Review paper

AN ESTIMATION OF WORKING CAPITAL MANAGEMENT ON PROFIT USING LOGISTIC REGRESSION AND DISCRIMINANT ANALYSIS

ABSTRACT

Aims: This paper estimates working capital management on profit using logistic regression and discriminant analysis on manufacturing and industrial firms in Ghana.
Study design: Research Paper.
Place and Duration of Study: Ghana, Secondary data for 2009 to 2014.
Methodology: Data in the form of ratios were computed from the audited annual financial reports of 13 manufacturing and industrial firms listed on the Ghana Stock Exchange covering the period from 2009 to 2014. This enables us to see whether a firm is profitable in a year or not.
Results: The results showed that the logistic regression of the dependent variable (Profit) on the independent variables such as Average Collection Period etc. was found to be significant and that there is no difference in variances for two firm classifications and this implies that a linear discriminant function $\hat{m}_{(2)}$ is effective in discriminating a firm who has managed its working capital on profit from one which did not.
Conclusion: This study showed that the binary logistic regression model estimates correctly at least 75% of firm's likelihood of managing working capital on profit while correctly discriminating the firms as having an effective management.

Keywords: Binary logistic regression, working capital management, profitability, discriminant analysis.

1. INTRODUCTION

Recently, management of working capital has been a major concern to financial economists and accountants because it has an effect on the profit of firms. Economist and financial analyst have over the years conducted research on the relationship between working capital management and the profit of the firm. Chiou, Li and Han-Wen [4] defined working capital management as the involvement of measures and policies by using firm's current assets and

liabilities in such a way that will sustain the working capital. Company's choice on policies to manage firm's working capital have an effect on profitability.

Filbeck and Krueger [6] suggested that the progress of a firm depends on the ability of the managers to effectively supervise inventories, receivables and payables. Management of working capital in underdeveloped countries such as Ghana is imperative as creditors give short-term credit to the long-term market. This may be due to the relatively higher inflation rate in Ghana compared to other developed or developing countries [1]. Due to scarcity of the finances of firms, there is the need for firms to effectively and efficiently manage their working capital to gain profit.

Irfan [7] sampled 253 non- financial listed companies of Karachi Stock Exchange to investigate the impact of working capital management on the performance of the firm in Pakistan. The Ordinary Least Square Regression, Logistic regression and Pearson Correlation techniques were used to analyze the results from the balance sheet of Stock Listed Companies on Karachi Stock Exchange published by State Bank of Pakistan. He identified from the result that only current asset over total sales from the five chosen components of working capital management showed significant negative association between working capital management and both proxies of performance which is return on assets and return on equity whereas current asset over total asset, debtor's turnover, inventory turnover and current ratio showed significant positive association with performance. The results from the Logistic regression showed that current ratio, current assets over total asset and current assets over total sales affect profit of firms.

Deloof [5] used correlation and regression analysis to examine a sample of 1,009 Belgian non-financial firms for a period of 1992-1996 and identified a significant negative association between gross operating income and the number of day's accounts receivable, accounts payable and inventories of Belgian firms. He recommended that managers must minimize the inventories and days of account receivable in order to increase profits of corporate firms.

Mathuva [10] used Pearson and Spearman's correlations, the pooled ordinary least square and the fixed effects regression models to assess the effect of the components of working capital management components on the profit of corporate firms using a sample of 30 firms listed on the Nairobi Stock Exchange for the periods 1993 to 2008. He found that there a highly significant negative association existed between accounts collection period and

profitability and a highly significant positive association between the inventory conversion period, average payment period and profitability.

Almazari [3] analyzed a sample of 8 Saudi cement manufacturing companies listed in the Saudi Stock Exchange for the period of 5 years from 2008-2012 to assess the association between the working capital management and the firms' profitability. The study used Pearson Bivariate correlation and regression analysis and discovered that current ratio had the highest impact on profit and suggested that the cement firms must set a trade-off to prevent liquidity or profit from being affected. He also identified that an increase in firm size result in increase in profit. Also profit decreases when there is an increase in debt financing. Hence a high correlation between the working capital management and profitability using linear regression.

