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# Usefulness of Z scoring models in the early detection of financial problems in bankrupt Spanish companies

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***Abstract***

***Purpose:*** To determine the predictive capacity of two Z scoring models in situations of bankruptcy in the Spanish context.

***Design/methodology:*** The research intends to answer four questions: (1) Is Altman's Z scoring model a better predictor of possible financial problems than the version developed by Amat et al.? (2) Is the timing of the economic cycle a condition of the temporary gap (pre-crisis period, crisis and post-crisis) in the models proposed by Altman and Amat et al.? (3) Is the business sector a condition of the temporary gap in the two models? and (4) Is the gap conditioned by the size of the company in both scoring models? In order to determine the answers to these questions, and based on the data obtained from the SABI database for the period 2005 to 2015, a descriptive and bivariate analysis is performed.

***Findings:*** The application of statistical techniques reveal that in Spanish companies, the Amat et al. scoring model is more effective in the early detection of financial problems than the Altman scoring model.

***Research limitations/implications:*** The research has focused on bankrupt Spanish companies prior to February 2017. Therefore, the conclusions could differ in the case of expanding the sample.

***Practical implications:*** Due to the fact that insolvency is a problem that concerns different social actors, such as shareholders, suppliers, financial institutions and workers, it is important to know the predictive capacity of the different scoring models in order to make adequate decisions.

***Social implications:*** It is important to know the predictive capacity of the different scoring models to generate third-party confidence in relation to the companies. This also improves the transparency of companies vis-à-vis third parties.

***Originality/value:*** There is a large body of literature related to the early detection of bankruptcies, but there is a lack of literature on the early detection of financial problems prior to bankruptcy. The originality of the research lies in its focus on the study of Spanish companies in an effort to detect early financial problems.

***Keywords:*** Bankruptcy, Scoring models, Prediction, Financial problems

***Jel Codes:*** M1, M4

## 1. Introduction

The recent economic and financial crisis has rekindled the debate on the management of financial risk and the reliability of the models for predicting business failure. The research on the predictive capacity of these models has pivoted between solutions that use historical data from financial statements as their basis and those that include information on the market and macroeconomic context (Tinoco & Wilson, 2013).

Among the first, the Altman model (1968) with its subsequent adaptations continues to be one of the most commonly studied. From the author's initial formulation based on a sample of 66 American listed industrial companies, he defines a synthetic indicator based on accounting ratios that enable us to classify companies according to their financial risk. Later studies have analyzed the different limitations that conditioned its initial formula, and in spite of this, it makes several contributions that demonstrate its validity today. Among these limitations are the sectoral uniformity of the initial sample, the temporal and geographic scope of the study and the methodology used, among others.

In turn, and in light of the gap that exists between the detection of a financial risk and its later entry into bankruptcy, the validity of the model has been question, in terms of its power to predict legal bankruptcy situations, even more so when they depend on factors that go beyond the exclusively financial conditioning factors.

In order to verify the validity of the model in the Spanish context, the study described here analyzes the reliability of the most recent version of the Altman model (1983) and one of its adaptations to the Spanish context (Amat, Manini & Renart, 2016), in order to determine whether the variables related to the business sector, company size or the time in the economic cycle when the measurement is taken, condition the time gap that occurs between the detection of the financial risk and the bankruptcy situation.

## 2. Contribution of the literature

In the framework of the models predicting the business bankruptcy situation based on accounting information, the Altman model (1968) and its subsequent evolutions continue to be the leading model.

To develop his predictive model, Altman (1968) selected a set of 22 financial ratios capable of predicting situations of bankruptcy. Through a linear discriminant analysis (LDA), Altman identified a combination of five ratios capable of discriminating between companies that are in a bankruptcy situation and those that are not. This combination of ratios, or synthetic indicator, also referred to as the Z-Score, consists of five accounting ratios, each weighted by a coefficient. Each of the 5 ratios used belonged to one of the following categories: liquidity, profitability, indebtedness, solvency and rotation.

