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Credit Risk Assessment for Commercial Loans

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ABSTRACT

The purpose of this research is to provide practical tool for credit evaluation of firms by using cash flow statements as the basis. A predictive function for firm credit score is introduced using the expected cash flow adjusted for internal and external state effects. The data used in this research came from 10 publicly traded companies in SP500 for in-sample testing. Out-of-sample test was accomplished by an additional 10 companies from NASDAQ. We assert that the Cash Flow Base (CFB) distribution method as a tool for commercial loan assessment is inadequate. This research introduces the use of the distribution of the Altman Z-score as a means for commercial risk assessment. The use of failure rate *H(t)* in this paper allows lenders to specified the level of default risk tolerance and decide whether to grant the loan. We verified our method in out-of-sample testing. Our Comparative Altman Z-Score forecasting method was able to identify risky firms with 0.95 confidence. The contribution of this research lies in its practical and interdisciplinary applications in risk management for banking and finance.

Keywords:
Altman Z-score, bankruptcy, cash flow analysis, credit evaluation, risk assessment

JEL Code: C10, C13, C14, C46, E27, G11, G17

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1.0 INTRODUCTION

Credit risk assessment is a practical issue in commercial loan application evaluation. There are many tools used in credit risk assessment (Brown & Moles, 2014), for example, Data Envelopment Analysis and econometric modeling had been employed. Data Envelopment Analysis (DEA) had also been used in credit risk evaluation as in Troutt *et al*. (1996); Simak (1999), Cielen and Vanhoof (1999) and more recently by Emel *et al*. (2003), Paradi *et al*. (2004) and Cielen *et al*. (2004). Econometric method had been employed by Zavgren (1985), Keasey and Watson (1987), and Becchetti and Sierra (2003) to predict company failures. This research examines company cash flows as the indicator for credit risk for commercial loan evaluation. The research question presented by this paper is *whether cash flow distribution analysis is an effective tool for company evaluation in commercial loan?*

The assessment of credit worthiness may involve several scenarios. One scenario may involve newly established company with no track record of past financial performance. In this case, it is nearly impossible to assess the company's financial performance on the basis of past operations. Another scenario involves the loan applicant experiencing financial distress. For companies with track records of financial performance, cash flow analysis may be used for credit worthiness evaluation. In this paper, we use cash flow statements for credit risk evaluation. We evaluated the Cash Flow Distribution approach and the Altman Z score method as possible tools for corporate risk assessment. The Altman Z is used as a default test to verify whether the company experiences financial distress.

The objective of this paper is to provide a practical tool for pre-qualifying loan application through the use of cash flow analysis. The intended contribution of this research lies in the utility of the proposed credit assessment tool for stakeholders: $\Phi(Z_i)$.

2.0 LITERATURE REVIEW

2.1 Cash Flow Distribution as a Tool for Credit Evaluation

One line of literature for credit risk assessment is the use of the distribution cash flow statements. In a study of construction companies in the US, Huang *et al*. (2013, p. 612) proposed a cash flow based structural model (CFB) as:

$$C_{it} = E(C_{it}) + \sum_{j=1}^{k} \alpha_{ij} F_{jt} + \xi_{it} \tag{1}$$

where C_{it} = the i^{th} firm's free cash flow; α_{it} = sensitivities of the i^{th} firm's C_{it} to the j^{th} state factor; F_{jt} = unobservable state factors; ξ_{it} = idiosyncratic factor of i^{th} firm that causes variation in the firm's C_{it}; and h_{it} = variance explained by systematic factor. The distribution of the error is defined as $\xi_{it} \to N(0, \sqrt{1-h_{it}})$. Huang *et al.* predicts the firm's cash flow as an expected cash flow adjusted for the level of the firm's cash flow sensitivity to external shock.

The model in (1) claims that the firm's free cash flow tends to be mean reverting. The model assumes that there are *k* factors and the factor loading is α_{it}, the mean reverting effect of the model renders the distribution to be a *Gaussian* process (Appendix 1) where the state factor is given by:

$$dF_{jt} = \alpha_{F_j} \left[b_{F_j} - F_{j,t-1} \right] dt + \sigma_{F_j} dz_j \tag{2}$$

where F_{jt} stands for the j^{th} state value at time *t*; α_{F_j} is the velocity of the mean reverting process of F_{jt}; the last period's state factor is $F_{j,t-1}$. The state factor may also change over time, the variation of F_{jt} is given by σ_{F_j}. The last term dz_j is the Wiener process.

The CFB model proposed by Huang *et al.* finally asserts that the firm's present value is given by;

$$V_{it} = \left[\sum_{\tau=t+1}^{T} \frac{C_{i\tau}}{(1-\gamma_A)^{\tau-t}} \right] + \frac{C_{iT}(1+\mathrm{g})}{(1+\gamma_A)^{T-t}(\gamma_A - g)} \tag{3}$$

where V_{it} = present value of the cash flow at time *t*; $C_{i\tau}$ = firm's remedial cash flow at time *t*; T = beginning time of constant growth; C_{iT} = firm's remedial cash flow at time *T*; γ_A = constant growth rate after time *T*.