Akoto, Awunyo-Vitor and Angmor [1] investigated the correlation between working capital management practices and profitability of listed manufacturing firms on Ghana Stock Exchange using data collected from annual reports of all the 13 listed manufacturing firms in Ghana covering the period from 2005-2009. Employing panel data methodology and regression analysis, the study identified a significant negative correlation between Profitability and Accounts Receivable Days. Also a significant positive correlation existed between the firms' Current Asset Ratio, Current Asset Turnover, Cash Conversion Cycle, Size and profitability of firms. The study recommended that incentives need to be generated by managers to minimize accounts receivable to 30 days to create value for their shareholders.

2. METHODOLOGY

We propose a methodology that seeks to address the problem of inadequate response on working capital management which is clear in most stock exchange all over the world. The second seeks to discriminate firms with regards to them having effective working capital management on profit.

2.1 Estimation of Working Capital Management on Profit

Suppose D_i is the ith firm working capital management on profit for t years and K_i is the ith firm's profitability in a year (nominal) for 6 years. Then on average, the ith firm works $h_i = \frac{K_i \times t}{6} (i = 1, 2, 3, ..., n)$ on profit in t years, where n is the total number of firms who had acquire (non-zero) profit in the last t years at the time of study. Next, let

$R_i = \frac{D_i}{h_i}, i = 1, 2, ..., n$ then a firm is said to have managed its working capital on profit if

$R_i > m, \text{where} \, 0 < m < 1$

For the ith firm, we define a dichotomous variable y_i such that $z_i = \begin{cases} 1 \text{ if } R_i > m \\ 0, \text{otherwise} \end{cases}$, where m is the threshold. Menard [9] examined the use of the binary logistic regression for a dichotomous outcome variable with covariates which are statistically significant to show the likelihood of belonging to any of the two categories

Now suppose the binomial logistic regression model:

$$\log it(\lambda_i) = \beta_0 + \beta_1 X_1 + ... + \beta_k X_k + \varepsilon \quad (1)$$

$\lambda_i = P(y_i = 1 / X_1, X_2, ..., X_k)$ is significant and correctly classifies at least 75% of firms who have managed their working capital on performance (Alan, 2012), then an estimate of the model can be written as:

$$\log it(\hat{\lambda}_i) = \hat{\beta}_0 + \hat{\beta}_1 X_1 + ... + \hat{\beta}_k X_k \quad (2)$$

where $\hat{\beta}_i, i = 0, 1, ..., k$ are estimates of the parameters β_i and $\hat{\lambda}_i$ is the estimate of the likelihood of a firm managing its working capital on profit.

Given the explanatory variables $X_1, X_2, ..., X_k, \lambda_i$ can be estimated as follows:

$$\hat{\lambda}_i = \frac{\exp\left\{\hat{\beta}_0 + \hat{\beta}_1 X_1 + ... + \hat{\beta}_k X_k\right\}}{1 + \exp\left\{\hat{\beta}_0 + \hat{\beta}_1 X_1 + ... + \hat{\beta}_k X_k\right\}} \quad (3)$$

Model (3) is then used to estimate the likelihood of a firm's working capital management on profitability for all firms observed to have worked to gain profit in the past t years.

These estimates are then used to generate a discriminant model (function).

2.2 Discriminant models (functions)

Suppose the random variable λ has probability density functions $f_1(\lambda) \text{ and } f_2(\lambda)$ for the populations θ_1 (firms that managed their working capital on profit) and θ_2 (firms that did not manage their working capital on profit), respectively. A firm whose likelihood π of managing working capital on profit must be assigned to either $\theta_1 \text{ or } \theta_2$.

Let Ω denote the sample space of λ and $A_1 \text{and} A_2 = \Omega - A_1$ form a partition of Ω. If A_1 is the set of all values of λ for which a household is classified as θ_1 and A_2 is the set of values of λ for which a household is classified as θ_2, then the (conditional) probability of classifying a population as belonging to θ_1 when actually it belong to θ_2 is given by; $P(2|1) = P(\lambda_{ij} \in A_2 \,|\, \lambda_{ij} \in \theta_1) = \int_{A_2} f_1(\lambda) d\lambda$ and the (conditional) probability of classifying a population as belonging to θ_2 when actually it belongs to θ_1 is; $P(1|2) = P(\lambda_{ij} \in A_1 \,|\, \lambda_{ij} \in \theta_2) = \int_{A_1} f_2(\lambda) d\lambda.$ According to Johnson and Wichern [8] a reasonable classification rule should have an expected cost of misclassification (ECM) as small as possible with:

$$ECM = c(2|1)P(2|1)P(1) + c(1|2)P(1|2)P(2) \quad (4)$$

Where, $c(i|j)$ is the cost of misclassifying a population $\theta_j \, as \, \theta_i, (i = 1,2) \, and \, P(i), (i = 1,2)$ is the prior probability of θ_i and $P(1) + P(2) = 1$

