Journal of Engineering and Applied Sciences 12 (10): 2618-2622, 2017
ISSN: 1816-949X

An Empirical Study on Financial Factors Affecting Corporate Insolvency Growth Rate Using AREM

Chang-Ho An
Department of Financial Information Engineering (Statistics), Seokyeong University,
Seokyeong-ro, 124 Seongbuk-gu, 02713 Seoul, Koran

Abstract: The current global economy is very complex and uncertain. The slow growth trend continues due to the combination of many risk factors such as the US interest rate hike, China's export slump caused by the economic crisis, Japan's Yen weakness, emerging nation's crisis due to China Shock and falling oil prices due to shale oil. Due to the long-term global economic downturn, Korea's economy has been hit hard and the liquidity of companies has deteriorated, resulting in the rapid spread of insolvent companies. Therefore, companies need to find and analyze financial factors affecting corporate insolvency in order to minimize social and economic losses caused by corporate insolvency. Therefore, in this study, we performed the ratio analysis using the financial statements of the image, broadcasting and communications and information service industries and analyzed the financial factors of the insolvency and tested the suitability of the model by applying the Auto Regressive Error Model (AREM) which is a time series model to the analysis of financial statement and comprehensive income statement. It was confirmed that Current Ratio (CUR) and Net Working Capital Ratio (NWCA) in the liquidity analysis, Debt Ratio (DER) and Net Worth Ratio (NWA) in the stability analysis, Gross Profit margin (GPR) in the profitability analysis, Non-Current Asset Turnover (NCAT) and Receivable Turnover (RET) in the activity analysis and Net Profit Gross Rate (NPGR) in the growth analysis were the financial factors that had effect on the corporate insolvency growth rate. It was also confirmed that the coefficient of determination including the error model indicating the explanatory power of the model in the goodness of fit test was very suitable and the results of the Generalized Durbin-Watson (GDW) test confirmed that there was no autocorrelation in the error term of the final model.

Key words: Ratio analysis, Autoregressive Error Model, coefficient of determination, Generalized Durbin-Watson test, residual analysis

INTRODUCTION

The economic situation in Korea is very serious due to many risk factors such as investment and consumption slowdown due to political uncertainty of the Brexit, sharp rise in interest rates in accordance with protectionist trade policies and expansionary fiscal policies of the US government, a sharp fall in the real estate market and domestic demand in China and the delayed economic recovery in resource-rich countries due to the sustaining low resource prices. In recent years, the recession of the global economy has been prolonged and has had a great impact on the entire industry in Korea. We expect that the risk of insolvency in liquidity, stability and profitability of Korean companies will continue to increase. When a company becomes insolvent and bankrupt, it causes serious economic loss to the investors, employees, customers, creditors, consumers and government authorities that are associated with the company as well as social unrest. Therefore, we should strive to prevent insolvency in advance and to minimize the economic and social losses caused by corporate insolvency. Efforts to predict corporate default by using corporate financial information have been studied for a long time and the existing research is as follows: corporate insolvency prediction model was first developed by univariate analysis (Beaver, 1966), a multivariate discriminant analysis technique that utilizes the financial ratios of firms as a discriminant variable for credit risk has been proposed (Altman, 1968) and a new forecasting model that combined financial ratios which were predictive indicators used by Beaver was proposed (Deakin, 1972). A logit analysis model that pointed out the problems of multivariate discriminant analysis was presented (Ohlson, 1980), a probit model that improved the logit model was proposed (Zmijewski, 1984) and the predictability of airline's defaults was predicted by neural network using the airline's financial ratios (Davalos *et al*., 1999). Recently, it has been confirmed that the activity indicator is an important variable for prediction of corporate default (Davalos *et al*., 2010) and it was highlighted that the growth index is also an important variable for prediction of corporate default (Kim, 2011). In terms of the effect of the debt ratio on the governance structure and the rate of capital restructuring, it is found that managers with high corporate governance are more likely to monitor investors, so management should make decisions to maximize investor's interests rather than their own interests (Morellec *et al*., 2012) and dummy variables were added to reduce the effects of unobserved time series on capital structure (Chang *et al*., 2014). A comparison of housing price index forecasting models was made using time series models (Lim, 2014). Finally, the ratio of unlisted firms was analyzed and a multiple regression model was proposed (Chang-Ho, 2016). As the study utilizing statistical models in the IT industry, there is one that analyzed time series data input through a cycle in the internet of lightweight devices (Chae *et al*., 2016) and as the study using data mining, there is Facebook insights data analysis (Cha *et al*., 2016), etc. In this study, we try to find financial factors of corporate default by applying Autoregressive Error Model which is a time series model through analysis of ratio of financial statements of image, broadcasting and communication and information service industries.