The rationale for determining the present value of the cash flow is to obtain the current monetary value. With known present value of the firm's cash flow, the next step is to determine the threshold for the firm's default on the loan. Huang *et al.* provides the probability of default as: (i) if $0 < \ell V_{t-1} < \hat{D}_t$, the default probability is given by:

$$f(x) = \begin{cases} \dfrac{2}{\ell V_{t-1}\left(\hat{D}_t\right)} x, & \text{if } \; 0 < V_t < \ell V_{t-1} \\ \dfrac{2}{\hat{D}_t\left(\hat{D}_t - \ell V_{t-1}\right)} [\hat{D}_t - x], & \text{if } \; 0 < V_t < \hat{D}_t \\ 0 & \text{if } \; V_t > \hat{D}_t \end{cases} \tag{4}$$

and (ii) if $\ell V_{t-1} > \hat{D}_t$, the default probability is given by:

$$f(x) = \begin{cases} \dfrac{2}{\left(\hat{D}_t\right)^2} x, & \text{if } \; 0 < V_t < \hat{D}_t \\ 0 & \text{if } \; V_t > \hat{D}_t \end{cases} \tag{5}$$

The decision rule is governed by the Credit Quality Score (CQS). If CQS is closer to 0, it is considered credit worthy; if CQS is closer to 1, the firm is classified as having poor credit. The CQS decision rule for $0 < \ell V_{t-1} < \hat{D}_t$ is summarized as:

$$CQS_t = PD_t = \Pr(D_t > V_t) = \begin{cases} 1 - \dfrac{V_t^2}{\hat{D}_t\left(\ell V_{t-1}\right)} & \text{if} \quad 0 < V_t < \ell V_{t-1} \\ \dfrac{\left(\hat{D}_t - V_t\right)^2}{\hat{D}_t\left(\hat{D}_t - \ell V_{t-1}\right)} & \text{if} \quad \ell V_{-1} < V_t < \hat{D}_t \\ 0 & \text{if} \quad V_t > \hat{D} \end{cases} \tag{6}$$

Huang *et. al*. summarized the decision CQS when $\ell V_{t-1} > \hat{D}_t$ as:

$$CQS_t = PD_t = \Pr(D_t > V_t) = \begin{cases} 1 - \left(\dfrac{V_t}{\hat{D}_t}\right)^2 & \text{if} \quad 0 < V_t < \hat{D}_t \\ 0 & \text{if} \quad V_t > \hat{D} \end{cases} \tag{7}$$

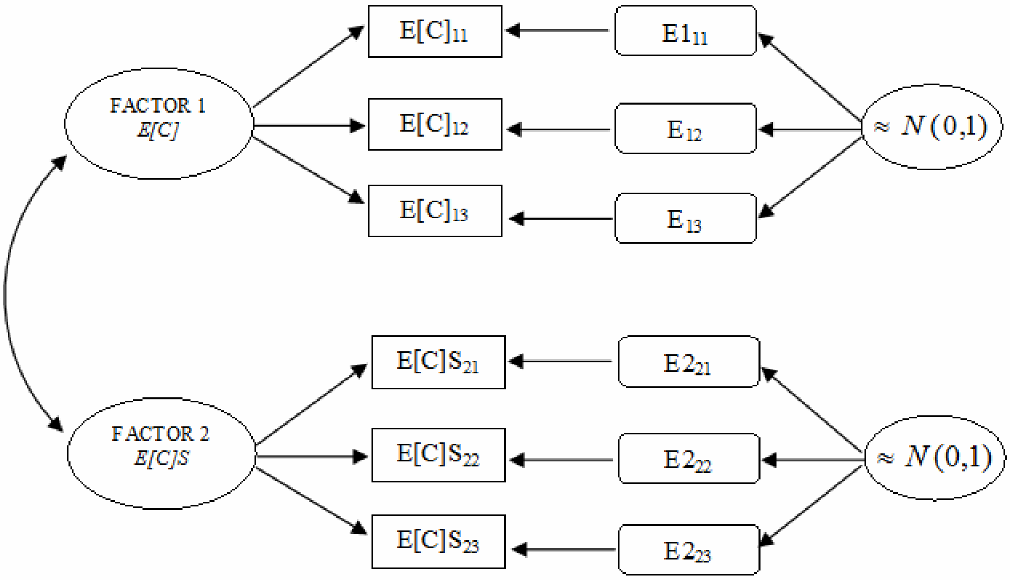
In this literature review, we contest that $C_{it} = E(C_{it}) + \sum_{j=1}^{k} \alpha_{ij} F_{jt} + \xi_{it}$ presented by Huang *et al.* and its predecessors (Liao et al., 2009, and Duffie & Lando, 2001) is not accurate for two reasons: (i) the method for calculating the expected value of the cash flow $E[C_{it}]$ was not given, and (ii) the second term in the equation $\sum_{j=1}^{k} \alpha_{ij} F_{jt}$ is not correct because this second term must be multiplied by the first term as $E[\mathrm{C}_{it}]\left(\sum_{j=1}^{k} \alpha_{ij} F_{jt} + \xi_{it}\right)$ and depending on the direction of the shock, the adjustment may be plus or minus as shown below:

$$C_{it} = E[C_{it}] \pm E[\mathrm{C}_{it}]\left(\sum_{j=1}^{k} \alpha_{ij} F_{jt} + \xi_{it}\right) \tag{8}$$

A third flaw is found in the state factor argument. The state factor in (2) is assumed to behave as a Gaussian process. This assumption is untenable. A state factor may be represented as extreme or non-extreme. The shock from the external environment, as a state factor, may be short-lived or permanent. In case where the shock is short-lived, the distribution may be mean reverting. The Gaussian assumption may be valid in this case. However, if the effect of the shock is permanent, the assumption of mean reverting is invalid. The formula used to predict the firm's present value (3) is usable only if the data is normally distributed and there is no effect of external shock. The assumption of normality had been criticized for being not reflective of real life situation. (Doganoglu *et al.*, 2007). It was shown that asset returns are non-elliptical (Chicheportiche & Bouchaud, 2012). Admittedly normal distribution is not always found in practical context (Geary, 1947). The assumption of normality contradicts the concept of "state factor" if state factor represent real life situation and real life situation does not confirm to normal distribution. In this paper, we found that the in-sample CDF falls outside of one standard unit of the standard normal curve and the out-of-sample set falls within the normal curve. Thus, the assumption that the data should be $N(\mu,\sigma^2)$ in the CFB model is not supportable. We offer a better method called *Comparative CDF of Altman Z-Score.*

The credit assessment in the CFB model consists of three steps: (i) Estimate the firm's cash flow, (ii) calculate the expected cash flow; and (iii) determine the firm's default probability. The conceptual framework for CFB is illustrated in Figure 1. We offered corrections to the three defects mentioned above in the methodology section.

