Predicting Bankruptcy Among U.S. Companies: A Study Based on Altman's Z-Score and Almamy's J-UK Model

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This thesis aims to compare the famous two bankruptcy prediction models (the Altman Z-score and the U.K. based J-UK model) and investigates which model is a better predictor of bankruptcy when applied for US companies. Expectations were that Altman's Z-score would have a lower predictive ability due to its focus on manufacturing firms and lower significance compared to when it was first revealed in 1968. It was also expected that the J-UK model would have a higher predictive power due to the additional cash flow variable. The models were tested based on a multiple discriminant analysis (MDA) which revealed that the discriminating ability of the J-UK model was significantly higher. However, both models had a high classification ability which is like due to my sample size and availability of data which was not the case when the J-UK model was initially applied in the UK.

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1. INTRODUCTION

Over the past century, a lot has changed in the assessment of financial stability or bankruptcy prediction. The first widely accepted bankruptcy prediction model was established by Edward Altman in 1968. Before that, companies used to hire external agencies to perform qualitative analysis on clients. Later, studies were established using a variety of ratio measurements because one thing was clear back then: financially distressed companies have different financial ratios than healthy companies (Altman, 1968). For example, healthy companies have positive retained earnings while struggling companies often have negative retained earnings and less liquidity.

Altman's original bankruptcy model is widely used nowadays. It is being used in a variety of industries to evaluate financial conditions (Chen and Church, 1996). The model is also being used in multiple business situations where there is need for the assessment of financial stability. In this case, this research defines financial stability as a company's ability to stay solvent. Moreover, the model is used by commercial banks who use it as a part of their periodic loan review process while investment bankers apply the model to support security and portfolio analysis (Grice and Ingram, 2001). The model has also been used as a decision tool for managers and as a part of auditors' assessment of their clients' abilities to remain solvent (AICPA, 1987; Dugan and Zavgren, 1988). Additionally, the assessment of credit risk is increasingly important given the requirements of Basle II and explosive credit growth (Agarwal and Taffler, 2007).

This thesis will be based on the research made by Altman in 1968 who invented the Z-score. I will apply further research made by Almamy et al. (2015) who contributed to Altman's research by adding an additional cash flow variable and tested both Altman's Z-score and their own score in the UK, called the J-UK model. Almamy et al. concluded that his model was a better predictor of bankruptcy in the UK based on its discriminating ability.

This paper will focus on listed US companies and investigate which bankruptcy model explains the bankruptcy better. The research question therefore will be: *Is the J-UK model a better predictor of bankruptcy than the Altman (1968) Z-score based on U.S. companies?*

Multiple studies have focused on the comparison between the Altman Z-score and bankruptcy scores that where either based on the Z-score or built with an entirely new set of variables. Also, research has focused to find changes of bankruptcy scores when it comes to different time periods or different sample sizes and compositions. So far, there has not been researched focused on the comparison between two bankruptcy scores in a different country. My research is filling a research gap by finding similarities and differences by applying previously conducted research in an entirely new setting.

The reminder of this paper is structured as follows. Section 2 will review the existing literature and theoretical framework used in this paper while section 3 will cover the methodology and data used in my research. Section 4 will provide a discussion of the results. Finally, section 5 will contain a conclusion of my research and recommendations for further research.

2. LITERATURE REVIEW

2.1 Altman's Z-Score

Earlier conducted researched played a huge role for Altman when it came to deciding how to structure his model. Prior research after the 1930's found that bankrupt companies showed significant different ratio measurements than non-bankrupt companies according to a study covering over 900 bankrupt and non-bankrupt companies from 1942 (Altman, 1968)

A study 2 years prior to Altman found that the use of ratio analysis was indeed appropriate (Beaver, 1966). Beaver sampled bankrupt and non-bankrupt firms and tested them using variables divided into six core groups.

- Cash-flow ratios
- Net income ratios
- Debt to total assets ratios
- Liquid assets to total assets ratios
- Liquid assets to current debt ratios
- Turnover ratios

However, the problem with previous research is that it was not clear which ratios were the most useful. Researchers disagreed and had their own key indicators which they deemed to be the most valid according to Beaver (1966).

