

Risk Evaluation of Power Grid Investment Based on Logistic Regression Model

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Abstract: The power grid investment is affected by natural, economic, policy and many other uncertain factors. Long development cycle and large-scale funds are needed by the investment. Therefore, risk management is an important element in the process of power grid investment. In this paper, power sale price, power sale quantity, power purchase price and asset liability ratio are analyzed. Logistic theory is used to build risk evaluation model of the power grid investment. Case study suggests that the model is an efficient method to fit the risk evaluation of power grid investment projects, which can deal with many uncertain factors and evaluate the risk of projects.

Keywords: Power Grid Investment; Risk Evaluation; Logistic Regression Model; Probability Analysis; Empirical analysis

1. Introduction

The power grid investment refers to the investment related to the basic construction of power grid, including the power transmission and distribution projects of various voltage levels, small infrastructure projects and other special projects.^[1] The power grid investment has long development period and big capital scale, and meanwhile, affected by natural, economic, policy and many other uncertain factors. Therefore, the risk management is the important operation and management activity in the course of the power grid investment.

The power grid enterprise investment mode is similar to the investment mode of the real estate industry, both of which are affected by many macro factors. It is beneficial to transform the study of the power grid investment from the qualitative analysis to quantitative analysis by measuring the possible losses of the power grid enterprises in case of meeting small probability event assumed and other extreme

adverse conditions and analyzing the negative influences of these losses to the profitability and capital fund^[2]. In the paper, we will carry out the study on risk probability of the power grid investment with logistic model.

2. Risk model building of power grid investment

Logistic model is used for forecasting the probability of occurrence for some condition of the dependent variable in different changes of the independent variables by finding the key influence variables. Logistic regression requires that the value of the dependent variable Y is the categorical variable and the independent variable, as the risk factors, can be continuous variable, rank variable, categorical variable etc. Since there are many indexes impacting on the power grid investment risk, the logistic regression model is able to solve such problem well^[3]. In this model, it assumes that the probability of the risk for the power grid enterprise investment is a set of vectorial functions composed of the explanatory variable, which can be used for carrying out the data processing and evaluating the risk probability of the power grid enterprise, and this set of probability values is obtained by the maximum likelihood function^[4].

2.1. Model assumption

Some assumptions of the logistic regression model are very similar to those in the linear regression:

1. The data must be from the random sample.
2. The dependent variable is identified as the function of many independent variables.
3. The logistic regression is also sensitive to the multicollinearity, and the multicollinearity existing between the independent variables will lead to the expansion of the standard deviation.

The logistic regression model also has some assumptions different from those of the linear regression:

1. The dependent variable of the logistic regression model is a binary variable, which can be only taken two values, i.e. 0 or 1. The study focuses on the conditional probability of event occurrence.

2. The non-linear relationship is presented between the dependent variable and its variables in the logistic regression model.

3. The same distribution assumption which exists in the linear regression model is not required in the logistic regression model.

4. The assumptions on the distribution of independent variable are also not provided in the logistic regression model. Its variable can be continuous, discrete and virtual and it does not need to assume that the multivariate normal distribution is presented between them.

2.2. Logistic model building

The logistic regression steps are shown in Fig.1.

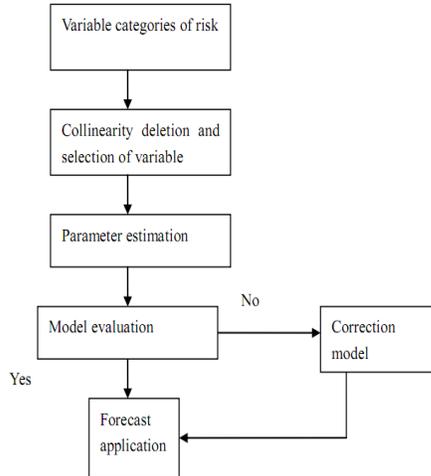


Fig.1. Logistic regression steps

In the logistic model, it assumes that the following non-linear relationship is presented between the probability of occurrence of dependent variable and its influence factors:

$$P_i(Y=1) = \frac{e^{(a_0 + \sum_{i=1}^k a_i X_i)}}{1 + e^{(a_0 + \sum_{i=1}^k a_i X_i)}} \quad (1)$$