Figure 1. Conceptual Framework of Cash Flow Distribution Method



2.1 Altman's Z-score Model

A second line of literature deals with financial distress assessment by using fnancial ratios. Under the Altman approach, financial distress studies may be called "bankruptcy prediction studies." This approach employed parametric model using the firm's financial ratios.

Altman (1968) applied the model to a sample of manufacturing companies in the US. Subsequent studies reaffirmed the applicability of the Z-Score model to privately held companies (Deakin, 1972; Ohlson, 1980), non-manufacturing firms (Grice and Ingram, 2001; Altman, 2000), banks (Sinkey, 1975; Chotalia, 2014), insurance companies (Trieschmann and Pinches, 1973; Pinches and Trieschmann, 1977).

Altman's research identified five key ratios to predict failure and the model expresses these ratios in the form of a relationship with other ratios in the model with assigned a relative weighting. The bankruptcy score sorts firms into bankrupt and non-bankrupt groups according to their Z score (Aziz *et al.*, 2006). In 1968, the Altman Z-score model was parametized as:

$$Z = 0.012X_1 + 0.014X_2 + 0.033X_3 + 0.006X_4 + 0.999X_5 \quad (9)$$

where X_1 = working capital/asset; X_2 = retained earnings/asset; X_3 = EBIT/total assets; X_4 = market value of equity/total assets; X_5 = sales/total assets; Z = overall index (Altman, 1962 & 2000).

The model was later modified (Altman, 1983, p. 122) to cover private firms as:

$$Z' = 0.717X_1 + 0.840X_2 + 3.107X_3 + 0.420X_4 + 0.998X_5 \quad (10)$$

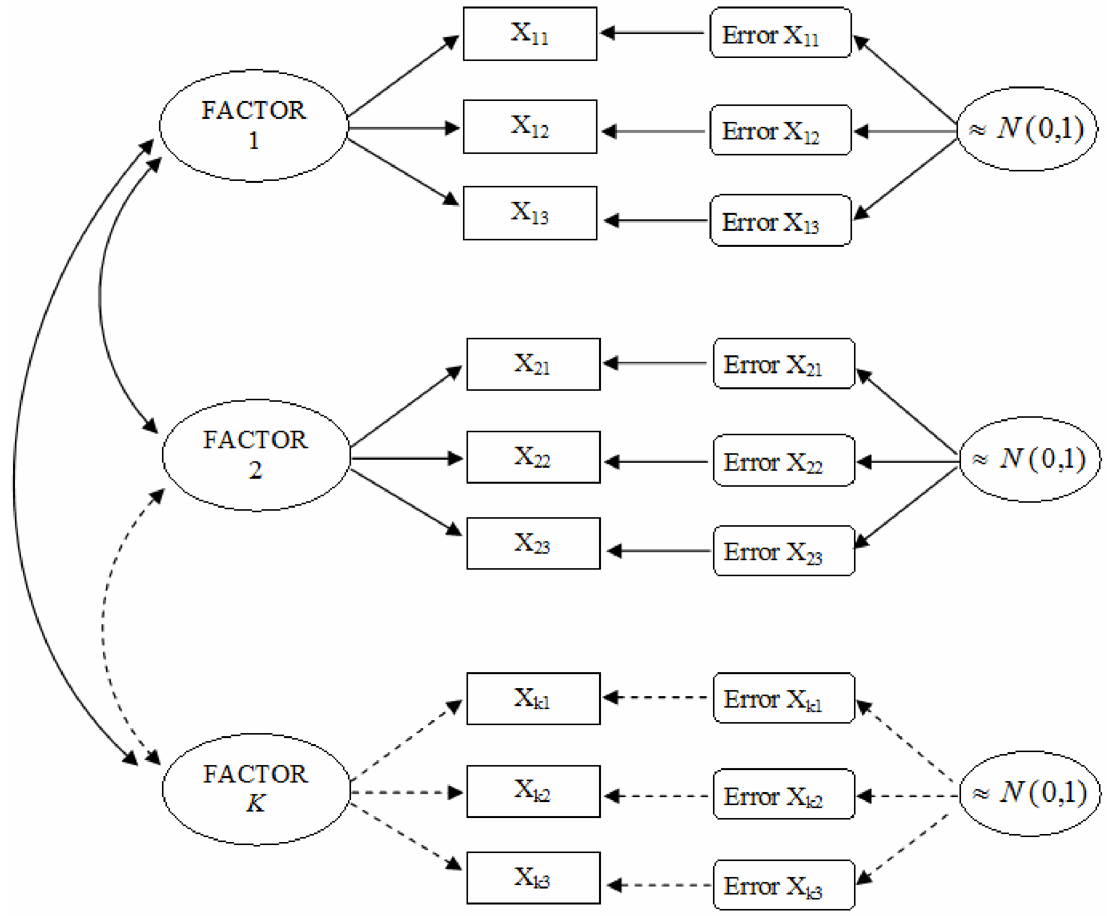
The decision rule is governed by: $Z' > 2.60$ means "safe;" $1.10 < Z < 2.60$ means "gray area" and $Z < 1.11$ means that the firm is in financial distress.