After applying numerous tests, the linear function that best identified, from a paired sample of 66 traded American companies in the industrial sector, the 33 companies that went bankrupt within the next two years following the closing date on the statements used, was that shown below:

$$Z=1.2X_1+1.4X_2+3.3X_3+0.6X_4+0.999X_5$$

Where, $X_1$ is the working capital/total assets, $X_2$ is the retained profit/total assets, $X_3$ is the operating profit/total assets, $X_4$ is the market value of the net equity/total debt and $X_5$ is the total sales/total assets.

Having obtained this synthetic indicator, the lower the $Z$ value, the greater is the likelihood of bankruptcy. The testing of the Altman model determined certain ranges that would permit companies to be classified, according to their financial health. Accordingly, if the $Z$-score is lower than 1.81, it can be determined that the company is at risk for bankruptcy, while if it is above 2.99, it can be considered to have good financial health; if it falls between the two values indicated, it is considered to have an uncertain position, where it would be difficult to predict its future evolution.

This model, originally developed based on accounting data from 66 traded American manufacturing companies, was later adapted for non-traded manufacturing companies (Altman, 1983). During the re-estimation process, the

value of $X_4$ was replaced by $X_4'$, defined as the accounting value of the net equity/total debt, thus eliminating any reference to the market value. Following the same process as that used in 1968, the new indicator, renamed with the expression $Z'$, was defined as follows:

$$Z'=0.717X_1+0.847X_2+3.107X_3+0.42X_4+0.998X_5$$

Where, $X_1$ is the working capital/total assets, $X_2$ is the retained profit/total assets, $X_3$ is the operating profit/total assets, $X_4$ is the market value of the net equity/total debt and $X_5$ is the total sales/total assets.

And the redefined ranges for the following frontier values are: 1.23 (instead of 1.81) and 2.9 (instead of 2.99).

In turn, and in the same work (Altman, 1983), the author adapted the model to non-manufacturing companies. This time the model was called $Z''$- Score, and was defined as:

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

In this case, $X_1$ is the working capital/total assets, $X_2$ the retained profit/total assets, $X_3$ the operating profit/total assets and $X_4$ the net accounting value/total debt. And the intervals are defined as follows: if $Z''$ is less than 1.1, the company is at risk for bankruptcy, and if it is above 2.6, the company has good financial health; but on the other hand, if it is between the two values, it is difficult to predict its future evolution.

In the wake of Altman, and in light of the limitations inherent to both the sample used and the methodology applied, many authors have analyzed the goodness of fit of the model in contexts other than the original ones, and many have also offered new predictive solutions for business bankruptcy (Moyer, 1977; Zmijewski, 1984; Mensah, 1984; Holmen, 1988; Begley, Ming & Watts, 1996; Grice & Ingram, 2001; Balcaen & Ooghe, 2006).

Some of these authors have tried to overcome the limitation inherent in the time frame of Altman's study (Begley et al., 1996; Mensah, 1984). The results indicate that the predictive capacity of the model is not stable over time and therefore it is influenced by the financial periods being analyzed. Grice and Ingram (2001), in turn, provide empirical evidence that shows that these models are valid, although their predictive capacity worsens when applied to recent periods. In these cases, it is better to re-estimate the model and work with updated coefficients. These studies show that, while the structure of the model is still useful as a predictor, the value of the coefficients does not remain stable over time.

Another limitation of the model that later works have attempted to overcome is the size of the sample used by Altman and the lack of proportionality it has with the real situation of companies in a bankruptcy situation, as compared to the rest of the companies with no financial risk (Zmijewski, 1984). Studies such as that by Platt and Platt (1991), in turn, have demonstrated that better results are obtained when the coefficients are adjusted according to the specific sector being analyzed.