MATERIALS AND METHODS

Auto-regressive Error Model: Since, the financial data used in this study are time series data observed at the time of T observations from the observed object, the error term generally has autocorrelation. In other words, when estimating the mean of the time series variables using the regression model and then calculating the residuals, the residuals have a correlation with their past values. The Autoregressive Error Model in which the error term follows the autoregressive model is a model in which y_{t-k}, $k \geq 1$, the value at time (t-k) has important information to explain y_t when y_t is defined as a value observed at time t. It is defined as follows:

$$\begin{aligned} y_t &= X'_t\beta+\varepsilon_t,\ t = 1, 2, ..., T \\ \varepsilon_t &= \phi_1\varepsilon_{t-1}+\phi_2\varepsilon_{t-2}+...+\phi_p\varepsilon_{t-p}+\nu_t \\ \nu_t &= \text{i.i.d}N(0, \sigma_v^2) \end{aligned} \quad (1)$$

Here, the model of the error term ε_t is called an autoregressive model with order of p and is simply expressed as an AR (p) model. ν_t is an independent and identically distributed random variable with an average of 0 and a variance of σ_v^t and is assumed to be independent of ε_{t-k}, $k \geq 1$.

The auto-correlation test of the error term and the determination of AR (p): The existence of the autocorrelation of the error term ε_t is tested using the residual $\hat{\varepsilon}_t$ of ε_t obtained by the Ordinary Least Squares estimator of (OLS) β and ε_t uses the Generalized Durbin-Watsonstatistic (GDW) as the autocorrelation test. The GDW statistic is used to test the alternative hypothesis $H_1 = \phi_j > 0$ against the null hypothesis $H_0 = \phi_j > 0$ under the condition $\phi_1 = \phi_2 = ... = \phi_{j-1} = 0$ when the error term model is $\varepsilon_t = \phi_j\varepsilon_j + \nu_t$ and the test statistic for this is as follows (Vinod, 1973):

$$d_j = \frac{\sum_{t=j+1}^{T}(\hat{\varepsilon}_t - \hat{\varepsilon}_{t-j})}{\sum_{t=1}^{T}\hat{\varepsilon}_t^2} \quad (2)$$

However, it is known that the GDW statistic d_j is biased when the independent variable X_t has a lagged variable of the dependent variable y_t (Dezhbakhsh, 1990). In order to determine the order AR (P) of the error term, it is generally necessary to select the 1/3 power of the entire observation and obtain the residuals again to test whether there is a correlation through the Q-test. When the time series data follow ARMA (p, q) it is possible to sufficiently reflect the autocorrelation of ARMA (p, q) (Said and Dickey, 1984).