In 1982, another version of the Altman Z-score was introduced to cover non-manufacturing companies (Altman, 1982, p. 124). The third version of the Altman Z score is given by:

$$Z = 3.25 + 6.56X_1 + 3.26X_2 + 6.72X_3 + 1.05X_4 \quad (11)$$

For non-manufacturing firms, the safe zone is defined as $Z > 2.60$; the gray area is $1.10 < Z < 2.60$ and financial distress is defined as $Z < 1.10$. The model had an average accuracy of more than 85% in bankruptcy prediction (Aziz *et al.*, 2006) and is still the most popular technique in business failure identification.

Figure 2. Conceptual Framework of Structural Equation for Altman Z-Score Method



3. DATA

Secondary data was used for this study. There are two sets of data used in this research. The first set of data was used as an in-sample testing. This set of data consists of 10 companies selected from across industries listed in SP500. The second data set consist of 10 companies selected from the NASDAQ. This second set was used for out-of-sample testing. The rationale for using different data set for the our-of-sample test is to verufy the general applicability of the proposed model.

The financial statements used consist of 8 periods of reporting. The rationale for this short span of time for the study comes from the nature of risk assessment for commercial loan. Longer period, i.e. larger sample size, would provide inaccurate assessment of risk due to change in circumstances (IAS 39 and IFRS 7).

Ten companies from SP500 were used for in-sample testing. These companies were selected on the basis of their data availability and being cross-industries representation.

Table 1. Net Cash Flow for Eight Consecutive Quarters in In-Sample Set

SP500	Fiscal Year 2014				Fiscal Year 2015			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
MMM	1,954.00	2,125.00	1,929.00	1,897.00	1,791.00	2,983.00	1,605.00	1,954.00
GOOGL	16,639.00	19,620.00	15,605.00	18,347.00	16,976.00	18,453.00	18,068.00	16,639.00
ACP	0.24	0.29	0.46	0.44	0.51	0.52	0.49	0.47
AXP	20,740.0	18,430.0	21,264.0	22,288.0	23,572.0	21,071.0	19,938.0	20,740.0
T	3,611.00	11,305.00	2,458.00	8,603.00	4,444.00	20,956.00	6,202.00	3,611.00
ADSK	1,609.60	1,323.10	1,345.00	1,853.00	1,182.70	1,473.10	1,337.50	1,609.60
BAX	2,049.00	1,866.00	2,078.00	2,925.00	2,530.00	6,680.00	1,970.00	2,049.00
MLM	35.80	34.32	73.59	108.65	56.36	44.16	436.42	35.80
PXD	257.0	445.0	550.0	1,025.0	383.0	219.0	581.0	257.0
SBUX	1190.3	1019.4	1708.4	1857.0	1750.4	2080.5	1530.1	2263.5

In order to test the reliability of the proposed model, an out-of-sample test was employed. The out-of-sample data consist of eight consecutive quarters of net cash flows from 10 companies listed in the NASDAQ. The original 10 companies from SP500 (Table 1) were not used for out-of-sample test because we attempt to verify the generalizability of the model by applying it to true out-of-sample testing by not repeating the test of data from the same source, i.e. SP500. The 10 companies selected for the out-of-sample test is listed in Table 3.

Table 3. Net Cash Flow for Eight Consecutive Quarters in Out-of-Sample Set

NASDAQ	Fiscal Year 2014				Fiscal Year 2015			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
ABMD	34.74	17.48	19.47	22.40	40.43	54.42	53.22	34.74
APC	5,924.00	5,365.00	8,335.00	7,369.00	2,308.00	2,173.00	2,072.00	2,697.00
BJRI	34.86	25.89	24.39	30.68	25.96	25.45	26.57	34.86
CNL	18,157.00	23,237.00	11,210.00	44,423.00	64,836.00	22,429.00	17,329.00	18,157.00
HCOM	36,738.00	28,228.00	31,693.00	39,885.00	26,940.00	35,599.00	28,845.00	36,738.00
MHFI	1,531.00	1,617.00	1,918.00	2,497.00	1,176.00	1,720.00	1,441.00	1,531.00
RAVN	63.40	62.16	66.35	51.94	47.45	47.30	32.28	63.40
SMID	2.88*	2.85	4.24	3.57	2.27	1.94	0.99	2.88
TTWO	822.00	754.41	897.45	911.12	815.78	711.71	835.24	822.00
VEEV	188.88	140.11	132.13	129.25	107.56	119.77	16.26	188.88

*Billion dollars

4. METHODOLOGY

4.1 Sample Size Determination

Minimum sample size determination was accomplished under the Weibull method in Gou *et al.* 2013. It was explained that Weibull minimum sample calculation is accomplished three steps (Gou *et al.* 2013). The minimum sample size for Weibull's distribution function may be obtained by:

$$1 - CI = R^n \tag{12}$$

where CI = confidence interval; R = Weibull reliability; and n = sample size. The confidence used for sample size determination is 99%. Since $1 - CI = \alpha$, equation (15) may be written as:

$$\alpha = R^n \tag{13}$$

The mean of the Weibull reliability for the study period is $R + SD = 0.51$. Using 0.99 as the confidence interval, the value for alpha is $\alpha = 0.01$. The sample size is $n = 7$. The sample size used in this research is comprised of 8 operating quarters.

