

# The Business Failure Prediction Using Statistical Approach

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## ABSTRACT

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The topic of business failure is important because it can be used as a basis for policy making by stakeholders in a company or government. The results of business failure predictions can be used as company managers to take preventive measures for business failure. This study aim is to study the literature regarding the methods and results of predicting business failure from various sectors and regions. We used PRISMA (preferred reporting items for systematic reviews and meta-analyses) for conducting this research. As the result, we found twelve statistical methods for business failure prediction, including Hybrid Failure Prediction (HFP), Altman's Z-score Model, Data Envelopment Analysis (DEA), Logistic Regression (LR), Neural Networks (NN), Support Vector Machine (SVM), Kernel Fuzzy C-Means (KFCM), IN01, IN05, Ohlson Model, Cart-Based Model and Cash-Flow-Based Measures. The highest result obtained by using cart-based model for dataset of financial indicators of Slovak companies with 92,00% accuracy.

**Keywords:** Business Failure, Statistical Methodology, Review

## I. INTRODUCTION

One of the important issues of companies that many researchers study is the prediction of business failure. Companies can use information about bankruptcy predictions as a reference in making decisions. Predictions of business failure can be learned from the experiences of other companies and the company's existing internal conditions. From the results of this study, it can be seen the possibilities that will happen to the company in the future [1]–[4]

A company works because of the interaction between financial institutions, creditors, auditors, shareholders, employees, investors, customers and others. In other words, company performance is a moral and economic responsibility to all parties who interact with the company [5]–[8].

A business failure, especially at large estates, will have a social impact and decrease the economic performance of a region and even a country. With knowledge of business failure predictions, top-level management can make specific policies to reduce losses to the company. In addition, knowledge about

predicting business failure can be used by investors to develop new strategies for managing investments [9]–[12].

Due to the importance of predicting business failure, this study attempts to study the literature regarding the methods and results of predicting business failure from various sectors and regions. The business failure prediction methods, such as Logistic Regression (LR)[13], Neural Networks (NN) [14], Support Vector Machine (SVM) [15], Kernel Fuzzy C-Means (KFCM), Hybrid Failure Prediction (HFP), Data Envelopment Analysis (DEA), and so forth, will be reviewed.

This research can be useful for companies as a consideration for making predictive models in the company to determine the condition of their company in the future. To achieve the research goal, we defined the research questions of this research as follow:

- RQ1: What is the dataset used for business failure prediction research?
- RQ2: What is the statistical method used for predicting business failure?
- RQ3: What is the method that obtained the highest accuracy for business failure prediction?

## II. METHODS AND MATERIAL

This research is adapted PRISMA method which is introduced by Moher et al. in 2005 for review scientific articles [16]–[18]. The completed phases of research can be seen in Figure below.

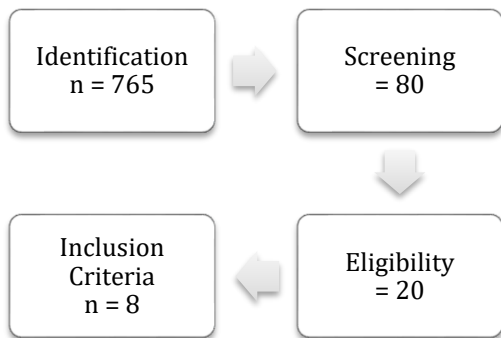


Figure 1: Research phase of this study

To complete phase of research, we find out the articles from, Science Direct, Google Scholar, *IEEE Xplore* and Wiley Online Library and ProQuest by using keyword “business failure prediction. The final data of this research after we conducted inclusion criteria phase can be seen in Table 1 below.