Another aspect that has been questioned is whether the model should be used as a predictor of a company's bankruptcy or as an indicator of financial difficulties, leaving aside the insolvency that may result from them. In this regard, Grice and Ingram (2001) state that, while companies with financial difficulties have a greater likelihood of going bankrupt than financially healthy companies, many of these companies do not end up declaring bankruptcy. In this sense, the authors warn that one of the limitations of the Z indicator is that it does not include any variable related to conditioning factors that are non-financial in nature, that hasten the court declarations of insolvency (credit, labor and legal situations, etc.). For this reason, and having tested the consistency of the model, the authors have determined that the model does not discriminate beyond financial insolvency, and therefore does not present a better fit for companies in a technical situation of insolvency.

Using a similar argument, Tinoco and Wilson (2013) sustain that the "legal" date a company declares bankruptcy does not represent the "real" date of financial insolvency. Contributing an analysis of British firms, the authors show that there is a marked time delay (as much as three years, and with a mean of 1.17 years) between the time when companies enter into a state of financial insolvency and the legal date of their declaration of bankruptcy.

This evidence is consistent with the results of Theodossiou (1993), which show a delay of approximately 2 years for American companies.

Finally, in reference to its initial geographic limitation, we can highlight those studies that have considered the applicability of the model to specific geographic contexts, other than the American setting (Xu & Zhang, 2009; Almamy, Aston & Ngwa, 2016; Boďa & Úradníček, 2016; Amat et al., 2016). As a general conclusion, we can indicate that the different works carried out reveal that a readjustment of the coefficients, and in some cases, of the variables used, based on the specific situation of the geographic area analyzed, provides a better predictive capacity for the model.

In this sense, and due to its relevance for the work presented below, we can highlight the work by Amat et al. (2016), which develops a version of the Altman model with a better capacity to detect situations of insolvency in the Spanish context. In this case, and based on a set of 40 ratios that have previously been used in the literature analyzed to detect business insolvencies, a linear discriminant analysis is applied to detect a combination of ratios that better discriminate the companies in a situation of financial insolvency. To accomplish this, a group of 2,000 companies were analyzed that received short-term loans from a certain bank during 2008.Of the 2,000 loans granted, 144 presented repayment problems during the period between when the loan was granted and the end of 2010.

The analysis of the results obtained enabled the authors to develop a $Z^*$ indicator different from that of Altman, which is specified by the following expression:

$$Z^*=-3.9+1.28X_1+6.1X_2+6.5X_3+4.8X_4$$

Where $X_1$ is the current assets/current liabilities, $X_2$ the net equity/total assets, $X_3$ the net results/total assets and $X_4$ the net results/net equity. The ranges defined in this model are: if $Z^*$ is less than 0, it can be determined that the company might have financial problems, and if it is greater than 0, it can be considered to have good financial health.

From the literature presented, which reveals that in spite of the limitations indicated, the Altman model is still one of the most commonly used, the work presented below intends to determine its predictive capacity in insolvency situations in the Spanish context. It thus intends to answer the following research questions:

- Is the most recent version of the Altman model a better predictor of possible financial problems than the version developed by Amat et al.?
- Does the time during the economic cycle (pre-crisis, crisis and post-crisis) in the Altman and Amat et al. models condition the time delay?
- Does the business sector condition the time delay in the two models?
- Does the size of the company, in both models, condition the delay?

To answer these questions, the work is divided into the sections highlighted below: first, the methodology used is described, followed by the analysis of the results obtained and ending with the conclusions drawn from the study.

## 3. Methodology

Based on the data obtained from the Iberian Balance Sheet Analysis System (SABI) for the companies involved in bankruptcy proceedings in February 2017 and for the period 2005 to 2015, a descriptive and bivariate analysis was carried out in order to answer the questions raised.

This interval is chosen as it includes the periods prior to the economic crisis (2005-2007), during the crisis (2008-2013) and after the crisis (2014 and 2015), according to the terms established by the INE (National Institute of Statistics), based on the evolution of the Spanish gross domestic product (GDP).

