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Predicting Listed Companies' Failure in Jordan Using Altman Models: A Case Study

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Abstract

The Altman Z-score (1968) model and the Altman Z''-Score model (1993) have been created and applied in the US and other developed countries in a specific era. It is therefore possible that their results are not generalisable to less developed countries in today's context. We tested the generalisability of these two statistical failure prediction models in the Jordanian environment. We used a sample of 71 failed and 71 non-failed companies that were chosen based on the same industry, year of data, and a comparable size of total assets. We tested if the two models predict failures as they did in the US and European countries and if these models are thus relevant for Jordanian firms. We found that the original Altman Z-Score (1968) model still works effectively. The model is generalisable in the Jordanian context for assessing failed industrial companies. For service companies, however, we found that the Altman models could not provide strong indicators to differentiate between failed and non-failed companies.

Keywords: generalisability, AMODELS, failure prediction

1. Introduction

The collapse of stock markets has thrown a lot of companies out of business and destroyed many economic sectors throughout the world. Auditors are obligated by auditing standards to assess and report about companies' capability to continue as a going-concern. In spite of that, companies fail after receiving clean or unqualified audit opinions.

Statistical failure prediction models (SFPMs) can predict business failure with a high accuracy rate within a few years before the failure. Valid SFPMs thus can reduce losses for investors and other stakeholders, by sending alert signals in a timely manner.

Most SFPMs have been developed for and tested in developed countries (e.g. the US and European countries). Amongst the most common SFPMs are the Altman Z-Score 1968and Altman Z''-Score 1993 (AMODELS). Studies have demonstrated that the AMODELS and their variants have a very high degree of accuracy in predicting corporate financial failure in the US as well as in some emerging markets. Altman used a multiple discriminant analysis (MDA) to classify companies into high or low default risk categories.

One cannot be sure, however, that SFPMs like the AMODELS are as effective in classifying companies in high or low default risk categories in different industries, economic and political environments and/or in different time periods. Their results may not be generalisable to less developed countries in the current context.

In this study, our objective is to determine whether the AMODELS are appropriate and generalisable in the Jordanian economic environment. We use the AMODELS in our study, as they are among the most commonly used SFPMs and they are rather successful in evaluating the health of a company in developed countries. Additionally, the AMODELS are simple and practical to use.

We applied the two AMODELS to 94 industrial companies and 48 service companies. The sample of industrial companies contained 47 failed companies and 47 non-failed companies; the sample of service companies included 24 failed and 24 non-failed companies. The data were gathered for three years prior to failure.

Our research results are interesting for investors, auditors and other stakeholders in Jordan. They provide empirical proof about the generalisability of the AMODELS to the Jordanian context. So far, only a very limited number of studies have been done in Arabic countries in general and in Jordan in particular to test SFPMs such as the two AMODELS, and their samples sizes have been very small.

We found that the original Altman Z-score (1968) model is generalisable in the Jordanian context for assessing failed industrial companies. Error rates were low, and the Type I and Type II correct classification rates of the model in all three years before non-failure were high.

For service companies, however, we found that the AMODELS were not good to distinguish between failed and non-failed Jordanian companies. Especially for the Altman Z''-Score (1993) model this is remarkable, as it was specifically designed to predict failure in a non-manufacturing environment. These results indicate that the two models are not generalisable to listed service companies in Jordan.

2. Prior Literature and Developing Hypotheses

Over the past few decades, several SFPMs have been developed and tested, based on various techniques and for different industries, economic and political environments and/or time periods.

In 1968, Altman used a MDA with a group of 22financial ratios (predictors) to develop the original model. He divided the predictors into five standard ratio groups, including profitability, solvency, liquidity, leverage, and turnover ratios. He applied the MDA to 33 pairs of bankrupt and non-bankrupt US companies. The bankrupt group included industrial companies that filed a bankruptcy petition under Chapter X of the National Bankruptcy Act during the 1946-1965 periods. The model was estimated as a function that discriminates between bankrupt and non-bankrupt companies. After several attempts, Altman (1968) reported his original model as well as another model developed in 1993as is shown in Table 1.

Table 1. The AMODELS and their cut-off points

Year	Altman models (AMODELS)	Cut-off points
The Altman Z-score (1968)	$Z = 1.2X_1 + 1.4X_2 + 3.3X_3 + 0.6X_4 + 1.0X_5$ Eq. (1)	Z< 1.81 failure Z> 2.67 non-failure Z = 1.81 to 2.67 grey area
The Altman Z''-score (1993)	$Z'' = 6.56 X_1 + 3.26 X_2 + 6.72 X_3 + 1.05 X_4^*$ Eq. (2)	Z< 1.10 failure Z> 2.60 non-failure Z = 1.10 to 2.60 grey area

Notes: X_1: Working capital/total assets; X_2: Retained earnings/total assets; X_3: Earnings before interest and taxes/total assets; X_4: Market value of equity/book value of total liabilities; X_4*: Book value of equity/book value of total liabilities; X_5: Sales/total assets; Z-Scores = overall index

Despite the success of the AMODELS, over the years many authors have criticized their generalizability. Some research has indicated that the AMODELS are weak in classifying companies' positions in countries other than the US and other developed countries. The models are not as effective in classifying companies into failed or non-failed groups in different economic and political environments (e.g. Grice & Ingram, 2001; Padawy, 2004; Atow, 2006; Gerantonis, Vergos & Christopoulos, 2009). As such, their results may not be valid in the context of Jordan. Therefore, our first hypothesis is divided into two sub-hypotheses as follows:

H1a: The Altman Z-score (1968) model does not achieve high accuracy rates in evaluating the financial position of industrial companies in Jordan.