TABLE I  
DATA COLLECTION

Title	Publication	Source
Developing a business failure prediction model via RST, GRA and CBR	Expert Systems with Applications	[19]
Business failure prediction for publicly listed companies in china	Journal of Business & Management	[20]
Prediction of agricultural enterprises distress using data envelopment analysis	Proceedings of the 11th International Scientific Conference European Financial Systems	[21]
Financial ratio selection for business failure prediction using soft set theory	Knowledge-Based Systems	[22]
Business failure prediction using Fuzzy C-Means with kernel method	DEStech Transactions on Social Science, Education and Human Science	[23]

Title	Publication	Source
Predictive potential and risks of selected bankruptcy prediction models in the Slovak business environment	Journal of Business Economics and Management	[24]
Business failure prediction using cart-based model: A case of Slovak companies	Ekonomicko-manazerske spektrum	[25]
A comparison: accrual versus cash flow based financial measures' performance in predicting business failure	Journal of Accounting and Finance	[26]

### III. RESULTS AND DISCUSSION

To answer research questions as the result of this research, we elaborated it into three section, including dataset, statistical method and comparison of prediction result.

#### A. *Dataset*

In 2009, Lin et al. (2009) used dataset form Taiwan Stock Exchange Corporation (TSEC) for predicting corporate failure. Wang et al. (2010) used Chinese publicly listed companies for the period of September 2000-September 2008 for predicting corporate failure.

Bányiová et al. (2014) utilized dataset of Slovak agricultural companies from Ministry of Agriculture and Rural Development of the Slovak Republic. Xu et al. (2014) used data sets from Chinese listed firms

from the Shenzhen Stock Exchange and Shanghai Stock Exchange in China.

Moreover, Lu et al. (2016) used dataset from Shenzhen and Shanghai Stock Exchange, Gavurova et al. (2017) used CRIBIS (CRIF – Slovak Credit Bureau, s.r.o.) and Böhm et al. (2017) utilized Mattermark Dataset. Durica et al. (2019) used dataset of financial indicators of Slovak companies, and Bhandari et al. (2019) used COMPUSTAT dataset for prediction business failure. The completed list of dataset can be seen in Table below.

TABLE II  
DATASET OF BUSINESS FAILURE PREDICTION

Year	Data	Location	Source
2009	Taiwan Stock Exchange Corporation (TSEC)	Taiwan	[19]
2010	Dataset of delisted firms and matching non-delisted firms in China.	China	[20]
2014	Ministry of Agriculture and Rural Development of the Slovak Republic	Slovak Republic	[21]
2014	Shenzhen Stock Exchange and Shanghai Stock Exchange	China	[22]
2016	Shenzhen and Shanghai Stock Exchange	China	[23]
2017	CRIBIS (CRIF – Slovak Credit Bureau, s.r.o.)	Slovak	[24]
2017	Mattermark Dataset	USA	[27]
2019	Dataset of financial indicators of more than 100,000 Slovak companies	Slovak	[25]
2019	COMPUSTAT	Global	[26]

**B. Statistical Method**

Based on research result, we found twelve statistical methods that is implemented for predicting business failure as can be seen in Table below.

TABLE III  
STATISTICAL METHODS

Method	Source
Hybrid Failure Prediction (HFP)	[19]
Altman's Z-score Model	[20]
Data Envelopment Analysis (DEA)	[21]
Logistic Regression (LR)	[22]
Neural Networks (NN)	[22]
Support Vector Machine (SVM)	[22], [27]
Kernel Fuzzy C-Means (KFCM)	[23]
IN01	[24]
IN05	[24]
Ohlson Model	[24]
Cart-Based Model	[25]
Cash-Flow-Based (CF-Based) Measures	[26]

In 2009, Lin et al. proposed Hybrid Failure Prediction (HFP) for prediction business failure. The research used Rough Set Theory (RST) as a data pre-processor for Case Based-Reasoning (CBR), and that CBR utilized attribute weights derived from the Grey Relational Analysis (GRA), which showed the good performance in business failure prediction.

TABLE IV  
RESULT OF HYBRID FAILURE PREDICTION

Original data	Testing data	
	0 (Healthy firms)	1 (Management firms)
0 (Healthy firms)	9	1
1 (Management firms)	4	16
The average accuracy is 83.3%		

Source: [19]

In 2010, the research by Wang et al. predicted failure of Chinese companies using Altman's Z-score model. In 2014, Bányiová et al. proposed Data Envelopment Analysis (DEA) as new approach for corporate failure prediction in agriculture enterprises which is focused to efficiency of decision-making units.

DEA is a mathematical method based on linear programming that aims to analyse homogeneous subject groups in terms of the efficiency of the decision-making unit. In general, DEA can be done by calculating the technical efficiency of the decision making unit or the percentage of inputs that have been converted into outputs [21].