The regions $A_1 \, and \, A_2$ that minimize the ECM, according to Johnson and Wichern [8] are defined by the values λ for which the following holds:

$$A_1 : \frac{f_1(\lambda)}{f_2(\lambda)} \geq \frac{c(1|2)P(2)}{c(2|1)P(1)}$$

$$A_2 : \frac{f_1(\lambda)}{f_2(\lambda)} < \frac{c(1|2)P(2)}{c(2|1)P(1)} \quad (5)$$

According to Johnson and Wichern [8], If $\theta_i (i = 1,2)$ has a normal distribution with mean μ_i and variance σ_i^2, then the density ratio based on λ is given by:

$$\frac{f_1(\lambda)}{f_2(\lambda)} = \frac{\frac{1}{\sqrt{2\pi}\sigma_1} \times e^{-\frac{1}{2}\left(\frac{\lambda-\mu_1}{\sigma_1}\right)^2}}{\frac{1}{\sqrt{2\pi}\sigma_2} \times e^{-\frac{1}{2}\left(\frac{\lambda-\mu_2}{\sigma_2}\right)^2}}$$

$$= \left[\frac{\sigma_2}{\sigma_1}\right]^{\frac{1}{2}} e^{-\frac{1}{2}\left[\left(\frac{1}{\sigma_1^2}-\frac{1}{\sigma_2^2}\right)\lambda^2 - 2\left(\frac{\mu_1}{\sigma_1^2}-\frac{\mu_2}{\sigma_2^2}\right)\lambda + \left(\frac{\mu_1^2}{\sigma_1^2}-\frac{\mu_2^2}{\sigma_2^2}\right)\right]} \quad (6)$$

Rearranging and taking the natural logarithm of both sides, the first inequality in (3), by trivial algebra becomes:

$$\frac{1}{2}\left(\sigma_1^2-\sigma_2^2\right)\lambda^2 + \left(\mu_1\sigma_2^2-\mu_2\sigma_1^2\right)\lambda + \left(\mu_1^2\sigma_2^2-\mu_2^2\sigma_1^2\right) \geq \sigma_1^2\sigma_2^2 ln\sigma_1\sigma_2 c(1|2)P(2)c(2|1)P(1)$$

However, if $\sigma_1 = \sigma_2 = \sigma$ Eq. (6) becomes:

$$\frac{f_1(\lambda)}{f_2(\lambda)} = \left[\frac{\sigma_2}{\sigma_1}\right]^{\frac{1}{2}} e^{\frac{(\mu_1-\mu_2)\lambda}{\sigma^2} - \frac{1}{2\sigma^2}(\mu_1^2-\mu_2^2)} \quad (8)$$

Again re-arranging and taking the natural logarithm of both sides, the first inequality of (5) becomes:

$$(\mu_1-\mu_2)\lambda - \frac{1}{2}\left(\mu_1^2-\mu_2^2\right) \geq \sigma^2 \ln\left[\frac{c(1|2)P(2)}{c(2|1)P(1)}\right] \quad (9)$$

Now, labeling the left hand side of (7) and (9) as quadratic and linear discriminant functions $m_{(1)}$ and $m_{(2)}$ and the corresponding right hand sides as the critical values $c_{(1)}$ and $c_{(2)}$ respectively, the sample estimate of the discriminant functions and their critical values are given by:

$$\hat{m}_{(1)} = \frac{1}{2}\left(s_1^2-s_2^2\right)\lambda^2 + (\bar{\lambda}_1 s_2^2 - \bar{\lambda}_2 s_1^2)\lambda + (\bar{\lambda}_1^2 s_2^2 - \bar{\lambda}_2^2 s_1^2) \quad (10)$$

with $\hat{c}_{(1)} = s_1^2 s_2^2 \ln\left[\left(\frac{s_1}{s_2}\right)^{\frac{1}{2}} \frac{c(1|2)P(2)}{c(2|1)P(1)}\right]$