One of the key concepts of Altman's approach is the choice of performing a multiple discriminant analysis instead of a simple univariate approach. This is based on the idea that a company with very low profitability ratios could still survive given that there was enough liquidity and a low debt load for example.

Moreover, the MDA approach is often applied in the investment industry to classify firms into standard investment categories (Smith, 1965).

Altman's sample selection was based on 66 corporations. 33 of these companies had filed for bankruptcy while the other 33 companies were still active. All companies were chosen in the timeframe between 1946 and 1965.

Altman then chose key ratios based on their popularity in the literature prior to 1968 while also introducing new variables in his study. His variables and formula can be seen below.

$$Z = .012X_1 + .014X_2 + .033X_3 + .006X_4 + .999X_5$$

Where X_1 = working capital/total assets

X_2 = retained earnings/total assets

X_3 = EBIT/total assets

X_4 = equity value/book value of total debt

X_5 = sales/total assets

2.2 Altman's Results

First and foremost, Altman found that all variables except for sales/total assets were significant at the 0.001 level. However, the contribution to the discriminating model itself has the second highest ranking as I discussed in the variable breakdown part of this paper.

The most important variable when it comes to the relative contribution is EBIT/total assets as can be seen in Table 1.

Table 1. Z-score relative contributions of variables & test of significance

Variable	Scaled Vector	Ranking	Significant at the 0.001 level
WC/TA	3.29	5	Yes
RE/TA	6.04	4	Yes
EBIT/TA	9.89	1	Yes
EQ/TL	7.42	3	Yes
S/TA	8.41	2	No

Retrieved from Altman (1986)

The contribution from EBIT/total sales can be explained by the fact that companies in financial turmoil have earnings close to zero or below according to Altman.

Moreover, the initial sample of 33 non-bankrupt and 33 bankrupt companies showed that the Z-score has predicted 94% of all bankruptcies correct and 97% of all non-bankrupt companies. However, two years prior to bankruptcies, these values fall to 72% for bankrupt companies and 94% for non-bankrupt companies.

The reason behind that move is that company fundamentals dramatically worse once bankruptcy gets closer. A discriminant model then automatically improves its predictive ability.

This is also visible when looking at the application aspect of the Z-score. Generally, a Z-score below 1.81 indicates bankruptcy while a value above 2.99 indicates non-bankruptcy. The values in between are what Altman calls a 'grey area'.

2.3 Current Generalizability of Altman's Z-Score

In 2001, Grice and Ingram studied the generalizability of Altman's bankruptcy model. Their study focused on three key questions as stated below.

- Is Altman's original model as useful for predicting bankruptcy in recent periods as it was when Altman developed his model?
- Can this model as useful for predicting bankruptcy of non-manufacturing companies as it is for manufacturing companies?
- It the model able to predict financial distress conditions as it is for predicting bankruptcy?

The first finding was a previous paper from Begley et al. (1996) which sampled 65 bankrupt and 1300 non-bankrupt companies. The first thing that strikes is the different sample size which only contained 4.7% companies that went bankrupt. Altman oversampled bankruptcies which does not represent the current population, nor did it represent the population in 1968.

However, Begley also applied a different sample of 100 bankrupt and 100 non-bankrupt companies to test how the prediction accuracy had changed compared to Altman's 1968 study. The new model achieved a 78% classification accuracy which was different from Altman's results.

Moreover, Mensah (1984) tested bankruptcy models in different time periods in the 1970s to test for different economic stages and found significant differences.

Grice found a significant difference between Altman's research and the same research at a later stage. Accuracy of distressed predictions dropped from 96% in 1968 to 70.9% between 1988-1991. Moreover, Grice and Ingram found that both financial distress and bankruptcy were equally predicted. When it comes to the difference between manufacturing and non-manufacturing firms, Grice found that the Z-score is considerably more significant when applied to manufacturing firms. Nonetheless, Almamy applied their research on both manufacturing and non-manufacturing firms to generalize both models which will also be done in my research.

2.4 Market Based versus Accounting Based Variables

Another aspect that has been researched after Altman's Z-score paper had been published is the difference between accounting variables and market-based variables.