The sample size under Gou is verified by the DeMoivre-Laplace Central Limit Theorem equation:

$$\lim_{n \to \infty} \Pr\left[\frac{X_n - n^* p}{\sqrt{npq}} \right] \tag{14}$$

where X_n = number of incidence of increase in net cash flows in the sample period; n = 8 operating quarters; $p = (s+1)/(n+2)$; and $q = 1 - p$. Solve for n*, thus:

$$n^* = \frac{\left(Z\sqrt{npq}\right) + X_n}{p} \tag{15}$$

For in-sample group, $n^* = 13.16$ and for the out-of-sample group, $n^* = 13.50$. This number represents two fiscal years of sample. By dividing the result by 2 to obtain the one year minimum sample size, the final sample sizes are $n^* = 6.58$ for in-sample and $n^* = 6.75$ for out-of-sample set. These values are consistent with the Gou method where $n = 7$.

4.2 Company Cash Flow Distribution

The cash flow distribution is tested by comparing the observed CDF against the standard CDF under one unit of standard deviation. Within one standard unit, the CDF is 0.68 for the null hypothesis. The decision rule states that $H_0 : CDF \le 0.68$ is not statistically significant; this means that the distribution is within the expected region. The alternative hypothesis is $H_A : CDF > 0.68$ or that the distribution lies outside of the normal range of expectation. The CDF formula is given by:

$$CDF = \frac{1}{2}\left[1 + erf\left(\frac{X - \mu}{\sigma\sqrt{2}}\right)\right] \tag{16}$$

which is approximately:

$$\langle CDF \rangle = \Phi\left(\frac{X - \mu}{\sigma}\right) \tag{17}$$

For the null hypothesis, $\langle CDF \rangle = CDF^* = 0.68$. The observed value for the CDF is obtained by:

$$CDF = \Phi\left(\frac{\overline{X} - \mu}{S}\right) \tag{18}$$

where $\overline{X}$ = sample mean for the 8 periods in the sample; μ = estimated mean; and S = sample standard deviation.

In addition to the individual data set's distribution, the cash flow distribution method requires the use of market performance distribution. This second requirement is not feasible. The cash flow is a quarterly data. However, market performance is tracked daily. Using a three month's average would require the market to be stable so as to capture the mean reverting characteristic of the market. For this reason, we urge that the CFB method as a means to assess credit worthiness is not practicable.

4.3 Altman Z Score as Alternative Tool for Credit Worthiness Testing

The Altman Z-score is used as an alternative to Huang *et al.*'s CFB approach. The relevant version of the Altman Z-score is given as:

$$Z = 6.56X_1 + 3.26X_2 + 6.72X_3 + 1.05X_4$$

where X_1 = working capital/asset; X_2 = retained earnings/asset; X_3 = EBIT/total assets; X_4 = market value of equity/total assets; and Z = overall index. The decision rule is $Z > 2.60$ means "safe;" $1.10 < Z < 2.60$ means "gray area" and $Z < 1.10$ means that the firm is in financial distress (Altman *et al.*, 2014).

5. FINDINGS

The testing for normality was first accomplished in order to verify the claim of the CFB method. The CFB method assumes that the cash flow is normally distributed. It is a common practice to use the Anderson-Darling (AD) test to verify normality. The AD test is given in two parts: (i) AD observed value, and (ii) AD* or the theoretical value. The data is considered normally distributed if $AD \le AD*$ and not normally distributed if $AD > AD*$. The AD observed is obtained by;

$$AD = -n - S* \qquad (19.1)$$

$$S* = \sum\left(\frac{2k-1}{n}\right)\ln F(X) + \ln(1 - \mathrm{F(X)}) \qquad (19.2)$$

The theoretical value AD* is given by:

$$AD* = AD\left(1 + \frac{0.75}{n} + \frac{2.25}{n^2}\right) \qquad (20)$$

This approach to normal distribution test is problematic because the equation (AD*) is biased in favor of finding $AD \le AD*$. Therefore, we approach normality by comparing the CDF of the data to the CDF* of the assumed normality.

The empirical cumulative distribution function (CDF) was obtained through the Weibull CDF:

$$CDF = 1 - \exp\left(-\left(\frac{X}{\mu}\right)^{1/\beta}\right) \qquad (21)$$

The observed CDF is compared to the assumed normal distribution CDF:

$$CDF = \frac{1}{2}\left[1 + erf\left(\frac{X-\mu}{\sigma\sqrt{2}}\right)\right] = \Phi\left(\frac{X-\mu}{\sigma}\right)$$ where erf is the error function, *see* (17).

The first set of calculation involves the modeling of the predictive function of the cash flow for each stock in order to verify the direction of the trend of the cash flow movement. The trend direction is indicated by the value of *beta*. The decision is governed by the following logic: if $\beta < 1$, the trend is decreasing with respect to time; if $\beta > 1$, the trend is increasing with respect to time, and if $\beta = 1$ there is no trend direction (Weibull, 1951). From ten companies in the in-sample test, two companies showed decreasing trend and eight companies showed increasing trend. The significance of this finding is the ability of this trend analysis method under Weibull can allow us to predict the direction of movement of the company's cash flow.

Table 1. In-Sample Empirical Evidence of Cash Flow Distribution

SP500 Ticker	Linear Model	Cash Flow CDF	System Reliability	Expected CF Beta (β)
MMM	Y = 8.75 + 0.09X	0.64	0.36	11.07
GOOGL	Y = 9.77 + 0.002X	0.63	0.37	458.80
CNP	Y = -0.76 + 0.23X	0.62	0.38	4.38
AXP	Y = 9.96 + 0.014X	0.63	0.37	73.48
T	Y = 8.69 + 0.035X	0.64	0.36	28.54
ADSK	Y = 7.28 -0.009X	0.63	0.37	-116.58
BAX	Y = 7.88 + 0.103X	0.63	0.37	9.72
MLM	Y = 4.35 + 0.291X	0.66	0.34	3.44
PXD	Y = 6.01 - 0.01X	0.63	0.37	-104.92
SBUX	Y = 7.49 + 0.19X	0.63	0.37	5.15

In Table 1, the mean time to failure or the cumulative distribution (CDF) of the system is between 0.62 and 0.84 as compared to the CDF of the normal distribution within one standard deviation is $CDF^* = 0.68$. In order to verify whether the data falls within the range of normal expectation in comparison to normal distribution curve, the Fisher transformation is used where:

$$Z_F = 0.50 \ln\left(\frac{1+k}{1-k}\right) \quad (22)$$

where k is the observed value. In this case, k is the individual CDF. The value of Z_F is used to determine the upper or lower range of the CDF* by:

$$Z_{obs} = Z_F \pm Z_\theta \sqrt{\frac{1}{n-3}} \quad (24)$$

The result of the calculation is shown in Table 2. The difference between the observed CDF and that of the theoretical CDF* (assumed normal distribution) is not statistically significant for in-sample set.