H1b: The Altman Z''-score (1993) model does not achieve high accuracy rates in evaluating the financial position of service companies in Jordan.

In addition, studies have revealed that SFPMs in general and the Altman Z-score (1968) model in particular, are sensitive to industry type. The overall classification accuracy rate of the model was considerably higher for industrial firms than for the entire sample that involved service firms (Zmijewski, 1984; McGurr & DeVaney, 1998; Grice, 2000; Grice & Ingram, 2001) (Note 1). There are no particular reasons to assume this will be different in the Jordanian context. Thus, our second hypothesis is:

H2: The Altman Z-score (1968) model does not achieve high accuracy rates in evaluating the financial position of service companies in Jordan.

Furthermore, Altman (1968) used MDA to find predictors which best discriminate between failed and non-failed companies. This statistical method is based on restrictive assumptions (e.g. multivariate normal distribution, multicollinearity and homogeneity of variances/covariance). Studies have reported that Altman violated these assumptions (e.g. Deakin, 1972; Eisenbeis, 1977; Joy & Tollefson, 1978; Zavgren, 1985; Barnes, 1987; Ooghe, Joos & Bourdeaudhuij, 1994). Additionally, studies have indicated that differences in the economic environment may change the relationships between the dependent variable and predictors. The model's coefficients may need re-estimation (e.g., Platt & Platt, 1990; Grice & Dugan, 2001). Furthermore, other studies have noted a potential search bias in the predictor selection method used by Altman (Scott, 1981).

Accordingly, it may be that the predictors used by the AMODELS are weak and do not differentiate between failed and non-failed industrial and service companies in a specific environment, like the Jordanian context. Thus, our third hypothesis is divided into two sub-hypotheses as follows:

H3a: The predictors used by the Altman Z-Score (1968) model do not discriminate well between failed and non-failed industrial companies in Jordan.

H3b: The predictors used by the AMODELS do not discriminate well between failed and non-failed service companies in Jordan.

3. Study Problem and Objectives

Most SFPMs have been developed and applied in the US and other developed countries in a specific era. It is therefore possible that these models are not as effective in classifying firms into failed and non-failed categories in different industries, different economic and political environments and/or in different time periods. Their results may not be generalisable to less developed countries like Jordan.

In our study, we apply the AMODELS to Jordanian industrial and service companies. We chose the two AMODELS as our study object for several different reasons: they are commonly used SFPMs, they are simple to use and they achieve high classification accuracy rates. Our objective is to see whether the two AMODELS predict business failure with a degree of accuracy in Jordan similar to the degree of accuracy in the US and in other developed countries.

More specifically, we consider the following questions:

1) Are the AMODELS as useful for predicting failure in Jordan as for other contexts, since they were developed and tested by Altman in developed countries?
2) Is the Altman Z-Score (1968) model useful for predicting failure of service companies in Jordan and how long prior to failure does the model give high accuracy rates in predicting failure?
3) Are the predictors used by AMODELS valid to discriminate between failed and non-failed industrial and service companies in Jordan?

4. Study Design

This section defines business failure, the data and sample size and the selection criteria. In addition, it explains the methodology used to apply the AMODELS.

4.1 Business Failure

The opposite of the going-concern status, so to speak, is to say that the company will fail within one year from the balance sheet date. Studies define business failure as the act of filing for bankruptcy. For example, Altman (1968) defines bankruptcy as filing for Chapter 11 bankruptcy. This definition is suitable in the US, where corporations use Chapter 11 of the federal Bankruptcy Code to continue business while the company reorganizes. This is in line with Gilbert, Menon & Schwartz (1990) who suggest that financial dimensions that discriminate bankrupt from non-bankrupt companies are different from those that separate bankrupt from distressed firms.

Other studies use specific criteria to define business failure. For instance, Beaver (1967) uses a definition of failure which comprises default on a loan, an overdrawn bank account, and non-payment of a preferred stock dividend. Alternatively, failure may be defined in a legal sense. Deakin (1972), for example, uses failure to include only those entities which experienced bankruptcy, insolvency, or were otherwise liquidated for the benefit of creditors.