Hillegeist et al., (2004) for example argued that accounting variables had a lower ability of predicting bankruptcy because asset values are often understated relative to their market share. They also argued that market-based variables like volatility predicted bankruptcy because stock listed companies started to increase their volatility when financial situations worsen. Moreover, Hillegeist et al. raise the point that investors who influence market-based variables retrieve their information from a large variety of indicators. Meaning that market-based indicators are forward looking while Altman's methodology was based on backward looking information.

Agarwal and Taffler (2007) had three reasons why accounting-based variables can be considered less valid.

- Accounting variables say something about the past instead of the future.
- True asset value may vary from the book value of these assets
- Accounting variables are subject to manipulation

Market based variables on the other hand are unable to be manipulated by management and contain information from other sources than management statements like quarterly or annual reports.

That being said, research from 2004 showed that the Z-score is slightly more appropriate that models using market-based variables (Reisz and Perlich, 2004).

Moreover, Agarwal and Taffler researched the difference between the Z-score model and the market-based KMV model from Scholes (1973) and Merton (1974) concluded the following.

- The Z-model is statistically more accurate than a KMV model while the difference is not significant.
- A Z-score applied in a competitive loan market would significantly increase a bank's risk-adjusted revenues.
- Both the market-based and the Z-score model contain significant information to predict bankruptcy even though they do not subsume each other.

Summarizing, Agarwal and Taffler concluded that traditional accounting measures are not inferior to market-based models.

2.5 Applying the Altman Z-Score in the UK

In 2015, J. Almamy, J, Aston and L.N. Ngwa researched the application of Altman's model in the UK. Their research was based on applying the Altman Z-score to UK based companies and to add an additional indicator.

First, Almamy et al. sampled 1000 non-bankrupt UK companies and 90 bankrupt companies between 2000 and 2013.

This sample and the extended time period allowed to find enough information to generate the same formula Altman came up with which was structured as follows: $Z = XT_1 + XT_2 + XT_3 + XT_4 + XT_5$. Furthermore, Almamy incorporated earlier remarks that Altman oversampled bankrupt companies. Altman used 30 non-bankrupt and 30 bankrupt companies. This is not representative of the population.

They then added an additional factor being the ratio of operational cash flow to total liabilities.

Some companies were excluded given that there was not enough information to calculate the ratios. This was also the reason that the additional cash flow variable was not significant. Nonetheless, Almamy et al. found that the addition of the cash flow variable increased the significance of all variables but equity valuation to total debt as can be seen in Table 2.

Table 2. Overview of Altman UK and J-UK variables and significances

Altman UK Variables	Sig.	J-UK Variables	Sig.
WC/TA	0.000	WC/TA	0.000
RE/TA	0.012	RE/TA	0.000
EBIT/TA	0.395	EBIT/TA	0.000
EQ/TL	0.031	EQ/TL	0.074
S/TA	0.054	S/TA	0.000
		OCF/TL	0.631

All J-UK variables are equal to the Altman variables with the additional J6 variable being operational cash flow/total liabilities

The final J-UK model, after including an additional variable and a different sample size can be seen below.

$J\text{-}UK = 1.484J_1 + 0.043J_2 + 0.390J_3 + 0.004J_4 - 0.424J_5 + 0.75J_6$

Where,
J_6 = operational cash flow/total liabilities

When applied in the UK, Almamy and his colleagues found that the Altman model correctly classified 54.4% of all companies based on a paired sample basis. The J-UK model on the other hand correctly classified 82.9% of all companies.

Moreover, both models were tested using Wilks' Lambda to assess which one had the higher discriminating ability. Wilks' Lambda is a value between 0 and 1. The outcome explains what part of the variability is left unexplained.

The original Altman approach had a Wilks' Lambda score of 0.995 while the renewed J-UK model came in at 0.983. This indicates that the J-UK model has a higher predictive value indeed.

Regarding the aforementioned theories and approaches, it becomes clear that Altman's approach is still widely used and valid even though new research has been made using market-based variables. However, Almamy, Astron and Ngwa found a way to further improve the Z-score by adding a new variable and by changing the sample size. However, this model has not been back tested in the U.S. Thus, the following hypothesis is proposed;

H1: The J-model has a better ability to predict bankruptcy than Altman's Z-score

3. METHODOLOGY

In this section, I will discuss the variables and data used to compare the two models from Altman (1968) and Almamy and explain how I am going to measure which one has the higher discriminating ability.