and

$$\hat{m}_{(2)} = (\bar{\lambda}_1 - \bar{\lambda}_2)\lambda - \frac{1}{2}(\bar{\lambda}_1^2 - \bar{\lambda}_2^2) \quad (11)$$

with $\hat{c}_{(2)} = s^2 \ln\left[\frac{c(1|2)P(2)}{c(2|1)P(1)}\right]$

where, $\bar{\lambda}_i = \frac{1}{n_i}\sum_{j=1}^{n_i}\lambda_{ij}$ and $s_i^2 = \frac{1}{n_i - 1}\sum_{j=1}^{n_i}(\lambda_{ij} - \bar{\lambda}_i)^2$ are based on samples of size n_i from population $\theta_i (i = 1, 2)$; and $s^2 = \frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{n_1 + n_2 - 2}$ is the pooled sample variance.

By the minimum ECM rule, a firm with λ likelihood of managing profit is classified as managing working capital on profit if:

$$\hat{m}_{(2)}(\lambda_{ij}) = \frac{1}{2}(s_1^2 - s_2^2)\lambda_{ij}^2 + (\bar{\lambda}_1 s_2^2 - \bar{\lambda}_2 s_1^2) + (\bar{\lambda}_1^2 s_2^2 - \bar{\lambda}_2^2 s_1^2) \geq \hat{c}_{(2)}, For\ \sigma_1 \neq \sigma_2 \text{ or}$$

$$\hat{m}_{(1)}(\lambda_{ij}) = (\bar{\lambda}_1 - \bar{\lambda}_2)\lambda_{ij} - \frac{1}{2}(\bar{\lambda}_1^2 - \bar{\lambda}_2^2), \text{for } \sigma_1 = \sigma_2 \quad (12)$$

The discriminant functions $\hat{m}_{(1)}$ and $\hat{m}_{(2)}$ are effective in classifying a firm as having managed working capital on profit or not if μ_1 is significantly different from μ_2.

3. RESULTS AND DISCUSSION

To apply the methodology proposed by this study, data in the form of ratios were computed from 13 manufacturing and industrial firms listed on the Ghana Stock Exchange covering the period from 2009 to 2014. Data which were the audited annual financial reports were collected from the Fact Book of the Ghana Stock Exchange and the web portals of the firms. This enables us to see whether a firm is profitable in a year or not. The dependent variable used in this study was Profitability. In order to analyze the effects of working capital components on the profitability of manufacturing companies in Ghana, profitability is measured by Return on Assets (ROA), which is defined as the ratio of earnings before interest and tax to total assets. Management of working capital was assessed for 6 years $(i.e, k = 6)$.

For each firm, 6 years of non-zero profit z_i was computed from the nominal non-zero working capital. The proportion R_i of non-zero working capital accounted for by working capital on profit was computed for each of the 13 manufacturing and industrial firms who have managed their working capital on profit. The study used a threshold value of $m = 0.05$; and so all firms with $R_i > 0.05$ were classified to have managed their working capital on profit. Thus, the dependent variable for the binary logistic regression is defined by $Y_i = 1$ for managing working capital on profit and $Y_i = 0$, otherwise. After multicollinearity diagnosis,

Average Collection Period (X_1), Inventory Conversion Period (X_2), Average Payment Period (X_3), GROWTH (X_4), Debt Ratio (X_5), Current Ratio (X_6) and Company Size (X_7) were the explanatory variables used in setting up the logistic regression model.

The logistic regression of the dependent variable (Y_1) on the above variables was found to be significant ($\chi^2 = 376.206, df = 7, p - value < 0.001$) . Table 1 shows the estimates of the fitted binary logistic regression model for the data. The fitted logistic regression equation is given by:

$$\log it(\hat{\pi}) = -2.035 - 0.021\mathrm{X}_1 + 0.002\mathrm{X}_2 + 0.008\mathrm{X}_3 + 0.147\mathrm{X}_4 - 0.62\mathrm{X}_5 + 0.032X_6 + 0.09X_7$$

This implies that:

$$\hat{\pi}_i = \frac{\exp\{\hat{\beta}X^{'}\}}{1+\exp\{\hat{\beta}\mathrm{X}^{'}\}}$$

Where,

$$\hat{\beta} = \left(-2.035 - 0.021 + 0.002 + 0.008 + 0.147 - 0.62 + 0.032 + 0.09\right)^{'} \text{ and } X = (1, x_1, x_2, x_3, x_4, x_5)^{'}.$$

Equation (11), was used to compute the likelihood $\hat{\lambda}$ of managing working capital on profits for 13 manufacturing and industrial firms.