A total of 1,132 companies were obtained from the SABI. Given the needs proposed by the calculations involved in the two scoring models, the number of companies with sufficient valid data to perform the calculations was smaller than the total. Therefore, to calculate the Altman Z" index, the sample used includes 453 valid observations (40.02%), and to calculate the index by Amat et al., Z*, the sample is 450 (39.75%).

Of these companies, it is observed that in some cases, the index does not detect the bankruptcy situation throughout the entire period studied. Accordingly, 61 cases are observed for Altman's Z" index and 19 cases for the Z index described by Amat. Therefore, the final sample consists of 392 (34.63%) valid cases for Altman's Z" and 431 (38.07%) for the Z* index by Amat et al.

A new variable is calculated for each company and model, which we call the "time delay," and which shows the difference between the first time that the index of a model detects possible financial problems until bankruptcy proceedings are officially begun.

Likewise, the sample is segmented as follows:

- By sector: based on the official CNAE classification for 2009, it is determined whether a company belongs to the agricultural (subgroups 01 to 03), industrial (subgroups 05 to 32 and 35), construction (subgroups 41 to 43) or services (subgroups 33, 36 to 39 and 45 to 99) sectors, as described by García-Gallego and Mures-Quintana (2013).
- By size: according to the number of employees on staff in 2016, we have microenterprises (less than 10), small businesses (10-50), medium-sized companies (51-250) and large companies (more than 250).
- For the structural period of the Spanish economy: pre-crisis (2005-2007), crisis (2008-2013) and post-crisis (2014-2015).In order to classify it into one period or another, reference is made to the first time that the index, either by Altman or Amat et al., detects possible financial problems.

The analysis is carried out using traditional statistical techniques. Specifically, a descriptive analysis is carried out, using contingency tables to evaluate whether the delay between the time when an index detects financial problems in a company and bankruptcy is declared is conditioned by the economic sector into which the company is classified, the size of the company or the economic period. As Amat et al. (2016) argues, we use these techniques because the aim is to monitor Altman's (1968) focus and because good performance has been demonstrated in the previous literature (Amat et al., 2016; Abdou and Pointon, 2011).

## 4. Study results

The results obtained are structured in two sections; the first analyzes whether the Altman model and the model by Amat et al. are good predictors to detect bankruptcy situations, and the second studies which of the selected variables (sector, size and economic cycle), for both models, condition the time delay between the detection of the possible insolvency of a company and the declaration of bankruptcy.

### 4.1. Predictive capacity of the models by Altman and by Amat et al.

The analysis of Table 1 shows a great predictive capacity for both models, since the total percentages of detection are greater than 87%.However, the Z scoring model by Amat et al. is more effective than the Z" scoring model by Altman, having detected financial problems prior to the declaration of bankruptcy in 95.8% of the companies.

| Model | Total number of companies in bankruptcy (1) | Possible insolvency detected by the model (2) | Effectiveness of detection (2/1) x 100 |
|---|---|---|---|
| Altman's Z" | 453 | 392 | 86.5% |
| Amat's Z* | 450 | 431 | 95.8% |

Table 1. Percentage of bankruptcy detection in the models

These high percentages have been observed over an interval of 11 years (2005-2015).Upon further analysis, we see in Table 2 that more than 70% of the companies in bankruptcy proceedings have a time delay of six to twelve years between the year in which both models detected possible financial problems and the declaration of bankruptcy by the companies. Only one-fifth of the companies experienced a delay of between one and three years. The results of both models are independent, and there is no relationship between them (Pearson's Chi-square statistic has a value of 605.508, with a significance of 0.00, although 33.3% of the boxes have an expected value of less than 5).

| Time delay | Companies according to the Z" model by Altman | | Companies according to the Z* model by Amat et al. | |
|---|---|---|---|---|
| 1-3 years | 90 | 23% | 87 | 20.2% |
| 4 and 5 years | 26 | 6.6% | 28 | 6.5% |
| 6-12 years | 276 | 70.4% | 316 | 73.3% |
| | **392** | **100%** | **431** | **100%** |

Table 2. Delay in years in each model

### 4.2. Variables that condition the delay

Contingency tables are used to analyze the combined frequency distribution between the delay and three variables: economic sector, company size and economic period, evaluating the relationship between the variables using the chi-square statistic.