In this study, for data analysis purposes, a clear and consistent definition of failure or default is required. We found that delisting from the ASE is a very good proxy for failure in Jordan. We compared the companies listed in the Companies Guide of the ASE on a year to year basis. When a company was in the guide one year and not in it the next year, we considered the company as delisted. Then, to fine-tune the selection, and to avoid including companies that delisted for reasons other than default-related, we made a second selection within the list of delisted companies considering two criteria:

1) Either a company was found to be bankrupt based on the information of the Companies Control Department in Ministry of Industry & Trade database (Note 2).
2) Or the company was found to have incurred losses for the past three years or more which is the default definition used by the Companies Control Department in the Ministry of Industry & Trade.

4.2 The Data and Sample Size and Its Selection Criteria

A major obstacle in Jordanian business failure prediction research is the lack of some crucial data. Consequently, a significant portion of our research work reported here, and a related contribution of the study, involves data collection. The data collection effort involved a search for the names of failures that meet our failure definition, followed by a search for the financial data for those companies, and followed by a search for matching non-failed companies.

The sample was also selected on the basis of the following main conditions:

1) Financial reports are available for three years prior to failure (balance sheets and income statements).
2) Shares must have been publicly traded.
3) Fiscal year ends on 31 December.
4) Companies belong to the service and industry sectors (banks and insurance companies are excluded because the predictors vary in method from one industry to another).

This selection approach resulted in a sample of 71 listed companies (47 industrial and 24 service companies) that failed during the period 1989-2008. The 71 failed companies ranged in the size of their total assets from JD 115,700 (USD 163,137) to JD 92,911,180 (USD 131,004,764).

Previous failure research has mostly adopted a matched pairs method for drawing samples of failures and non-failures. We also matched our 71 failed companies with 71 non-failed companies that were selected on the basis of the same industry, year of data and a comparable size of total assets.

As a result, the number of firms used in the study is 142 companies as is shown in Table 2.

Table 2. Sample distribution by failed and non-failed companies

Sample	Failure	Non-failure	Total
Industrial Companies	47	47	94
Service companies	24	24	48
Total	71	71	142

The data was derived from the financial reports of the 142 companies for three years prior to failure. We collected three financial reports for each company. Therefore, 426 financial reports were obtained.

4.3 Methodology

The methodology involves calculating values of Z-scores for each firm, and then placing each firm into three zones, namely non-failed, grey and failed, on the basis of the cut-off points for each zone provided by the AMODELS. The Z-scores were calculated for each of the study samples using Altman's coefficients from equations Eq. (1) and Eq. (2) shown in Table 1.

The Altman Z-score (1968) model includes five predictors (X_1, X_2, X_3, X_4, X_5) and the Altman Z''-Score (1993) model contains only four predictors (X_1, X_2, X_3, X_4*). The two models use the same predictors, with a different definition for X_4, and with the exclusion of X_5 in the Altman Z''-score (1993) model. The predictors stand for:

X_1 = working capital/total assets.

X_2 = retained earnings/total assets.

X_3 = earnings before interest and taxes/ total assets.

X_4 = market value equity/book value of total liabilities.

X_4* = book value equity/book value of total liabilities (i.e. X_4* differs from X_4 in that it uses the book value rather than the market value of equity).

X_5 = sales/total assets and.

Z-Scores = overall indexes.

We calculated the Type I and Type II correct classification rates and the overall classification accuracy rate of the two AMODELS using the full 1989–2008 sample (142 firms), a subset of the sample comprising only industrial firms (94), and a subset of the sample containing only service firms (48 firms). We also considered the Type I and Type II errors. The Type I error rate is the ratio of the number of failed companies incorrectly classified as non-failed by the AMODELS to the total number of companies in the sample; and the Type II error rate is the ratio of the number of non-failed companies incorrectly classified as failed by the AMODELS to the total number of companies in the sample. We also introduced two analogous terms to evaluate the accuracy of the failure or non-failure prediction:

- The Type I correct classification rate is defined as the number of failed companies correctly predicted as failed by the AMODELS divided by the total number of companies in the study sample.
- The Type II correct classification rate is defined as the number of non-failed companies correctly predicted as non-failed by the AMODELS divided by the total number of companies in the study sample.

In addition, we considered the combined accuracy and error rate as follows:

- The overall classification accuracy rate is the number of companies correctly classified (failed and non-failed) by the models divided by the total number of companies in the study sample.
- The overall error rate is the number of companies incorrectly classified (failed and non-failed) by the models divided by the total number of companies in the study sample.

As we already pointed out, the data were collected for three years prior to failure. We applied the models to the three years. Consequently, the total number of observations used to test the models was 426 observations. We applied the Altman Z-score (1968) model to both industrial and service firms (426 observations) and the Altman Z''-score (1993) model only for service firms (144 observations). For service firms, we were thus able to compare the accuracy rates of the two models.

We used Mann-Whitney tests to test the predictive power of each predictor used by the AMODELS in discriminating between the failed and non-failed companies. This test has the ability to show the significant differences in the means of the predictors between the two samples (failed and non-failed).

