed companies and non-listed companies. In order to build a financial early warning model by industry, each module is classified based on different industries. The early stage of the former module is based on the financial warning model developed by listed companies in the manufacturing industry. The market positioning is for large-scale manufacturing listed companies with more financial information and complex financial systems. Non-listed companies are defined as

manufacturing non-listed companies that have recently been established or have relatively small financing methods that mainly rely on debt. The second is the financial early warning learning platform derived from the financial early warning model, which is suitable for the learning and practice of finance and economics courses, such as Financial and Commercial Data Visualization Analysis, and to be used by finance and economics majors and social learners in colleges and universities or higher vocational colleges.

3.1. Main content of the financial early warning system based on big data and deep learning technology

The financial warning system is mainly divided into a financial warning prediction section and a financial warning learning platform. The prediction section is mainly aimed at enterprise development, using preliminary data to establish the financial warning system. Enterprises can regularly input relevant financial data to obtain future financial forecasts. If there is a warning system, they can analyze the relevant data of the system and adjust the company's operations in a timely manner to prevent financial risks. On the other hand, the learning platform is mainly developed for social finance personnel and school students. Employed finance personnel can learn about financial warning through this platform, improve their professional level, enhance employment competitiveness, and better assist their company management personnel in analyzing financial risks. The learning platform can be adopted as a practical training course for students majoring in finance and economics. Schools can purchase platform accounts in bulk, while students can use the professional course knowledge learned to relate various financial factors with financial risks based on early warning models. This understanding and prevention of financial risks would improve the professional level and comprehensive ability of college students.

3.1.1. A financial warning model for enterprise use

The financial warning model includes two major modules: the financial warning model for listed companies in different industries and the financial warning model for non-listed companies in different industries. The former is based on a non-linear logistic indicator system model for different industries, including financial indicators based on big data analysis, non-financial indicators, and network data indicators, whereas the latter is based on a multivariate logistic indicator system model for non-listed companies, including financial indicators and non-financial indicators.

The models for manufacturing listed companies and non-listed manufacturing companies are described below.

3.1.2. A financial warning platform for learners to use

Based on the enterprise financial early warning system, the financial early warning platform for learners is derived. This platform includes financial report data and network data of listed and non-listed companies. According to the given data, students can build financial early warning models for the learning and practice of the Financial and Commercial Data Visualization Analysis course. Social learners can complete the learning of relevant courses of financial data visualization analysis through models and data, as well as improve their financial forecasting, analysis, and management capabilities.

3.2. Implementation path of the financial early warning system based on big data and deep learning technology
3.2.1. Financial warning for listed companies

Financial data and non-financial data of listed companies are derived from Guotai'an platform. Web crawlers are used to obtain massive non-financial data, including online public opinion and other data, on the web [9]. First, industry classification of listed companies is carried out, and a financial early warning

model is then constructed based on the financial and non-financial indicators. Excel, SPSS, web crawler, and Python are used.

3.2.2. Financial warning for non-listed companies

A financial indicator warning model is established based on the financial data of Shanghai, Shenzhen, Shandong SME Growth Enterprise Market and the intelligent financial sharing platform data. Based on the financial warning model of small and medium-sized enterprises, enterprises can import existing data into the model and provide timely feedback on financial warning indicators. Enterprises can adjust their operational management strategic planning based on the feedback.

3.2.3. Financial early warning learning platform

According to the financial early warning system model, the financial early warning learning platform is derived. This learning platform is suitable for the learning and practice of Financial and Commercial Data Visualization Analysis and other courses in colleges, higher vocational colleges, and universities.

4. Research prospects

At present, most financial early warning systems are targeted at listed companies. With the deepening of China's market economy reform and the rapid development of its capital market, there is little research on non-listed companies, compared to listed companies, owing to the significant gap between their scale, strength, financial management personnel, and systems as well as the difficulty in collecting financial data due to unclear sources. Small and medium-sized enterprises are small in scale, have flexible operations, and have few industry restrictions. However, these traits contribute to their vulnerability to macroeconomic impacts, poor asset and technological structure, and low survival ability. Due to the fierce market competition, these enterprises would be confronted with even more daunting challenges. Therefore, regular and necessary financial warning analysis will inevitably become a development trend for these enterprises in the future.

Disclosure statement

The author declares no conflict of interest.

Author contributions

The author confirms sole responsibility for the study conception and design as well as manuscript preparation.

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