Method of estimation of parameter: Since, the correlation coefficient matrix Ω is a function of in the Auto-regressive Error Model $\phi_1, \phi_2, ..., \phi_p$, the consistent estimator of the AR coefficients is obtained by the following method in order to obtain an estimate of the correlation coefficient matrix Ω. The first method is to obtain the auto-correlation function of the residual $\hat{\varepsilon}_t$ obtained by regressing the dependent variable y_t to the independent variable $x_{t1}, x_{t2}, ..., x_{tp}$ by using the least squares estimator to solve the Yule-Walker equation satisfying this autocorrelation function and then to estimate the consistent estimator of $\phi_1, \phi_2, ..., \phi_p$. The second method is an extension of Durbin's method. The regression coefficient estimator of $y_{t-1}, y_{t-2}, ..., y_{t-p}$ which is obtained by regressing dependent variable y_t to independent variables $y_{t-1}, y_{t-2}, ..., y_{t-p}$ and $x_{t-1}, x_{t-2}, ..., x_{t-p}$ is assumed to be an estimate of $\phi_1, \phi_2, ..., \phi_p$. Let $\hat{\Omega} = \Omega(\hat{\phi})$ by using the estimators obtained by the first and second methods and solve:

$$\hat{\beta}_{FGLS} = \left(X'\hat{\Omega}^{-1}X\right)X'\hat{\Omega}^{-1}y$$

Then, the estimator becomes a Feasible Generalized Least Square (FGLS) estimator.

RESULTS AND DISCUSSION

Auto-correlation and fitness test of error term: A generalized Durbin Watson test was conducted to confirm the presence of autocorrelation in error term ε_t and as a result, there was an autocorrelation in all the lags of the liquidity, stability, profitability, activity and growth analyses. As the result of fitness test, the explanatory power of the model is very low: $R^2 = 0.0538$ in liquidity analysis, $R^2 = 0.055$ in stability analysis, $R^2 = 0.0883$ in profitability analysis, $R^2 = 0.0808$ in activity analysis and $R^2 = 0.0228$ in growth analysis.

Auto-regressive Error Model estimation and testing: Since, the auto-correlation exists in the error term, the autocorrelation test results of the error term by the backward elimination method are as follows. In the liquidity analysis, the time lags 1, 4, 5, 8, 9, 10 were finally significant and the total R^2 including the error model showed high fitness of 0.8792. As a result of the parameter estimation β, the independent variables CAR and QUR were not significant. In the stability analysis, the time lags 1, 4, 5, 6, 8, 9, 10 were finally significant and the total R^2 including the error model showed high fitness of 0.8848. As a result of the estimation of parameter β, the independent variables TBBPA and ICR were not significant. In the profitability analysis, the time lag 1 was finally significant and the total R^2 including the error model was 0.8843. As a result of the estimation of parameter β, independent variables EBTR, OPC, NISE, OPR, EATA, IEIBITA and ROI were not significant. In the activity analysis, the time lags 1, 4, 5, 6, 8, 9, 10 were finally significant and the total R^2 including the error model showed high fitness as 0.8939. As a result of the estimation of parameter β, the independent variables TAT, EQT, INT and PAT were not significant. In the growth analysis, the time lags 1, 3, 4, 5, 7, 8, 9, 11 and 12 were finally significant and the total R^2 including the error model was 0.8983. As a result of the estimation of the parameter β, the independent variable TAGR was not significant.

The final model of Auto-regressive Error Model: The final results of the Auto-regressive Error Model on the corporate default growth rate using only the significant time lags after removing the insignificant independent variables in the above five analyses are shown in Table 1-5.

Estimation result was $\hat{\beta}_0 = 21.2749$, $\hat{\beta}_1 = -0.0408$ and $\hat{\beta}_2 = -0.1015$. The total R^2 including the error model after eliminating the independent variables CAR and QUR was 0.9020 indicating high explanatory power. Therefore, the final model is as follows:

Table 1: Final model of liquidity analysis

Estimates of auto-regressive parameters

Lags	Coefficient	SE	t-values
1	-0.923305	0.067125	-13.76
4	0.011422	0.119615	0.10
5	-0.013905	0.119589	-0.12
8	0.013646	0.119684	0.11
9	-0.002561	0.143216	-0.02
10	0.074936	0.107002	0.70

Parameter estimates

Variables	df	Estimate	SE	t-values	Approx pr>|t|
Intercept	1	21.2749	4.6240	4.60	<0.0001
CUR	1	-0.0408	0.0144	-2.83	0.0057
NWCA	1	-0.1015	0.0284	-3.57	0.0006