5. Study Results

5.1 The Predictive Power of the AMODELS

In this section, we first describe the results of the application of the original Altman Z-score (1968) model to both the industrial and service companies in Jordan. Next, we describe the results of the application of the Altman Z''-score (1993) model to service companies in Jordan.

5.1.1 The Altman Z-Score (1968) Model

5.1.1.1 Industrial Companies

The predictive power of a model is calculated by determining the rate of correct and incorrect classifications (classification accuracy). We considered Type I and Type II correct classification rates and the overall classification accuracy rate – as discussed and defined in the methodology – in evaluating the AMODELS in this Jordanian context.

In Table 3, we present the results obtained when applying the Altman Z-score (1968) model to industrial companies. There are two parts in Table 3. In the first part, we present the classification of companies according to the outcome of the Altman Z-score (1968) as failed, as doubtful (grey area), and as non-failed. In the second part, we show the Type I and Type II errors of the model.

As is shown in Table 3, the Type I correct classification rate of the Altman Z-score (1968) model was 85.10%, 89.36% and 89.36% for predictions within the first, the second and the third year, respectively. However, the Type II correct classification rate was only 61.71%, 59.59% and 51.06% within the first, the second and the third year, respectively. Additionally, the overall classification accuracy rate of the model is 73.40%, 74.46%

and 70.21% within the first, second and third year, respectively.

The Type I error of the Altman Z-score (1968) model was 12.78%, 6.39% and 10.46% within one, two and three years prior to the failure. As for the Type II error, it amounted to 29.78%, 29.78% and 36.18% one, two and three years prior to the failure.

Table 3. Application of Altman Z-Score (1968) model for Jordanian industrial companies

Year	Actual State	Classification of Altman Z-score (1968) Model			Type I and Type II errors	
		Z <1.81 Failed	1.81< Z > 2.67 Grey Area	Z > 2.67 Non-failed	Type I errors	Type II errors
T-1	Failed	40 (85.10%)	1 (2.12%)	6 (12.78%)	6 (12.78%)	14 (29.78%)
	Non-failed	14 (29.78%)	4 (8.51%)	29 (61.71%)		
	Overall	69 (73.40%)				
T-2	Failed	42 (89.36%)	2 (4.25%)	3 (6.39%)	3 (6.39%)	14 (29.78%)
	Non-failed	14 (29.78%)	5 (10.63%)	28 (59.59%)		
	Overall	70 (74.46%)				
T-3	Failed	42 (89.36%)	0 (0.0%)	5 (10.64%)	5 (10.46%)	17 (36.18%)
	Non-failed	17 (36.18%)	6 (12.76%)	24 (51.06%)		
	Overall	66 (70.21%)				

Notes: T-1: First year prior to failure; T-2: Second year prior to failure; T-3: Third year prior to failure.

The observed rates are more or less in line with the original Altman results, with one exception. The Type II error rate is somewhat higher. However, only Type I errors are likely to result in real losses for investors, banks and other interested parties. Type II errors typically result in 'opportunity' losses: investors can lose the opportunity to make a good investment, banks can lose the opportunity to lend money to a good customer, and sellers can lose the opportunity to sell. Additionally, as a result of Type II errors, a company itself might be affected by the self-fulfilling prophecy problem.

Researchers have estimated that Type I errors are 2 to 20 times more serious than Type II errors, with a most likely value of 15 times more serious, i.e. the costs for Type I errors are far higher than for Type II errors (Lee, Chiu, Lu, & Chen, 2002; Thomas, Edelman, & Cook, 2002; Zhoh & Elhag 2007). In addition, Etheridge & Hsu (2007) report that, because Type I errors generally are considered to be more costly than Type II errors, the relative costs of these types of errors must be considered when evaluating model desirability. Thus, we believe that the Type I error rate is more relevant in evaluating and developing SFPMs. However, decreasing the occurrence of Type I errors increases the occurrence of Type II errors.

We hypothesized in H1a that *the Altman Z-score (1968) model does not achieve high accuracy rates in evaluating the financial position of industrial companies in Jordan.* We observe, however, that error rates are small, and classification accuracy is high in all three years prior to failure. Consequently, we have to reject H1a. The Altman Z-score (1968) model works effectively in predicting failed industrial companies in Jordan.

5.1.1.2 Service Companies

In Table 4, we show the results obtained when applying the Altman Z-score (1968) model to service companies. As is shown in Table 4, the Type I correct classification rate of the model was 50%, 58% and 50% within the first, the second and the third year, respectively. As for the Type II correct classification rate of the model, we found 63%, 63% and 58% within the first, the second and the third year, respectively. The overall classification accuracy rate of the model was 56%, 60% and 54% within the first, the second and the third year, respectively.

The Type I errors of the Altman Z-Score (1968) model were 50%, 42% and 46% within the first, the second and the third year, respectively. The Type II error of the model was 29%, 33% and 21% within the first, the second and the third year, respectively. We thus observe that the Type I error rate resulting from applying the Altman Z-score (1968) model to Jordanian service companies are much higher than for Jordanian industrial companies.