The results of the contrast statistic show that in both models, there are only significant differences between the delay and the economic period (Tables 3 and 4). Therefore, the delay variable is not conditioned by either the economic sector in which the company's activity is performed, or by the size of the company. Therefore, the next step was to analyze the direction in which the delay was conditioned by the economic period for both models.

#### 4.2.1. Effect of the economic period on the delay for the Altman model

| Variables | | Economic period | | | Total | Contrast statistic |
|---|---|---|---|---|---|---|
| | | Pre-crisis | Crisis | Post-crisis | | |
| **Time delay** | **1-3 years** | 1<br>1.1%<br>0.4%<br>0.3% | 29<br>32.2%<br>29.6%<br>7.4% | 60<br>66.7%<br>100%<br>15.3% | **90**<br>**100%**<br>**23%**<br>**23%** | $\chi^2$=357.697[1]<br>**Sig.0.000** |
| | **4 and 5 years** | 1<br>3.8%<br>0.4%<br>0.3% | 25<br>96.2%<br>25.5%<br>6.4% | 0<br>0.0%<br>0.0%<br>0.0% | **26**<br>**100%**<br>**6.6%**<br>**6.6%** | |
| | **6-12 years** | 232<br>84.1%<br>99.1%<br>59.18% | 44<br>15.9%<br>44.9%<br>11.22% | 0<br>0.0%<br>0.0%<br>0.0% | **276**<br>**100%**<br>**70.4%**<br>**70.4%** | |
| **Total** | | **234**<br>**59.7%**<br>**100%** | **98**<br>**25.0%**<br>**100%** | **60**<br>**15.3%**<br>**100%** | **392**<br>**100%**<br>**100%** | |

[1]1 box (11.1%) has an expected frequency of less than 5

Table 3. Time delay according to the economic period of the Altman model

Table 3 shows that the 1-3 year time delay observed corresponds primarily to the post-crisis period of the economy (66.7%). On the other hand, if the delay variable is between 4 and 5 years, no detection is observed in the post-crisis period (0%), with this corresponding almost exclusively to the crisis period (96.2%). However, if the delay is greater than 6 years, the period to which it corresponds is basically the pre-crisis period (84.1%).

Furthermore, the distribution within the crisis period between the three delay groups is greater than 25% for each. By contrast, in the pre-crisis and post-crisis periods, we find an important difference with respect to the former, as there is a concentration of 100% in the 1-3 years segment of the post-crisis period and 99.1% in the 6-12 years segment of the pre-crisis period.

Therefore, in companies in bankruptcy, the Altman model detected 70.4% of the companies with possible financial problems between 6 and 12 years before they declared bankruptcy. These correspond primarily (84.1%) to the pre-crisis period.

### 4.2.2. Effect of the economic period on the delay for the model by Amat et al.

If we focus on the model by Amat et al., the results are no different than those for the Altman model. Table 4 shows that the delay of between 1 and 3 years has corresponded primarily to the post-crisis economic period (66.7%). On the other hand, if the delay is between 4 and 5 years, there is no detection in the post-crisis period (0%), as this corresponds almost exclusively to the crisis period (96.4%). Meanwhile, if the delay is greater than 6 years, the period to which it corresponds is basically the pre-crisis period (87.3%).

In addition, the distribution within the crisis period between the three delay groups is greater than 28% for each. By contrast, in the pre-crisis and post-crisis periods, we find an important difference with respect to the former, as in the first period 100% are concentrated in the 1-3 years segment, and in the second, the concentration is in the 6-12 years segment (99.3%).