3.1 Models

Both the bankruptcy models established by Altman in 1968 and Almamy (2015) are the foundation of this research. First of all because Almamy's model builds on Altman and because I am establishing a comparison of both models when applied in the United States.

(Altman) $Z = .012X_1 + .014X_2 + .033X_3 + .006X_4 + .999X_5$

(Almamy) $J\text{-}UK = 1.484J_1 + 0.043J_2 + 0.390J_3 + 0.004J_4 - 0.424J_5 + 0.75J_6$

In order to test the discriminating ability of both models, I am going to perform a multiple discriminant analysis based on a paired sample (bankrupt and non-bankrupt companies).

I will be able to get an overview of the predicted group memberships as well as the original group distributions which allows me to see which model has the higher classification ability.

Moreover, a test of equality of group means provides me with an overview of the significance per variable which makes it easier to compare the two models once a sixth variable is added.

After adding a sixth variable, I will be able to witness the change of significance among the variables of the two models.

After that, I will conduct a Wilks' lambda test which will give more insights on the overall significance of the discriminant models. The same approach was used by Almamy et al. in 2015.

That being said, the Wilks' lambda analysis is a measure of the class center separation and the variance proportion. This means that if only a small proportion of the variance is explained by independent variables, that there is no true difference between two groups. In this case bankrupt and non-bankrupt firms.

The value of Wilks' lambda is always a number between 0 and 1 where a higher value indicates that a certain grouping variable (in this case financial ratio) has a higher ability to discriminate.

Moreover, I will be able to compare my findings to previous research when it comes to the influence of certain key variables.

That is why it is so important to have a good overview of all variables and to get the meaning behind the ratios influencing Altman's and Almamy's bankruptcy models.

3.2 Variables

The variables used in my research are the components of the ratios used by Altman and the additional ratio incorporated by Almamy.

I will therefore start with a breakdown of the variables used by Altman. Note that I added the specific part of the Altman and Almamy models to the variable title.

Working capital/total assets (X1/J1)

This ratio is a measure of liquidity where working capital is the difference between current assets and current liabilities. Altman found this to be the most efficient liquidity ratio given that companies that lose money on a frequent basis tend to have declining net assets. The other two liquidity ratios he looked at where the current ratio and quick ratio who had a lower significance in Altman's prior research.

Retained earnings/total assets (X2/J2)

Retained earnings display a company's cumulative profitability. This ratio contains two aspects that I found to be extremely interesting and well thought out. The first thing being the incorporation of age. Bankruptcy models like the one from Taylor Shumway in 2001 added age as an extra variable, as measured by the number of calendar years a company is active. Altman's model on the other hand made the assumption that companies with a longer history had higher returned earnings. Simply because they have been in business for a longer period of time. This also means that younger firms are being discriminated against given that they have a lower ratio and therefore a higher bankruptcy probability according to Altman. However, he argued that this was a good representation of the real economy where younger companies, often in early business stages, have a lower chance of survival.

Later research from Canada found that an early age indeed caused a higher bankruptcy risk due to the fact that it takes time to create value adding capabilities (Thornhill and Amit, 2003).

EBIT/total assets (X3/J3)

The purpose of this ratio is to look at the true earnings power of a company's assets. In this case, Altman looked at earnings abstracting taxes and the influence of leverage.

Market value of equity/book value of total debt (X4/J4)

Market value is defined as the total market value of all preferred and common shares. Total debt is the sum of both short term and long term debt or total current liabilities plus total long term debt. The purpose of this ratio is to see how much a firm's assets can decline before liabilities exceed the assets of a given firm.

In case of stock listed company, there is another aspect that plays a role. Investors and traders who often incorporate many other indicators in addition to the ones discussed in this paper, tend to sell companies when they expect financial turmoil to happen in the future (Shumway, 2001). This gives the Z-score a predicting aspect.

Sales/total assets (X5/J5)

Total sales as a part of total assets indicate management's ability to generate top line growth in different situations. The overview of all indicators in Table 1, shows that this ratio is not significant by itself. However, Altman saw that this ratio had the second highest contribution to the overall discriminating ability of his model.

The variable added by Almamy et al. can be seen below.