Table 4. Application of Altman Z-Score (1968) model for Jordanian service companies

Year	Actual State	Classification of Altman Z-score (1968) Model			Type I and Type II errors	
		Z <1.81 Failed	1.81< Z > 2.67 Grey Area	Z > 2.67 Non-failed	Type I errors	Type II errors
T-1	Failed	12 (50%)	0 (0%)	12 (50%)	12 (50%)	7 (29%)
	Non-failed	7 (29%)	2 (8%)	15 (63%)		
	Overall	27 (56%)				
T-2	Failed	14 (58%)	0 (4%)	10 (42%)	10(42%)	8 (33%)
	Non-failed	8 (33%)	1 (4%)	15 (63%)		
	Overall	29 (60%)				
T-3	Failed	12 (50%)	1 (4%)	11 (46%)	11 (46%)	5 (21%)
	Non-failed	5 (21%)	5 (21%)	14 (58%)		
	Overall	26 (54%)				

We hypothesized in H2 that *the Altman Z-score (1968) model does not achieve high accuracy rates in evaluating the financial position of service companies in Jordan.* Contrary to our findings for industrial companies in Jordan, we indeed observe that the Altman Z-score (1968) model does not achieve high accuracy rates in predicting the financial failure of service companies in Jordan. Consequently, we cannot reject H2. We can conclude that the predictive power of the Altman Z-score (1968) model is weak in classifying failed service companies in Jordan.

5.2 The Altman Z"-Score (1993) Model-Service Companies

In Table 5, we present the results obtained when applying the Altman Z''-score (1993) model to service companies. As is shown in Table 5, the Type I correct classification rate of Altman Z''-score (1993) model was 50%, 46% and 38% within the first, the second and the third year, respectively. The Type II correct classification rate of the model was 67%, 71% and 75% within the first, the second and the third year, respectively. Additionally, the overall classification accuracy rate of the model was 58%, 58% and 56% within the first, the second and the third year, respectively.

The Type I error was 50%, 42% and 50% within the first, the second and the third year, respectively. The Type II error was much lower: 8%, 17% and 21% within the first, the second and the third year, respectively.

Table 5. Application of Altman Z"-Score (1993) model for Jordanian service companies

Year	Actual State	Classification of Altman Z''-score (1993) Model			Type I and Type II errors	
		Z <1.10 Failed	1.10< Z > 2.60 Gray Area	Z > 2.60 Non-failed	Type I errors	Type II errors
T-1	Failed	12 (50%)	0 (0%)	12 (50%)	12 (50%)	2 (8%)
	Non-failed	2 (8%)	6 (25%)	16 (67%)		
	Overall	28 (58%)				
T-2	Failed	11 (46%)	3 (12%)	10 (42%)	10 (42%)	4 (17%)
	Non-failed	4 (17%)	3 (12%)	17 (71%)		
	Overall	28 (58%)				

	Failed	9 (38%)	3 (12%)	12 (50%)		
T-3	Non-failed	5 (21%)	1 (4%)	18 (75%)	12 (50%)	5(21%)
	Overall	27 (56%)				

We hypothesized in H1b that *the Altman Z''-Score (1993) model does not achieve high accuracy rates in evaluating the financial failure of service companies in Jordan.* For service companies in Jordan, we indeed find only limited predictive power, even though the Altman Z''-score (1993) model was specifically designed for non-manufacturing companies. Consequently, we cannot reject H1b. We can conclude that the predictive power of the Altman Z''-score (1993) model is weak in classifying failed service companies in Jordan.

Based on the results above, we even find that the Altman Z-score (1968) model is somewhat better in the Type I correct classification than the Altman Z''-score (1993) model. On the other hand, the Type II correct classification of the Altman Z''-score (1993) model is better than for the Altman Z-score (1968) model. The overall conclusion remains that the predictive ability of both models is low for service companies in Jordan.

5.3 The Predictive Power of the Predictors

In the above section, we examined the predictive power of the Altman Z-score (1968) and the Altman Z''-score (1993) models as a whole. In this section, we examine the relative performance of the individual predictors used by these models in discriminating between failed and non-failed industrial and service companies. We computed mean values and used a Mann-Whitney test as a non-parametric statistical test for comparing the predictors used by the two AMODELS. We used a Mann-Whitney test because most of the AMODELS variables violate the normality assumption.

5.3.1 The Predictors of the Altman Z-Score (1968) for Industrial Companies

In Tables 6 through 8, we report mean values and Mann-Whitney test results for failed and non-failed industrial companies in the study sample using the Altman Z-score (1968) model. We did not apply the Altman Z''-score (1993) model to industrial companies, as the model is specific to non-manufacturing companies.

We find that all predictors, i.e. working capital/ total assets (X_1), retained earnings/total assets (X_2), and earnings before interest and taxes/total assets (X_3), market value of equity/book value of total debt (X_4) and sales/total assets (X_5), were lower in the failed than in the non-failed group. The non-failed industrial companies possess strong working capital, adequate retained earnings, liquidity and income. This enables them to continue as a going-concern.