Moreover, Xu et al. (2014) conducted used three forecasting methods, including Logistic Regression (LR), Neural Networks (NN) and Support Vector Machine (SVM) to evaluate the corporate failure prediction performance.

The research using SVM also conducted by Böhm et al. (2017) to classify business model based on their performance using data mining techniques, Support Vector Machines (SVM) [27]. This research identifying the survival of business model with an accuracy of 83.6 % using SVM with detail in Figure below.

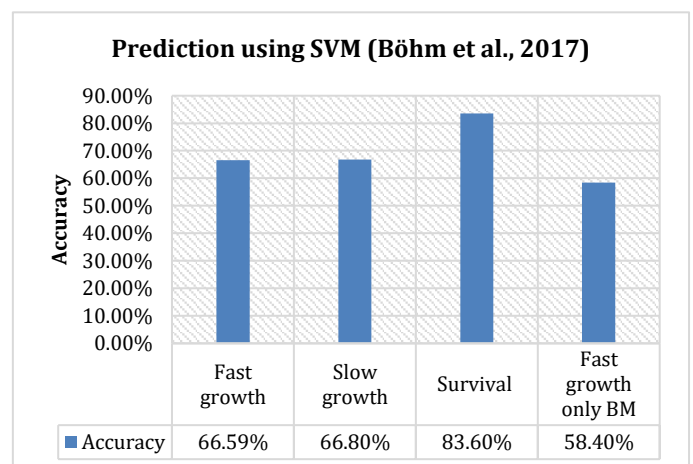


Figure 2: Result of prediction using SVM

In 2016, Lu *et al.* proposed and found Kernel Fuzzy C-Means (KFCM) with the polynomial kernel function obtained better performance than others. The other kernel that is used in this study are Gaussian, Polynomial, Sigmoid kernel function as elaborated below.

(1) Gaussian

$$K(x, y) = \exp\left(\frac{-\|x - y\|^2}{2\sigma^2}\right)$$

(2) Polynomial

$$K(x, y) = (a \cdot \langle x, y \rangle + C)^n$$

(3) Sigmoid

$$K(x, y) = (\tanh(a \cdot \langle x, y \rangle) + C)$$

The result of data processing using Kernel Fuzzy C-Means (KFCM) by using three kernel above is elaborated in Table below.

TABLE V  
RESULT OF KERNEL FUZZY C-MEANS (KFCM)

Group	Kernel function	Prediction accuracy (%)		
		Normal	ST	Total
1	Gaussian	93.87	61.61	77.74
2	Polynomial	93.24	65.84	79.54
3	Sigmoid	93.87	59.92	76.90

Source: [23]

In 2017, Gavurova *et al.* completed the research of bankruptcy prediction for Slovak business environment based on its predictive potential and risk by using IN01, IN05 and Ohlson Model. In 2019, Durica *et al.* also completed research regarding business failure in Slovak companies by using cart-based model.

Moreover, Bhandari *et al.* (2019) conducted study regarding accrual versus cash flow based financial measures' performance in predicting business failure.

In this study stated that CF-based measures are a better than the accrual-accounting-based measures for business failure predictor.

### C. Comparison of Prediction Result

Based on research data, Hybrid Failure Prediction (HFP) obtained accuracy 83,30%. The Altman's Z-score Model gained accuracy 87,50%. The Data Envelopment Analysis (DEA) achieved accuracy 69,77%. The Logistic Regression (LR) obtained accuracy 83,13%.

Moreover, Neural Networks (NN) obtained accuracy 84,30%. Support Vector Machine (SVM) gained accuracy 86,80%. Kernel Fuzzy C-Means (KFCM) achieved accuracy 77,74%. Altman's Z-score Model obtained accuracy 68,86%.

The IN01 achieved accuracy 70.00%. The IN05 achieved accuracy 66,57%. Ohlson Model gained accuracy 84,43%, Cart-Based Model gained accuracy 92,00%. The Cash-Flow-Based (CF-Based) Measures gained accuracy 82,17%.

The highest result obtained by using cart-based model for dataset of financial indicators of Slovak companies with 92,00% accuracy.