Operational cash flow/total liabilities (J6)

Almamy et al. did not elaborate extensively on their choice when it comes to the additional variable. The one thing that is clear however, it the lack of valid data Almamy et al. encountered during the execution of their research. Companies that lacked valid operational cash flow data were excluded from the sample. This difference can be seen in Table 2. Moreover, total liabilities are defined by an addition of current liabilities and long term debt.

3.3 Data

The data needed in order to be able to compare both the J-UK model and Altman's Z-score in the US are all variables as discussed in the variable section. These accounting variables are based on a paired sample of both bankrupt and non-bankrupt firms.

My sample incorporates the same distribution between bankrupt and non-bankrupt firms as the research conducted to construct the J-UK model which means that 9% of the total sample consists of bankrupt companies. This is much lower than the 50% of the Altman sample and in line with recent studies from the Kaplan Group that showed that on average between 8%-10% of all companies in New York and Florida go bankrupt in 2016. Only states that are less wealthy have a higher bankruptcy rate.

To sample companies, I used the Orbis database which allowed me to sample all data points from U.S. companies in a simple and well-organized manner.

My sample consists of 30 bankrupt firms and 330 non-bankrupt firms. All companies are or were listed companies. This sample is mainly based on the fact that I was able to find 30 suitable bankruptcy cases since 1998 of companies that were big enough and provided at least 5 out of 6 needed variables[1]. I then used the same bankruptcy to non-bankruptcy ratio Almamy et al. used to avoid

[1] Not all companies had available operating cash flow data whereas some companies missed even more variables

oversampling bankrupt companies. The total asset size of bankrupt firms ranges from $228 million to $5.4 billion and includes both manufacturing firms and non-manufacturing firms like mortgage providers. The average asset size is $1.1 billion. The data sample consists data found between 1998 and 2012 which captures both the accelerating and decelerating phases of a typical business cycle.

Moreover, the choice of using a bigger asset size allows me to use companies that have generally more available data which was a problem Almamy et al. encountered as they were not able to find sufficient information about operating cash flow.

The sample of non-bankrupt companies consist of 330 companies with asset sizes between $146 million and $440 billion. This massive difference between bankrupt and non-bankrupt asset sizes is due to the fact that many companies have had massive growth and because especially financial companies are having a big impact on this range. Note that the biggest companies in the bankrupt sample are also financial companies like the New Century Mortgage Corp. which went bankrupt during the financial crisis.

However, I reduced the median asset size to $9 billion by picking companies with a large as well as a small asset size which is a better representation of the current economy and asset sizes and incorporates both large financial companies and relatively smaller firms. It also prevents a large gap between the average bankrupt and non-bankrupt company. The average asset size is $24.7 billion.

4. RESULTS

In this section, I will discuss the results from the F-test, classification and Wilks' Lambda analysis.

4.1 Variable Significance

It is important to measure the variable significance before and after the addition of the cash flow variable to see whether the cash flow variable does indeed have an impact on other variables as Almamy found in his research. When applied in the U.S. with a different sample size and sample composition than the original Altman research in 1968, I find that every single variable but sales to total assets has a p-value below the 0.05 threshold as can be seen in Table 3. This confirms Almamy's findings who also found that sales did not have a significant impact. Moreover, this was also the finding of the original research from Altman in 1968. However, my findings show that earnings before interest and taxes do have a significant impact. The average EBIT/TA ratio for bankrupt companies is -0.16 while non-bankrupt ratios have an average ratio of 0.092. Moreover, the average ratio between retained earnings and total assets is 0.22 for non-bankrupt companies and -0.37 for bankrupt companies. My sample seems to have a very clear distinction between bankrupt and non-bankrupt companies which could be due to the fact that I have a lot of large cap companies that are financially solid while bankrupt companies obviously have low earnings and retained earnings.

Table 3. F-test summary for the Altman variables

F-test summary for Altman Ratios	F	Sig.
WC/TA	15.630	0.000
RE/TA	39.413	0.000
EBIT/TA	136.977	0.000
EQ/TL	12.350	0.001
S/TA	3.574	0.060

After I added the operating cash flow to total liabilities variable, I found another difference compared to the original research from Almamy as Table 4 reveals.