As a result, in companies in bankruptcy, the model by Amat et al. detected 73.3% of the companies with possible financial problems between 6 and 12 years before they declared bankruptcy. These correspond primarily (87.3%) to the pre-crisis period.

| Variables | | Economic period | | | Total | Contrast statistic |
|---|---|---|---|---|---|---|
| | | Pre-crisis | Crisis | Post-crisis | | |
| Time delay | 1-3 years | 1<br>1.1%<br>0.4%<br>0.2% | 28<br>32.2%<br>29.5%<br>6.5% | 58<br>66.7%<br>100%<br>13.5% | **87**<br>**100%**<br>**20.2%**<br>**20.2%** | $\chi^2$=412.116[1]<br>**Sig.0.000** |
| | 4 and 5 years | 1<br>3.6%<br>0.4%<br>0.2% | 27<br>96.4%<br>28.4%<br>6.3% | 0<br>0.0%<br>0.0%<br>0.0% | **28**<br>**100%**<br>**6.5%**<br>**6.5%** | |
| | 6-12 years | 276<br>87.3%<br>99.3%<br>64.0% | 40<br>12.7%<br>42.1%<br>9.3% | 0<br>0.0%<br>0.0%<br>0.0% | **316**<br>**100%**<br>**73.3%**<br>**73.3%** | |
| **Total** | | **278**<br>**64.5%**<br>**100%** | **95**<br>**22.0%**<br>**100%** | **58**<br>**13.5%**<br>**100%** | **431**<br>**100%**<br>**100%** | |

[1]1 box (11.1%) has an expected frequency of less than 5

Table 4. Time delay according to the economic period of the model by Amat et al.

## 5. Conclusions

The literature on models for predicting bankruptcy have kept the debate alive on the capacity of models based on accounting information versus those that use primarily market information. The different studies analyzed show that the model designed by Altman continues to have many followers, although its predictive power increases when its formulation is adapted to the context of the analysis.

Amat et al. (2016) make this adaptation to the Spanish case, finding a new expression with a greater capacity to detect situations of insolvency. In order to more closely determine the goodness of fit for said reformulation, the work presented has contrasted the predictive capacity of both models for Spanish companies in a situation of

bankruptcy. In turn, the analysis of these synthetic indicators for companies in bankruptcy has made it possible to analyze which are the conditions that determine the time delay between the detection for the first time of possible financial problems and the legal formalization of the insolvency situation. The determining factors analyzed are company size, the sector to which it belongs and the moment in the economic cycle when the financial problems are detected.

To do this, company data has been obtained from the Iberian Balance Sheet Analysis System (SABI) database for those companies that have declared bankruptcy during the period 2005-2015, and a descriptive and bivariate analysis has been carried out.

The results obtained make it possible to state that while both models are good predictors to detect bankruptcy situations, the formula by Amat et al. (95.8% detection rate), is more effective than that by Altman (86.5% detection rate).These results confirm that while Altman's formula continues to be suitable, its predictive power improves noticeably when it is adjusted to the specifics of the context being analyzed.

In relation to the time delay, the analysis performed reveals that, indeed, the economic period conditions said delay in both models. Specifically, the segment with 1-3 years of delay corresponds primarily to the post-crisis period, the segment between 4 and 5 years to the crisis period and the segment with a greater delay to the pre-crisis period. These results would confirm how the capacity of companies to resist adverse situations deteriorates as the period of economic recession lengthens, becoming most vulnerable once the recovery period is underway. The rest of the variables analyzed, sector and size, do not provide any conclusive results.

In any case, the results obtained reinforce the conclusions of works like that by Tinoco and Wilson (2013) and Theodossiou (1993), who had already demonstrated that bankruptcy declarations are not justified exclusively by financial reasons, rather they are influenced by other circumstances that elude the detection capacity of accounting figures. Therefore, models such as that by Altman, or the Spanish version by Amat et al. are good predictors of financial difficulties, while they do not necessarily predict, or within a specified period, the legal formalization of bankruptcy.

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