It is obtained by transformation:

$$P_i(Y=1) = \frac{1}{1 + e^{-\left[a_0 + \sum_{i=1}^k a_i X_i \right]}} \quad (2)$$

Wherein, P_i indicates the probability to be obtained; X_{ki} indicates independent variable; a_0 indicates the constant term; and $a_1, a_2 \dots a_k$ indicate the regression coefficient of Logistic regression model.

The logistic regression model is a probabilistic nonlinear regression model. The ratio of the above formula is always changed between 0 and 1, which is the value range of the probability P_i . The logistic transformation is carried out on the above formula, and its linear equation is:

$$\ln\left(\frac{p_i}{1-p_i}\right) = a_0 + \sum_{i=1}^k a_i X_i \quad (3)$$

3. Empirical analysis

In the paper, we build the risk evaluation model of the power grid investment with logistic regression theory on the basis of analyzing the risk factors impacting on the power grid investment ability, and thus find the important influence factors therein.

3.1. Risk factors of power grid investment

Considering that there are many influence factors of power grid investment ability, we recognize the four independent variables impacting on the risk of the power grid investment ability in combination of the previous experiences, including the power sale price X_1 , power sale quantity X_2 , electricity purchasing cost X_3 and asset-liability ratio X_4 of the big consumer. In the dependent variable, we take the return on assets as the standard of measuring whether the enterprise business is booming, which can reflect the investment management risk of the power grid enterprise, and comprehensively reflect the production and operation status of the enterprise^[5].

Return on assets = total enterprise profit / total average assets. In Table 1, it shows the situation of return on assets of power grid company in a province in 2003-2013.

Table 1 Return on assets in 2003-2013

Years	Return on Assets	Y
2003	0.33%	1
2004	0.75%	1
2005	0.81%	1
2006	1.61%	0
2007	2.60%	0
2008	0.23%	1
2009	0.09%	1
2010	2.40%	0
2011	2.22%	0
2012	2.82%	0
2013	2.54%	0

Considering that the dependent variable of the logistic regression model can be taken 0 or 1 only, we measure that the average return on assets of the power grid company in a province in the past 20 years is 1.5% by combining the investment status of power industry in the paper. Therefore, when the profit rate in one year is higher than 1.5%, it is thought that the investment risk is small, the power grid investment is relatively booming, and the dependent variable is set as 0; and when the profit rate in one year is lower than 1.5%, it is thought that the investment is not booming, and the dependent variable is set as 1.

Table 2 Standardized Data

Years	X ₁	X ₂	X ₃	X ₄	Risk
2003	-1.45	-1.43	-1.42	-0.32	1
2004	-1.00	-1.11	-1.11	-0.54	1
2005	-0.59	-0.99	-0.97	0.17	1
2006	-0.50	-0.67	-0.66	0.22	0
2007	-0.40	-0.29	-0.29	0.46	0
2008	-0.15	-0.05	-0.07	0.84	1
2009	0.13	0.16	0.15	1.36	1
2010	0.25	0.66	0.62	1.31	0
2011	0.26	0.96	0.91	-1.92	0
2012	1.75	1.23	1.26	-1.02	0
2013	1.71	1.53	1.57	-0.56	0

X₁ is power sale price. X₂ is power sale quantity. X₃ is electricity purchasing cost. X₄ is asset-liability ratio. The electricity purchasing cost and asset-liability ratio have the positive influence on the investment risk, namely, the electricity purchasing cost and asset-liability ratio are in proportion to the investment risk of the power grid enterprise. The power sale quantity and power sales price have the negative influence on the investment risk. When the power sale quantity and power sales price are increasing, the financing capacity of the enterprise is enhancing and the investment risk is reducing.