The first thing that strikes is that the influence of the new variable on the existing variables is non-existing according to Table 4. This is likely because these variables already had a very low p-value. Adding to that, I found that the new variable also was significant. This was not what Almamy found in his research given that many of his samples companies did not provide operating cash flow data. My sample on the other hand provides this data for every single company which is likely the reason why this variable is has a p-value below the 0.05 threshold.

Table 4. F-test summary for the J-UK variables

F-test summary for the J-UK model Ratios	F	Wilks' Lambda	Sig.
WC/TA	15.630	0.954	0.000
RE/TA	39.413	0.892	0.000
EBIT/TA	136.977	0.704	0.000
EQ/TL	12.350	0.963	0.001
S/TA	3.574	0.989	0.060
OCF/TL	17.916	0.948	0.000

4.2 Classification Results

The classification results for the Altman model show that 99.7% of all non-bankrupt companies in my sample have been correctly classified. The rate for bankrupt companies is much lower at 60.0%. This brings the total classification rate to 94.2%. The Altman UK model as applied by Almamy had a classification rate of 54.4%. This rate is much lower and also had a much bigger sample of 11,040 companies. Adding to that the clearer distinction between non-bankrupt and bankrupt companies from my sample makes it more logical that the classification rate from my sample and variables is higher. The same also happened during the initial research from Altman who found that his original model correctly classified 94% of all bankruptcies and 97% of all non-bankrupt companies.

Table 5. Classification results for the Altman model

Classification Results*			Predicted Group Membership		
			Non-Bankrupt	Bankrupt	Total
Original	Count	Non-Bankrupt	297	1	298
		Bankrupt	18	12	30
	%	Non-Bankrupt	99.7	0.3	100.0
		Bankrupt	60.0	40.0	100.0

** 94.2% of original group cases correctly classified*

The application of the J-UK model in the U.S. can be seen in Table 6. The outcome is not following the original findings from Almamy. The only difference compared to my findings for the Altman model is that in this case 99.3% of all non-bankrupt companies were classified correctly versus 99.7% in the Altman model as I showed in Table 5. This 4-basis point difference translates to exactly

one company. On top of that, the classification of non-bankrupt companies is exactly 60.0% which is equal to the Altman variables. Hence the total classification rate slightly declines to 93.9%. This is still higher than the original classification rate Almamy found when applying the J-UK model in the U.K.

Table 6. Classification results for the J-UK model

Classification Results*			Predicted Group Membership		
			Non-Bankrupt	Bankrupt	Total
Original	Count	Non-Bankrupt	296	2	298
		Bankrupt	18	12	30
	%	Non-Bankrupt	99.3	0.7	100.0
		Bankrupt	60.0	40.0	100.0

** 93.9% of original group cases correctly classified*

Another important thing to mention is that Grice (2001), who tested the influence of different time periods on the Altman Z-score, found that the classification rate came down from 83.5% in 1968 to 57.8% in the period between 1988-1991. This would also disagree with my findings given that Grice found that the longer the time between measurement and initial findings of the Z-score in 1968, the lower the discriminating ability. However, even though Grice used a similar bankrupt to non-bankrupt sample as Almamy (6.6 times as many non-bankrupt companies as bankrupt companies) he sampled companies that were in distress and had a low stock rating and bonds close to default as bankrupt companies. I only used companies that were officially bankrupt. This causes a clearer distinction between nonbankrupt and bankrupt companies and is likely the reason why my classification results differ from the findings from Grice.

Adding to that, it is remarkable that Heine, who revisited Altman's findings in 2000 found that the classification results did not drop significantly between his initial findings of 1968 and 1999. He made three classification tests between 1968 and 1999 and always got a total classification rate higher than 80% (Heine, 2000). This would support my own findings and confirm that the Z-score is indeed an appropriate tool years after its initial publication in 1968.

4.3 Wilks' Lambda Comparison

The Wilks Lambda score reveals two very interesting aspects as can be seen in Table 7. The first thing that got my attention is the difference compared to Almamy's original results. Almamy found a Wilks' Lambda score of 0.995 for the Altman model when applied in the UK and 0.983 for the original J-UK model. My research shows that the values are much lower at 0.649 for the Altman model and 0.638 for the J-UK model. In other words, the total variability that is left unexplained is lower among my samples which indicates an overall higher discriminating ability. There is more separation between the groups.