TABLE VI  
ACCURACY OF CART-BASED MODEL

Sample	Observed	Predicted		% Correct
		No	Yes	
Training	No	61,845	3,099	95,2%
	Yes	3,395	14,968	81,5%
	Overall	78,3%	21,7%	92,2%
Test	No	15,177	799	95,0%
	Yes	834	3,724	81,7%
	Overall	78,0%	22,0%	92,0%

Source: [25]

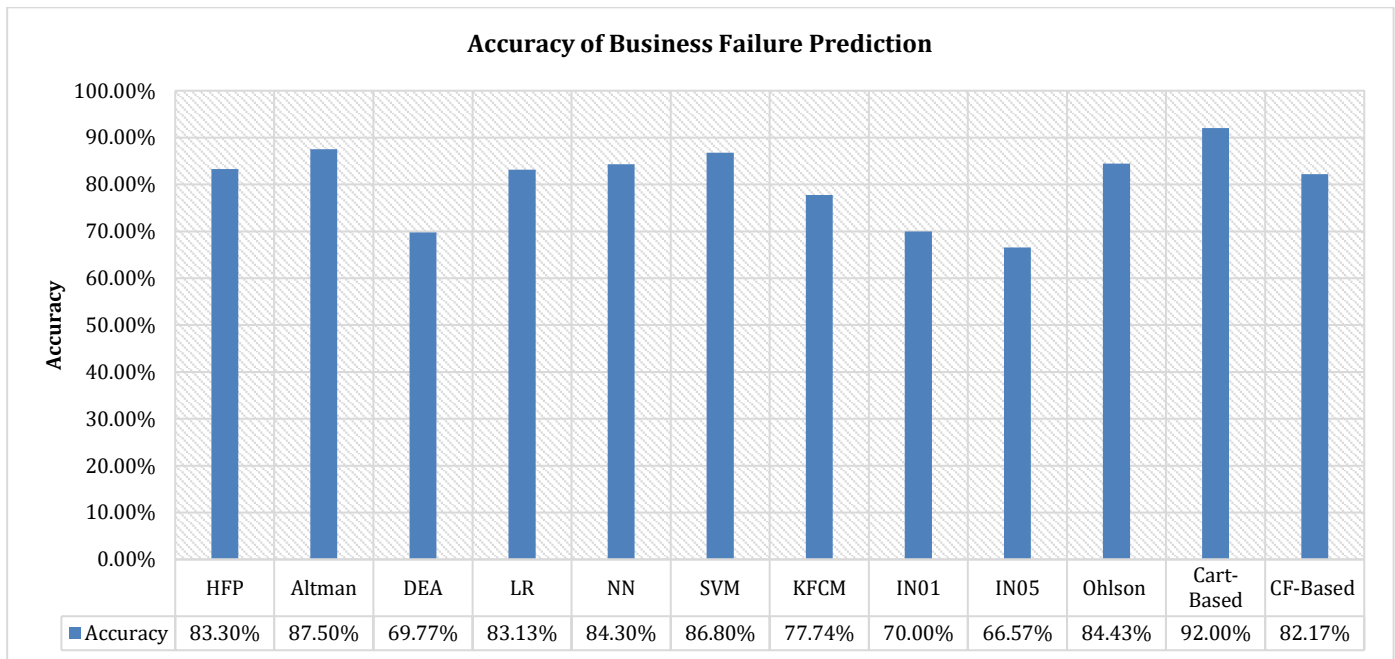


Figure 3: Result of business failure prediction

#### IV. CONCLUSION

In this research, we adapted PRISMA (preferred reporting items for systematic reviews and meta-analyses) for completing this research. As the result, we identified twelve statistical methods for business failure prediction, including Hybrid Failure Prediction (HFP), Altman's Z-score Model, Data Envelopment Analysis (DEA), Logistic Regression (LR), Neural Networks (NN), Support Vector Machine (SVM), Kernel Fuzzy C-Means (KFCM), IN01, IN05, Ohlson Model, Cart-Based Model and Cash-Flow-Based Measures. The highest result obtained by using cart-based model for dataset of financial indicators of Slovak companies with 92,00% accuracy.

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