The Mann-Whitney test shows that the differences between the groups of failed and non-failed industrial companies are significant at the 0.05 level for all predictors used by the Altman Z-Score (1968) model and for each of the three years. In other words, we find that all the predictors used by the Altman Z-Score (1968) model are valid for discriminating between failed and non-failed industrial companies. Additionally, the values of the Z-scores are considered good indicators for assessing the financial position of a company.

NPar Tests

Mann-Whitney Test: Industrial Companies

Table 6. Mean values of predictors and Mann-Whitney test (T-1)

Predictors	Failed sample mean %	Non-failed sample mean %	Mann-Whitney *p*-value
X_1	-0.739	0.273	0.000**
X_2	-0.638	-0.028	0.000**
X_3	-0.079	0.060	0.000**
X_4	2.320	49.34	0.000**
X_5	0.227	0.640	0.000**
Z-score	-0.421	5.840	0.000**

Table 7. Mean values of predictors and Mann-Whitney test (T-2)

Predictors	Failed sample mean %	Non-failed sample mean %	Mann-Whitney *p*-value
X_1	-0.183	0.274	0.000^{**}
X_2	-0.464	-0.026	0.000^{**}
X_3	-0.060	0.068	0.000^{**}
X_4	2.062	43.50	0.000^{**}
X_5	0.216	0.675	0.000^{**}
Z-score	0.361	6.154	0.000^{**}

Table 8. Mean values of predictors and Mann-Whitney test (T-3)

Predictors	Failed sample mean %	Non-failed sample mean %	Mann-Whitney *p*-value
X_1	-0.116	0.267	0.000^{**}
X_2	-0.411	-0.036	0.000^{**}
X_3	-0.074	0.047	0.000^{**}
X_4	1.967	87.09	0.000^{**}
X_5	0.258	0.636	0.000^{**}
Z-score	0.481	4.467	0.000^{**}

In Table 9, using Spearman's correlation rho, we find that there are significant correlations between the predictors X_1, X_2, X_3, X_4 and the value of the Altman Z-score (1968) for failed and non-failed industrial companies for all the periods (T-1, T-2, and T-3). We confirm that X_1, X_2, X_3, and X_4 have a significant and strong influence on the value of the Z-score. As for X_5 (sales/total assets), we did not find a correlation between this predictor and the value of the Z-score.

Table 9. The correlation between the predictors of the Altman Z-score (1968) model and Z-scores for industrial companies

Correlation Spearman's rho		T-1		T-2		T-3	
		Z-score (failed)	Z-score (non-failed)	Z-score (failed)	Z-score (non-failed)	Z-score (failed)	Z-score (non-failed)
X_1	Correlation Coefficient	.884	.352	.862	.446	.731	.457
	Sig. (2-tailed)	$.000^{**}$	$.015^{**}$	$.000^{**}$	$.002^{**}$	$.000^{**}$	$.001^{**}$
X_2	Correlation Coefficient	.783	.540	.684	.496	.744	.594
	Sig. (2-tailed)	$.000^{**}$	$.000^{**}$	$.000^{**}$	$.000^{**}$	$.000^{**}$	$.000^{**}$
X_3	Correlation Coefficient	.646	.538	.360	.534	.527	.603
	Sig. (2-tailed)	$.000^{**}$	$.000^{**}$	$.013^{**}$	$.000^{**}$	$.000^{**}$	$.000^{**}$
X_4	Correlation Coefficient	.712	.930	.776	.953	.744	.924
	Sig. (2-tailed)	$.000^{**}$	$.000^{**}$	$.000^{**}$	$.000^{**}$	$.000^{**}$	$.000^{**}$
X_5	Correlation Coefficient	.205	.291	.184	.204	.034	.209
	Sig. (2-tailed)	.166	$.047^{**}$	.217	.168	.820	.158
Z-score	Correlation Coefficient	1.000	1.000	1.000	1.000	1.000	1.000
	Sig. (2-tailed)	.	.	.	.	.	.

As a conclusion, our research findings indicate that most of the predictors used by the Altman Z-score (1968) model are significant for determining the Z-score values of industrial companies in the Jordanian context. These predictors have the power to distinguish between failed and non-failed industrial companies. Only X_5 (sales/total assets) lacks predictive power, contrary to findings in developed countries like the US and European countries.

We hypothesized in H3a that *the predictors used by the Altman Z-score (1968) model do not discriminate well between failed and non-failed industrial Jordanian companies.* Based on the above results, we must reject H3a. Indeed, the predictors used by the Altman Z-score (1968) model discriminate well between failed and non-failed industrial Jordanian companies.

5.3.2 The Predictors of the AMODELS for Service Companies

In Tables 10 through 12, we report mean values and Mann-Whitney test results for failed and non-failed service companies in the study sample using the AMODELS. We remind the reader that the Altman Z''-score (1993) model was specifically developed for non-manufacturing companies.