3.2. Primary election of variable and parameter estimation

3.2.1 Collinearity inspection

Since the relatively high correlation may be presented between the primary variables, the correlation test shall be carried out on the primary variables before carrying out the regression analysis, so as to eliminate the influence of multicollinearity to some extent^[6]. The correlation analysis shall be shown in Table 3, and it can be seen that the correlation coefficient of the variable is very high.

Table 3 Correlation Coefficient of Independent Variable

	X ₁	X ₂	X ₃	X ₄
X ₁	1			
X ₂	0.94025	1		
X ₃	0.949174	0.999559	1	
X ₄	-0.22563	-0.23079	-0.23322	1

3.2.2 Parameter estimation

Four selected variables are introduced into the logistic regression model and the set significance level P is 0.1. The final model is determined by forcibly entering the regression method, and the fitting result is shown in Table 4 and Table 5^[7]. Thus, the risk evaluation model of the power grid investment ability in a province is obtained.

Table 4 Classification Table (The cut value is .500.)

Observed		Forecasted			Correction of percentage
		y		0	
Step1	y	0	6		0
		1	0	0	5
	Total percentage				

Table 5 Fitting Result

		B	Wals	df	Sig.	Exp(B)
Steps	X ₁	-1.75	.003	1	.053	.000
	X ₂	-1.95	.003	1	.055	.000
	X ₃	1.45	.003	1	.054	.
	X ₄	2.45	.003	1	.053	.
	Constant	-1.58	.003	1	.053	.000

In Table 5, it shows the regression coefficient of the variables. If the confidence level is 90%, all the variables are passed P inspection. Thus, the logistic regression equation of fitting can be written.

$$P_i(Y=1) = \frac{1}{1 + e^{(-1.58 + 1.75X_1 + 1.95X_2 - 1.45X_3 - 2.45X_4)}} \quad (4)$$

3.2.3 Significance test of model

In Table 6, it shows the indexes on current goodness of fit, which include -2log likelihood value and two pseudo determination coefficients. -2log likelihood value is inversely proportional to the goodness of fit of the model^[8-9]. Here, when it is 0.00, the goodness of fit is very ideal. What the two pseudo determination coefficients reflect is that the independent variable explains the proportion of variation of dependent variable to its total variation, and it can be seen from the result in Table that, the independent variable explains that the proportion of variation of dependent variable to its total variation is 100%. Hosmer-Lemeshow test is used, and its null hypothesis is that the fitting is complete and full. It can be seen from the result in Table 7 that its half-probability value is 0.534, which shows that it cannot refuse the null hypothesis, namely, shows that the fitted value of the model is relatively satisfactory.

Table 6 Model Summary

Steps	-2 log likelihood	Cox & Sne11 R-square	Nagelkerke R-square
1	.000 ⁿ	.748	1.000

Since it has reached the maximum iterations, the estimation is terminated when the iterations are 20, and we cannot find the final solution.

Table 7 Hosmer and Lemeshow Test

Steps	Chi-square	df	Sig.
1	6.052	7	.534

4. Conclusion

The successful experiences of the bank and real estate enterprise on the risk management can be referenced by the power grid investment. We shall consider the influence of "abnormal but reasonable" impact to the stability of the power grid investment in the daily operation and management.

In the four selected influence factors of the independent variable, the influence of the asset-liability ratio is maximum, followed by the power sale quantity, power sale price and electricity purchasing cost. The power sale quantity and power sale price are negative correlation with the investment risk probability. The electricity purchasing cost and asset-liability ratio are positive correlation with the investment risk probability. Based on this, we can select the asset-liability ratio which having the biggest influence on the risk of the power grid investment ability as the situational factor to build the pressure test. This model can also be used for estimating the probability of the risk arisen from the investment of the future power grid enterprise by forecasting the power sale quantity and power sale price.

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