Yule-walker estimates; total $R^2 = 0.9020$

Table 2: Final model of stability analysis

Estimates of auto-regressive parameters

Lags	Coefficient	SE	t-values
1	-0.923234	0.067505	-13.68
4	0.010584	0.120404	0.09
5	-0.026599	0.144081	-0.18
6	0.007012	0.127305	0.16
8	0.007012	0.127302	0.06
9	-0.003262	0.144091	-0.02
10	0.075317	0.107633	0.70

Parameter estimates

Variables	df	Estimate	SE	t-values	Approx pr>|t|
Intercept	1	21.2960	4.6505	4.58	<0.0001
DER	1	-0.0413	0.0145	-2.86	0.0053
NWA	1	-0.1015	0.0286	-3.56	0.0006

Yule-walker estimates; total $R^2 = 0.9021$

Table 3: Final model of profitability analysis

Estimates of auto-regressive parameters

Lags	Coefficient	SE	t-values
1	-0.907190	0.043627	-20.79

Parameter estimates

Variables	df	Estimate	SE	t-values	Approx pr>|t|
Intercept	1	17.9529	6.9031	2.60	0.0108
GPR	1	-0.0450	0.0152	-2.97	0.0038

Yule-walker estimates; total $R^2 = 0.8952$

Table 4: Final model of activity analysis

Estimates of auto-regressive parameters

Lags	Coefficient	SE	t-values
1	-0.899868	0.069525	-12.94
4	-0.009534	0.119579	-0.08
5	-0.017991	0.141089	-0.13
6	0.019519	0.125748	0.16
8	0.017901	0.125745	0.14
9	-0.045863	0.141081	-0.33
10	0.108072	0.107433	1.01

Parameter estimates

Variables	df	Estimate	SE	t-values	Approx pr>|t|
Intercept	1	17.7688	4.4008	4.04	0.0001
DER	1	-0.0485	0.0211	-2.12	0.0301
NWA	1	-0.0391	0.0157	-2.48	0.0149

Yule-walker estimates; total $R^2 = 0.9003$

Table 5: Final model of growth analysis

Lags	Coefficient	SE	t-values
	Estimates of auto-regressive parameters		
1	-0.875797	0.085279	-10.27
3	-0.046717	0.129156	-0.36
4	0.030770	0.141344	0.22
5	-0.018800	0.129285	-0.15
7	0.002623	0.129302	0.02
8	0.012415	0.141378	0.09
9	0.018214	0.129242	0.14
11	-0.026124	0.128474	-0.20
12	0.096968	0.109247	0.89

Variables	df	Estimate	SE	t-values	Approx pr>|t|
		Parameter estimates			
Intercept	1	20.9106	4.1561	5.03	<0.0001
SGR	1	-0.0688	0.0390	-1.76	0.0815
NWGR	1	-0.0385	0.0310	-1.24	0.2178
NPGR	1	-0.0623	0.0198	-3.14	0.0023

Yule-walker estimates; total $R^2 = 0.9080$

$$\widehat{CRIC_t} = 21.2749\text{-}0.0408\ CUR_{t,1}\text{-}0.1015\ NWCA_{t,2}+\hat{e}_t$$
$$\hat{e}_t = 0.9233\hat{e}_{t-1}\text{-}0.0114\hat{e}_{t-4}+0.0139\hat{e}_{t-5}\text{-}0.0136\hat{e}_{t-8}+0.0025\hat{e}_{t-9}\text{-}0.0749\hat{e}_{t-10}$$

Estimation result was $\hat{\beta}_0 = 21.2749$, $\hat{\beta}_1 = -0.0408$ and $\hat{\beta}_2 = -0.1015$. The total R^2 including the error model after eliminating the independent variables TBBPA and ICR was 0.9021 indicating high explanatory power. Therefore, the final model is as follows:

$$\widehat{CRIC_t} = 21.296\text{-}0.0413\ DER_{t,1}\text{-}0.1015\ NWA_{t,2}+\hat{e}_t$$
$$\hat{e}_t = 0.9232\hat{e}_{t-1}\text{-}0.0105\hat{e}_{t-4}+0.0265\hat{e}_{t-5}\text{-}0.0203\hat{e}_{t-6}-0.007\hat{e}_{t-8}+0.0032\hat{e}_{t-9}\text{-}0.0753\hat{e}_{t-10}$$