Table 7. Wilks' lambda comparison between the Altman and J-UK models

Wilks' lambda for Altman and J-UK model			
Model	Wilks' lambda	Chi-square	Sig.
Altman	0.649	139.617	0.000
J-UK	0.638	144.913	0.000

The data also shows that the J-UK has a higher ability to discriminate given the lower Wilks' Lambda score. It also needs to be interpreted using the Chi-square analysis and the corresponding p-value which shows that the discriminant models are highly significant at the 5% significance level.

5. CONCLUSION AND IMPLICATIONS

5.1 Conclusion

The goal of this research was to find which bankruptcy model is a better predictor of bankruptcy when applied in the U.S. I compared both Almamy's J-UK model and the Altman Z-score based on the research question '*is the J-UK model a better predictor of bankruptcy than the Altman (1968) Z-score based on U.S. companies?'*.

Previous research showed that the variables chosen by Altman prevailed and were adopted by many researchers who applied their own research.

Begley et al. (1996) found that a different sample size had a significant impact on Altman's classification results whereas Mensah (1984) found that Altman's Z-score has different results when applied in different time periods.

Grice and Ingram (2001) also found that Altman's Z-score lost its classification predictability over the past decades. However, they also concluded that the Altman Z-score can be applied to both manufacturing and non-manufacturing companies while financial distress can be predicted as well as bankruptcy which adds to the justification when it comes to applying the Altman Z-score to predict financial stability.

My research confirms many of these previous findings by also showing unexpected results when it comes to the classification results of both the Altman and J-UK model when applied in the US.

Both the variables for the Altman and J-UK model are significant except for sales/total assets. Moreover, the added operating cashflow variable from the J-UK model did not influence the other variables. Moreover, the operating cashflow variable was significant by itself.

This difference is explained by looking at the availability of data. My own samples had operating cash flow for every bankrupt and non-bankrupt company whereas Almamy lacked this data which caused the insignificance of this variable. Moreover, my data consists of large non-bankrupt companies and larger bankrupt companies. The reason is because most companies after the year 2000 either presented all needed variables or almost none. This was especially the case for the bankrupt companies.

After applying a similar non-bankrupt to bankrupt sample ratio as Almamy, I had a total sample of rather large companies with the needed information for every variable. This is the reason why the classification rates for both models are higher than 93%. There is a very clear distinction between non-bankrupt and bankrupt companies which makes is rather easy for models to spot the failed companies.

That being said, the difference between the classification results is just one more correct bankruptcy prediction by the Altman model. However, when looking at the Wilks' lambda score we see that the discriminating ability of the J-UK model is significantly higher than the Altman model. Adding to that, it became also clear that both models had a

higher discriminating ability based on my sample which was expected given the much higher classification results.

Looking back at all data points, I have to say that the current use of the Altman Z-score by banks and financial institutions is justified. Even after all these years, this ratio is still a valid ratio with a high predictive power. However, this paper confirms that the additional cashflow variable increases the discriminating ability significantly which means that the J-UK model has the better predictor of bankruptcy when applied in the US.

5.2 Implications

My sample sizes are rather limited even though the total sample size still exceeds the original Altman sample from 1968. This is due to the lack of data from companies with a smaller asset size. I could have used more non-bankrupt companies given the large number of available options. However, this would have resulted in a different bankrupt to non-bankrupt ratio which would have interfered with the purpose of this study.

Adding to that, I could have chosen to use companies with missing operating cash flow data in my sample. That way, I would have had a similar sample composition like Almamy's original research. However, Almamy did not reveal what percentage of his companies did not have operating cash flow data. I therefore chose to include as much data as I could which included data from all variables.

5.3 Recommendations for Further Research

Further research would benefit from a closer look at the influence of company sizes on the predicting ability of the Altman Z-score. My researched showed that there was a very clear distinction between bankrupt and non-bankrupt companies. One of those reasons could be the big difference between company seizes. A series of comparisons between samples with smaller companies might reveal more about the influence of company sizes.

It would also be appropriate to study the effect of missing values on the outcome of variable significance of the Almamy J-UK score. As mentioned before the operating cash flow variable was not significant by itself but did influence the original Altman variables. These studies should look to study multiple samples of bankrupt and non-bankrupt companies each with a different number of missing operating cash flow values.

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