Table 2. In-Sample ΔCDF as a Tool for Normality Verification

SP500 Ticker	Observed *CDF*	Theoretical *CDF**	Diff. ΔCDF	Transform Z_F	ΔCDF Z_{obs}	Significant Range > 1.65
MMM	0.64	0.68	0.04	0.04	0.78	Not sig.
GOOGL	0.63	0.68	0.05	0.05	0.79	Not sig.
CNP	0.62	0.68	0.06	0.06	0.80	Not sig.

AXP	0.63	0.68	0.05	0.05	0.79	Not sig.
T	0.64	0.68	0.04	0.04	0.78	Not sig.
ADSK	0.63	0.68	0.05	0.05	0.79	Not sig.
BAX	0.63	0.68	0.05	0.05	0.79	Not sig.
MLM	0.66	0.68	0.02	0.02	0.76	Not sig.
PXD	0.63	0.68	0.05	0.05	0.79	Not sig.
SBUX	0.63	0.68	0.05	0.05	0.79	Not sig.

In the our of sample group, we were able to discover 7 out of 10 companies with decreasing trend in cash flow movement. As a tool for discovering risk companies, this approach is more effective than the cash flow structural modeling discussed in Huang *et al*. under CFB method. This result is reported in table 3. Similar calculation as described in table 2 was also carried out. The mean value of the in-sample set is $\overline{CDF} \cong 0.80$ which is more than 0.68. Therefore, the distribution of the cash flow is outside of the normal range of one standard unit of the normal distribution curve. However, in the out-of-sample set, $\overline{CDF} \cong 0.62$ which falls within the range of one standard unit of the normal distribution curve. These conflicting results further undermines the assumption made in the CFB method.

Table 3. Out-of-Sample Empirical Evidence of Cash Flow Distribution

NASDAQ Ticker	Linear Model	Cash Flow CDF	System Reliability	Expected CF Beta (β)
ABMD	Y = 3.57 + 0.18X	0.63	0.37	5.42
APC	Y = 8.08 - 0.38X	0.58	0.42	-2.65
BJRI	Y = 3.34 - 0.014X	0.63	0.37	-73.58
CNL	Y = 10.10 + 0.5X	0.63	0.37	19.26
HCOM	Y = 10.40 – 0.005X	0.63	0.37	-220.75
MHFI	Y = 7.39 - 0.043X	0.63	0.37	-23.51
RAVN	Y = 3.91 - 0.112X	0.63	0.37	-8.92
SMID	Y = 0.82 - 0.184X	0.62	0.38	-5.42
TTWO	Y = 6.71 - 0.004X	0.63	0.37	-228.06
VEEV	Y = 92.64 – 0.29X	0.60	0.40	3.45

The next test involves series of calculation for system analysis. The expected value (η) of the cash flow is calculated under Weibull's QQ plot approach. This result may be compared with the actual mean of the observed series. As part of the system analysis, we examined the mean time to failure rate or system failure rate or $H(t)$. The value of $H(t)$ for cash flow indicates the probability of company's financial failure. In the in-sample test we discovered two companies that has the probability of instantaneous failure of $H(t) = 1.0$. In the context of commercial loan evaluation, these companies represent cash flow risk.

Table 4. In-Sample Cash Flow Expected Value and System Failure Analysis

SP500 Ticker	Expected Value Eta (η)	Predictor Mean ($\overline{X}_{obs}$)	System Failure $H(t)$	System Survival $S(t)$
MMM	6,339.96	7,648.75	0.012	0.988
GOOGL	17,521.08	17,543.38	0.047	0.953
CNP	0.47	0.43	1.000	0.00
AXP	21,104.05	21,005.38	0.002	0.998
T	5,917.56	7,523.75	1.000	0.00
ADSK	1,446.98	1,466.70	0.016	0.984

BAX	2,648.39	2,768.38	0.005	0.995
MLM	77.22	103.14	0.090	0.910
PXD	408.57	464.63	0.00	1.000
SBUX	1,795.3	1,674.95	0.002	0.998

In the out-of-sample testing, despite the findings of 7 out of 10 companies showing decreasing trend in cash flow. Two companies (BJRI and SMID) shows immediate risk *H(t)* exceeding 50%. This means that in the out-of-sample data set, two companies manifest probable default in commercial loans according to their cash flow patterns form the last 8 operating quarters (Table 5).