We find that all predictors were lower in the failed than in the non-failed group in all three periods (T-1, T-2 and T-3), with the exception of X_4 and X_4*. The non-failed service companies possess strong working capital, adequate retained earnings, liquidity and income.

The Mann-Whitney test shows that the differences between the groups of failed and non-failed service companies are significant at the 0.05 level for X_2, X_3 and X_5 in the period (T-1), for X_1, X_2, X_3 and X_5 in the period (T-2), and for X_2, X_3 and X_5 in the period (T-3). The market value of equity/book value of total liabilities (X_4) and the book value of equity/book value of total liabilities (X_4*) are not significantly different between the failed and non-failed groups in all three periods. Thus, X_4 as used by the Altman Z-score (1968) model and X_4* as used by the Altman Z''-Score (1993) model do not contribute to discriminating between failed and non-failed service companies. In other words, we find that only some predictors used by the AMODELS are valid for discriminating between failed and non-failed service companies for all periods (X_2, X_3 and X_5). Other predictors are only valid for some periods (X_1), or not at all (X_4 and X_4*). Furthermore, the Z-Score is valid for discriminating between the two groups only for period (T-1). Additionally, the Z''-Score is not valid at all for all three periods.

NPar Tests

Mann-Whitney test: service companies

Table 10. Mean values of predictors and Mann-Whitney test in (T-1)

Predictors	Failed sample mean %	Non-failed sample mean %	Mann-Whitney *P*-Value
X_1	-0.261	0.230	0.091
X_2	-0.558	-0.042	0.000**
X_3	-0.043	0.050	0.003**
X_4	150.77	42.341	0.509
X_4*	69.50	41.48	0.240
X_5	0.246	0.441	0.030**
Z-score	89.47	26.23	0.000**
Z''-score	72.40	48.53	0.127

Table 11. Mean values of predictors and Mann-Whitney test in (T-2)

Predictors	Failed sample mean %	Non-failed sample mean %	Mann-Whitney *P*-Value
X_1	-0.307	0.201	0.010**
X_2	-1.069	-0.068	0.000**
X_3	-0.112	0.055	0.000**

X_4	141.738	26.427	0.741
X_4*	142.08	25.56	0.613
X_5	0.217	0.452	0.015**
Z-score	83.02	16.63	0.322
Z''-score	146.18	31.55	0.265

Table 12. Mean values of predictors and Mann-Whitney test in (T-3)

Predictors	Failed sample mean %	Non-failed sample mean %	Mann-Whitney *P*-Value
X_1	-0.060	0.161	0.338
X_2	-0.458	-0.058	0.000**
X_3	-0.122	0.051	0.000**
X_4	158.272	14.650	0.665
X_4*	160.42	12.07	0.564
X_5	0.217	0.395	0.032**
Z-score	94.06	9.46	0.458
Z''-score	165.85	13.88	0.650

In Table 13, applying Spearman's correlation rho to the Altman Z-score (1968), we find that there are significant correlations between the predictors X_1, X_2, X_4 and the Z-scores of failed and non-failed companies for all the periods (T-1, T-2 and T-3), with the exception of X_1 in years (T-2 and T-3) and X_2 in year (T-1), both in respect of non-failed companies.

As for X_3 and X_5, in most cases we do not find a significant correlation between these predictors and the value of the Z-score. For X_3, we find a significant correlation with the Z-score for failed firms only in years (T-1 and T-3) but not for the year (T-2), and not at all for non-failed companies. For X_5, we only find a significant correlation with the Z-score for failed firms in the three years, but there is no correlation at all for non-failed companies. This analysis proves that there is a clear weakness in the ability of predictors X_3 and X_5 to contribute to the value of the Z-score used by the Altman Z-score (1968) model to estimate the position of failed and non-failed service firms.

Table 13. The correlation between the predictors of the Altman Z-Score (1968) and Z-Score for service companies

Correlation Spearman's rho		T-1		T-2		T-3	
		Z-score (failed)	Z-score (non-failed)	Z-score (failed)	Z-score (non-failed)	Z-score (failed)	Z-score (non-failed)
X_1	Correlation Coefficient	.678	.469	.644	.381	.641	.206
	Sig. (2-tailed)	.000**	.021**	.001**	.066	.001**	.334
X_2	Correlation Coefficient	.688	.373	.693	.540	.576	.608
	Sig. (2-tailed)	.000**	.073	.000**	.006**	.003**	.002**
X_3	Correlation Coefficient	.465	.063	.320	.089	.480	.145
	Sig. (2-tailed)	.022**	.770	.127	.679	.018**	.498
X_4	Correlation Coefficient	.957	.978	.970	.953	.871	.982
	Sig. (2-tailed)	.000**	.000**	.000**	.000**	.000**	.000**
X_5	Correlation Coefficient	-.518	-.297	-.433	-.176	-.545	-.123

	Sig. (2-tailed)	.010**	.159	.034**	.412	.006**	.565
Z-score	Correlation Coefficient	1.000	1.000	1.000	1.000	1.000	1.000
	Sig. (2-tailed)						

In Table 14, applying Spearman's correlation rho to the Altman Z''-Score (1993), we find that there are significant correlations only between X_4* and the Z''-Score of failed and non-failed companies for all the periods (T-1, T-2 and T-3). For X_1, we only find a significant correlation with the Z-Score for non-failed firms in year (T-3). As for X_2 and X_3, we do not find a correlation between these predictors and the value of the Z-Score. This analysis proves that there is a very clear weakness in the ability of predictors X_1, X_2 and X_3 to contribute to the Altman Z''-Score (1993) model for Jordanian service companies.