Table 1: Fitted binary logistic regression

Variable	β	**SE**	**Odds ratio**	**p-value**
Constant	-2.035	0.352	0.421	0.000
ACP	-0.021	0.019	0.754	0.000
ICP	0.002	0.027	0.692	0.000
APP	0.008	0.0035	1.254	0.000
Size	0.147	0.024	0.932	0.000
DR	-0.62	0.157	1.48	0.008
CR	0.032	0.013	0.833	0.000
Growth	0.09	0.017	1.458	0.003

Source: Authors' computation using GSE

Table 1 shows the statistically significant binary logistic regression model for the manufacturing and industrial data. The variables Average Collection Period, Inventory Conversion Period, Average Payment Period , Growth, Debt Ratio, Company Size and Current Ratio was found to be significant at determining the likelihood of managing working capital on profit for firms captured in the data.

Table 2: Frequency distribution for classification of 13 manufacturing and industrial firms for 6 years making 78 observations with reported non zero- profit.

Classification	**N**	**Mean**	**S.D**	**S.E**
Effective Management	69	0.27	0.067	0.033
Non-Effective Management	9	0.34	0.022	0.0017
Total	78			

Source: Author's computation using GSE

Table 2 displays the descriptive statistics of likelihood of an effective management of a firm's working capital on profit. The Levene's test for the equality of variance of likelihood of managing a firm's working capital on profit by the two groups of firms was not significant (*F*= 0.782, p-value = 0.326). Hence, there is no difference in variances for two firm classifications and this implies that a linear discriminant function $\hat{m}_{(2).}Eq.(10)$ is appropriate.

Based on the data, an estimate of the common variance called the pooled variance for the two groups of households was found to be 0.004017. And hence the linear discriminant function for the likelihood of managing a firm's working capital on profit is given by;

$\hat{m}_{(2)} = (\hat{\lambda}_1 - \hat{\lambda}_2)\lambda - \frac{1}{2}(\hat{\lambda}_1^2 - \hat{\lambda}_2^2) = 0.042\lambda - 0.006219$ and

$\hat{c}_{(2)} = s^2 \ln\left[\frac{c(1|2)P(2)}{c(2|1)P(1)}\right] = 0$, on the assumption of equal cost of misclassification and equal prior probabilities for both groups of firms. Therefore a firm with π likelihood of managing profit is said to have managed working capital on profit if $\hat{m}_{(2)} > 0$. The independent sample t-test for equal mean likelihood of managing a firm's working capital on profit is significant (t = 12.625, df = 76, p-value<0.001) and so the $\hat{m}_{(2)}$ is effective in discriminating a firm who has managed its working capital on profit from one which did not.

This result is applied to the whole 13 manufacturing and industrial firms irrespective of whether or not a firm reported managing its working capital on profit after estimating the likelihood of capital management for each of the firm in the entire data set.

4. CONCLUSION

This study proposes a methodology for analyzing the management of working capital on profit in statistically underdeveloped countries. A binary logistic regression model, based on data from firms with reported non-zero working capital on profit, is proposed for the estimation of the likelihood of working capital on profit for all firms irrespective of whether they managed their working capital on profit or not. “Univariate “discriminant functions, also based on data from firms who managed their working capital on profit within the reference period of Ghana Stock exchange, were proposed for discriminating firms that made effective management of working capital on profit from those who did not.

An application of this methodology to the data from the Ghana Stock Exchange indicates that the binary logistic regression model estimates correctly at least 75% of firm’s likelihood of managing working capital on profit while correctly discriminating the firms as having an effective management.

A validation work should be conducted on the model using sample data from other sectors on the Ghana stock exchange to further affirm the strength of the model and to show its structural stability over time. However, this study clearly show that the methodology being proposed is efficient in classifying all firms as having effectively managed its working capital on profit or otherwise.

It is recommended that, the government should enforce that policies are implemented to safeguard manufacturing and construction firms in Ghana and restrict importation of goods into the country to boost the demand for goods or materials that are manufactured in Ghana both in the short or long run.

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