Table 5. Out-of-Sample Cash Flow Expected Value and System Failure Analysis

NASDAQ Ticker	Expected Value Eta (η)	Predictor Mean ($\overline{X}_{obs}$)	System Failure $H(t)$	System Survival $S(t)$
ABMD	35.43	34.95	0.144	0.856
APC	3,221.50	4,530.38	0.00	1.000
BJRI	28.12	28.58	0.773	0.227
CNL	24,235.38	27,472.25	0.008	0.992
HCOM	32,701.10	33,083.25	0.001	0.999
MHFI	1,619.49	1,691.38	0.005	0.995
RAVN	50.04	54.29	0.080	0.920
SMID	2.28	2.70	0.798	0.202
TTWO	817	821.21	0.086	0.914
VEEV	92.64	127.86	0.009	0.991

The results in tables 1 – 5 explain the distribution of the cash flows and risk assessment on the basis of cash flow trends and system analysis. Table 6 (in-sample) and 7 (out-of-sample), examine the Altman Z-score for each company. According to the calculation of the Altman Z-score under $Z = 6.56X_1 + 3.26X_2 + 6.72X_3 + 1.05X_4$ there is one company in the group (Ticker: CNP) that falls in the "gray zone". No company falls in the "distress zone."

Table 6. In-Sample Altman Z-Score Bankruptcy Model[1] for 8 Quarters*

SP500 Ticker	Z_1	Z_2	Z_3	Z_4	Z_5	Z_6	Z_8	Z_8
MMM	11.51	11.56	11.98	12.61	12.76	13.02	13.28	6.90
GOOGL	12.28	13.12	12.02	12.56	13.25	12.99	13.00	12.34
CNP	1.92	1.92	1.97	1.95	2.03	1.98	1.53	1.56
AXP	2.58	2.62	2.64	2.62	2.72	2.71	2.71	1.25
T	3.97	3.92	4.01	3.63	3.50	3.39	3.49	2.90
ADSK	5.22	5.15	4.92	4.60	4.71	3.21	2.69	2.26
BAX	7.59	7.61	7.72	8.19	8.50	7.68	7.20	6.93
MLM	6.34	6.73	6.60	6.43	6.27	6.34	6.36	5.84
PXD	5.92	5.69	6.50	6.56	6.30	5.97	7.75	4.94

[1] The model used for the calculation follows this formula: $Z = 6.56X_1 + 3.26X_2 + 6.72X_3 + 1.05X_4$. The decision rule is given by: $Z > 2.60$ is classified as "safe;" $1.10 < Z < 2.60$ is classified as "gray"; and $Z < 1.10$ is classified as "distress." The parameters are * X_1 = (Current Assets – Current Liabilities) / Total Assets; X_2 = Retained earnings / Total Assets; X_3 = Earnings Before Interest and Tax / Total Assets; and X_4 = Book Value of Equity / Total Liabilities.

SBUX	8.09	8.16	8.36	8.50	8.22	8.40	8.07	6.08

*Quarter 1 = Z_1, Quarter 2 = Z_0, …

The same test is used to re-test ten different companies in the out-of-sample test (Table 7). It was found that one company (MHFI) shows irregular Altman Z-score. This was later confirmed by Z-score forecasting that MHFI is a financially distressed firm. Nine firms in the out-of-sample group (except MHFI) are found in the safe zone.

Table 7. Out-of-Sample Altman Z-Score Bankruptcy Model for 8 Quarters

NASDAQ Ticker	Z_1	Z_2	Z_3	Z_4	Z_5	Z_6	Z_8	Z_8
ABMD	9.88	8.16	7.28	6.88	7.21	6.92	6.98	33.61
APC	5.71	5.48	5.66	5.18	4.76	4.95	4.27	3.29
BJRI	20.00	19.66	18.70	41.39	41.19	31.56	36.19	3.62
CNL	11.71	12.23	12.76	12.24	11.44	12.08	13.28	15.06
HCOM	15.59	15.86	15.26	14.58	15.23	15.95	15.83	15.65
MHFI	1.39	-1.72	7.39	8.34	4.26	3.73	3.49	1.17
RAVN	9.30	9.76	9.94	9.34	15.39	9.96	9.60	8.17
SMID	8.35	9.29	9.60	8.03	7.96	9.71	9.23	7.30
TTWO	5.13	5.14	5.14	4.93	4.95	4.98	4.91	3.86
VEEV	5.64	5.58	5.87	5.61	5.68	5.71	5.91	4.23

While tables 1 and 3 show the direction of the trend of the cash flow, tables 8 and 9 shows that direction of the trend and the scale of the expected value for the Altman Z-score. These two measurements used the Altman Z-score observed in previous 8 operating quarters as the bases for forecasting the trend and magnitude of future Altman Z-score. These measurements are useful and practical tools for corporate credit assessment. The expected level of the Altman Z-score is read from η, the direction of the trend is read from β, the risk of possible default may be read from $H(t)$, and the certainty is read from $S(t)$.

The findings presented in tables 8 & 9 go beyond cash flow analysis. These calculations shows the use of the cash flow as the basis to assess the company's financial distress, and the proposed forecast method allows the lender to assess corporate credit worthiness by using $H(t)$ as a risk indicator. With known risk tolerance level, the lender could use this forecast method to grant or deny credit. This method represents a practical tool that holds utility in banking operations and financial analysis.

Table 8. In-Sample Altman Z-Score Forecast from 8 Quarters

SP500 Ticker	$Y_{(i)} = a + bX$	η	β	CDF	R	$H(t)$	$S(t)$
MMM*	$Y_Z = 2.41 - 0.06X$	11.15	-16.68	0.07	0.94	0.07	0.93
GOOGL*	$Y_Z = 2.54 - 0.01X$	12.74	124.36	0.01	0.99	0.03	0.97
CNP**	$Y_Z = 0.58 - 0.06X$	1.79	-16.94	0.06	0.94	0.34	0.66
AXP**	$Y_Z = 0.82 - 0.12X$	2.28	-8.69	0.13	0.87	0.34	0.66
T*	$Y_Z = 1.23 - 0.02X$	3.43	-57.68	0.02	0.98	0.25	0.75
ADSK*	$Y_Z = 1.23 - 0.26X$	3.44	-3.89	0.36	0.64	0.22	0.78
BAX*	$Y_Z = 2.02 + 0.01X$	7.57	73.51	0.01	0.99	0.04	0.96
MLM*	$Y_Z = 1.84 - 0.02X$	6.28	-43.88	0.02	0.98	0.09	0.91

PXD*	$Y_Z = 1.84 + 0.00X$	6.17	310.18	0.00	1.00	0.29	0.71
SBUX*	$Y_Z = 2.05 - 0.05X$	7.75	-20.67	0.05	0.95	0.08	0.92

Use the η as the indicator for prospective Altman Z-Score:*Safe: $Z > 2.60$, **Gray: $1.10 < Z < 2.60$, and ***Distress: $Z < 1.10$.