Then, it might be that both AMODELS are not strong in assessing service companies' position due to the original predictors used by Altman, that they are approximately linked to total assets, a measure that will probably differ much between industrial and service companies.

Table 14. The correlation between the predictors of the Altman Z''-Score (1993) and Z''-Score for service companies

	Correlation Spearman's rho	T-1		T-2		T-3	
		Z'' (failed)	Z'' (non-failed)	Z'' (failed)	Z'' (non-failed)	Z'' (failed)	Z'' (non-failed)
X_1	Correlation Coefficient	0.129	0.071	0.133	0.022	0.102	0.437
	Sig. (2-tailed)	0.548	0.743	0.535	0.917	0.634	0.033**
X_2	Correlation Coefficient	0.079	0.119	0.185	0.108	0.061	0.176
	Sig. (2-tailed)	0.715	0.579	0.387	0.614	0.776	0.410
X_3	Correlation Coefficient	0.041	-0.132	0.083	-0.164	0.120	-0.083
	Sig. (2-tailed)	0.850	0.540	0.701	0.444	0.578	0.699
X_4*	Correlation Coefficient	0.999	1.000	1.000	1.000	1.000	0.997
	Sig. (2-tailed)	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**
Z''-score	Correlation Coefficient	1.000	1.000	1.000	1.000	1.000	1.000
	Sig. (2-tailed)						

We hypothesized in H3b that *the predictors used by the AMODELS do not discriminate well between failed and non-failed service Jordanian companies.* Based on the above results, we cannot reject H3a. This calls for a re-estimation of the models' coefficients in the Jordanian context or for developing new models based on another statistical method to obtain high accuracy rates.

6. Conclusions and Limitations

Since the 1960s, many studies have used the AMODELS as a tool in assessing the risk of financial failure of companies, especially in the US and European countries. Studies for Arab countries have been rare and generally based on small sample sizes.

In this study, we examined the relative performance of the predictors used by the two AMODELS [the original Altman Z-Score (1968) and the Altman Z''-Score (1993)] in discriminating between failed and non-failed industrial and service companies. We used a Mann-Whitney test to compare the two groups.

For industrial companies, we observed that most of the predictors used by the Altman Z-Score (1968) model are valid for discriminating between failed and non-failed companies in Jordan. Additionally, the values of the

Z-score are considered good indicators in assessing financial failure in Jordan. Not surprisingly, we found that non-failed industrial companies possess strong working capital, adequate retained earnings, liquidity and income. This enables them to maintain the integrity of the financial structure and operating assets and to work efficiently and continue as a going-concern.

In line with Altman's (1999) study, we found that the original Altman Z-score (1968) model still works effectively. The model is generalisable in the Jordanian context for assessing failed industrial companies. Error rates were low, and Type I and Type II correct classification rates of the model in all three years prior to (non)-failure were high.

For service companies, however, we found that predictors used by the AMODELS could not provide us strong indicators to differentiate between failed and non-failed companies in Jordan. Especially for the Altman Z''-Score (1993) model this is remarkable, as it was specifically designed to predict failure in a non-manufacturing environment.

For both models, the Type I and Type II correct classification rates are rather low in predicting failed and non-failed service companies and overall, and the error rates are high. These results suggest that the two models are not generalisable to listed service companies in Jordan. We even found that the Altman Z''-Score (1993) model is less useful in predicting the financial failure of service companies than the Altman Z-Score (1968) model.

Our study has some limitations, similar to other empirical studies. One is that the predictive power of the Altman Z-Score (1968) model predictors may significantly decline when applying the model in other emerging markets.One must therefore take care when generalising our findings to other countries, even to countries with common environmental factors with Jordan, as for example other Arab countries from the group of low-middle income countries, non-oil producing countries, code-law systems, with a comparable GDP per capita and a similar business landscape (e.g., Palestine, Syria and Egypt).

Another limitation was that the re-estimation or update process of the AMODELS' coefficients was not possible in the context of Jordan, because when we examined the predictors of the AMODELS, we found that most of them violate the normal distribution assumption, which is one of the most important MDA assumptions.

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Notes

Note 1. The overall classification accuracy rate mentions to the number of companies correctly predicted (failed and non-failed) by the model /the total number of companies in the study sample.

Note 2. Companies Control Department -Ministry of Industry &Trade: http://www.ccd.gov.jo/