Estimation result was $\hat{\beta}_0 = 17.9529$ and $\hat{\beta}_1 = -0.0445$. The total R^2 including the error model after eliminating the independent variables EBTR, OPC, NISE, OPR, EATA, IEIBITA and ROI was 0.8952 indicating high explanatory power. Therefore, the final model is as follows:

$$\widehat{CRIC_t} = 17.9529\text{-}0.045\ GPR_{t,2}+\hat{e}_t$$
$$\hat{e}_t = 0.9071\hat{e}_{t-1}$$

Estimation result was $\hat{\beta}_0 = 17.7688$, $\hat{\beta}_1 = -0.0485$ and $\hat{\beta}_2 = -0.0391$. The total R^2 including the error model after eliminating the independent variables TAT, EQT, INT and PAT was 0.9003, indicating high explanatory power. Therefore, the final model is as follows:

$$\widehat{CRIC_t} = 17.7688\text{-}0.0485NCAT_{t,1}\text{-}0.1015RET_{t,2} + \hat{\varepsilon}_t$$
$$\hat{\varepsilon}_t = 0.8998\hat{\varepsilon}_{t-1}\text{-}0.0095\hat{\varepsilon}_{t-4} + 0.0179\hat{\varepsilon}_{t-5}\text{-}0.0195\hat{\varepsilon}_{t-6} + 0.0179\hat{\varepsilon}_{t-8}\text{-}0.0458\hat{\varepsilon}_{t-9}\text{-}0.108\hat{\varepsilon}_{t-10}$$

Estimation result $\hat{\beta}_0 = 20.9106$ and $\hat{\beta}_1 = -0.0623$. The significant independent variable is NPGR and the total R^2 including the error model after eliminating the insignificant independent variables was 0.9080, indicating high explanatory power. Therefore, the final model is as follows:

$$\widehat{CRIC_t} = 20.9106\text{-}0.0623NPGR_{t,1}+\hat{e}_t$$
$$\hat{e}_t = 0.8757\hat{e}_{t-1}\text{-}0.0467\hat{e}_{t-3}+0.0307\hat{e}_{t-4}\text{-}0.0188\hat{e}_{t-5}\text{-}0.0026\hat{e}_{t-7}\text{-}0.0124\hat{e}_{t-8}\text{-}0.0182\hat{e}_{t-9}\text{-}0.0261\hat{e}_{t-11}\text{-}0.0969\hat{e}_{t-12}$$

The results above are the result of analyzing the financial factors influencing the corporate insolvency growth rate by using the financial information of the image, broadcasting and communication and information service industries by applying the Autoregressive Error Model. As Table 1-5 show the research model that finds the financial factors is very reasonable. Therefore, it is thought that it will reduce the socioeconomic loss of the nation and help the establishment of the management plan of the Korean companies. However, in order to increase practical utilization, it is necessary to compare and analyze the financial factors of each industry of all industries classified in industry standard classification table such as manufacturing industry, finance and insurance industry, etc. In addition, continuous research including both financial and non-financial information is required.

CONCLUSION

The results of this study can be used as an empirical basis for the decision of the range and intensity of corporate restructuring and corporate credit analysis in financial institutions, industrial policy, economic planning and financial market policy in government and management strategies and long-term management plan in management administration.

SUGGESTIONS

It is also suggested that steady research is needed to find out the financial and non-financial factors affecting corporate default by applying many methods such as vector time series analysis, artificial neural network analysis, etc. that identify the relationship between financial statement and income statement.

ACKNOWLEDGEMENT

This study was supported by research funding of Seokyeong University in 2017 school year.

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