There are two companies (MHFI and RAVN) that shows high *H(t)* which may pose a potential risk of default. Depending on the lender's risk tolerance level, *H(t)* of the Altman Z-score series may be used as an indicator for possible default.

Table 9. Out-of-Sample Altman Z-Score Forecast from 8 Quarters

NASDAQ Ticker	$Y_{Z(o)} = a + bX$	η	β	*CDF*	*R*	$H(t)$	$S(t)$
ABMD*	$Y_Z = 2.30 + 0.17X$	9.93	5.95	0.17	0.83	0.06	0.94
APC*	$Y_Z = 1.51 - 0.14X$	4.51	-7.12	0.17	0.84	0.14	0.86
BJRI*	$Y_Z = 2.99 + 0.37X$	19.86	2.67	0.37	0.63	0.01	0.99
CNL*	$Y_Z = 2.56 + 0.06X$	12.99	17.83	0.05	0.95	0.03	0.97
HCOM*	$Y_Z = 2.74 + 0.0X$	15.51	374.91	0.00	1.00	0.02	0.98
MHFI***	$Y_Z = 0.85 + 0.68X$	2.34	1.47	0.66	0.34	0.37	0.63
RAVN*	$Y_Z = 2.30 + 0.0X$	10.00	-316.54	0.00	1.00	0.58	0.42
SMID*	$Y_Z = 2.15 + 0.02X$	8.55	-47.90	0.02	0.98	0.09	0.91
TTWO*	$Y_Z = 1.55 + 0.06X$	4.72	-17.40	0.06	0.94	0.12	0.88
VEEV*	$Y_Z = 1.68 - 0.04X$	5.38	-23.18	0.05	0.96	0.12	0.88

Use η as the indicator for prospective Altman Z-Score: *Safe: $Z > 2.60$, **Gray: $1.10 < Z < 2.60$, and ***Distress: $Z < 1.10$.

6. DISCUSSION

The challenge of assessing credit worthiness in commercial loans is to find practical tools for the credit assessment. The CFB method reviewed in this paper proved to be ineffective. As presented in (1) – (7), CFB method looks good as an academic treatise, but lacks practical utility. By using the Altman Z-score, we present as alternative approach to cash flow analysis for purposes of financial distress. This method is not a new contribution. However, the use of series of Altman Z-score over a span of operating periods to run an Altman Z-score distribution and use that distribution as the basis for predicting cash flow risk---is a novel approach in cash flow analysis.

The combination of the Altman Z-score distribution and Weibull's system analysis provides a powerful tool for corporate credit evaluation. By reading the Weibull statistics, there is no need to create complicated "credit score." The reading of various Weibull statistics of the Altman Z-score series could provide a multi-aspect to credit evaluation of a firm's financial strength. The value of η provides the expected value of the Altman Z-score. As a point-wise forecast, η provides an empirical basis of the expected value. Secondly, the value of $H(t)$ provides a more accurate tool in probability reading for the current risk of failure in the Altman Z-score. This combined approach to risk assessment has practical utility in the banking business and financial analysis.

7. CONCLUSION

From the in-sample and out-of-sample testing, we learned that cash flow-based structural equation as credit risk assessment tool for commercial loan is not effective. The Altman Z-score is a better alternative. As a tool for assessing potential financial distress, the Altman Z-score could better serve as a tool to assess the firm's credit worthiness. This paper has extended the Altman Z-score by tracking the Altman Z-score over 8 consecutive quarters to obtain an Altman Z-score distribution.

This extension of the Altman Z-score analysis is a contribution to the literature. The argument that the current cash flow of the firm is a function of series of past series and the current market condition is rejected for *non sequitor* argument. The effect of the current market condition has already been incorporated into the process to produce the current cash flow; therefore, by restating it in the argument does not add anything to the proposition. The use of the QQ plot of the past Altman Z-score, or numerical measurement of the firm's financial health, is a better empirical tool for assessing the firm's credit worthiness.

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APPENDIX 1

Weibull QQ Plot Procedures

Firstly, the time function $F(t)$ is obtained by:

$$F(t) = \frac{i - 0.30}{n + 0.40} \tag{A.1}$$

From $F(t)$, the quantitative X and Y are obtained. The X_Q array is obtained by:

$$X_Q = \ln\left(\ln\left(\frac{1}{1 - F(t)}\right)\right) \tag{A.2}$$

The Y_Q array for the Altman Z-score is obtained by:

$$Y_Q = \ln(X_{obs}) \tag{A.3}$$

With known X_Q and Y_Q, the linear regression function is obtained by:

$$I = N\sum XY - \sum X \sum Y \tag{A4.1}$$

$$II = N\sum X^2 - \left(\sum X\right)^2 \tag{A4.2}$$

$$III = N\sum Y^2 - \left(\sum Y\right)^2 \tag{A4.3}$$

The slope of the line is simply $b = I / II$ and the intercept is given by $a = \overline{Y} - b\overline{X}$.