

Relationship between the Altman Z-Score model and the Z-Score financial indicators

Relación entre los indicadores financieros del modelo Altman Z y el puntaje Z

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Abstract: From a theoretical point of view, there is no general consensus on the identification of the financial difficulties of a company. The Altman Z-Score model is recognized in the literature as an indicator for measuring the probability of financial insolvency. While this model is widely used as a metric for predicting financial distress, there is no agreement on the factors that determine the behavior or outcome of the Z-Score. In this sense, the purpose of this study is to analyze the factors that determine the behavior of the Z-Score in Colombian companies. The research is developed under a quantitative methodological approach, with a correlational design. This research scope seeks to measure the association between the Altman Z-Score and the financial indicators that determine its outcome; for this purpose, it is analyzed a total of 2,684 companies of the Colombian commercial sector that reported financial information on a systematic basis during the period 2016-2020. The results of the statistical tests carried out reveal that there is a direct relationship between the indicator that measures the financial structure (equity/liabilities) and the Altman Z-Score. This leads to the conclusion that, from the point of view of Altman's model, a company that seeks to capitalize profits and keep debt levels under control will be a company with financial stability and a low probability of financial insolvency.

Keywords: liquidity, leverage, performance, financial structure, correlation, financial insolvency.

Resumen: desde un punto de vista teórico, no existe un consenso general sobre la identificación de las dificultades financieras de una empresa. El modelo Altman Z-Score es reconocido en la literatura como un indicador para medir la probabilidad de insolvencia financiera. Aunque este modelo es muy difundido y utilizado como métrica para predecir las dificultades financieras, no existe acuerdo sobre los factores que determinan el comportamiento o resultado del puntaje Z. En este sentido, el propósito de este estudio es analizar los factores que determinan el comportamiento del puntaje Z-Score en las empresas colombianas. Esta investigación se desarrolla bajo un enfoque metodológico cuantitativo, con un diseño de tipo correlacional. Este alcance de investigación busca medir la asociación entre el puntaje Z de Altman y los indicadores financieros que determinan su resultado; para tal fin se analizan un total de 2684 empresas del sector comercial colombiano que reportaron información financiera de forma sistemática durante el periodo 2016-2020. Los resultados de las pruebas estadísticas efectuadas revelan que existe relación directa entre el indicador que mide la estructura financiera (patrimonio/pasivo) y el puntaje Z de Altman. Adicionalmente, permiten concluir que, desde el punto de vista del modelo de Altman, las empresas que capitalizan sus beneficios y mantienen bajo control su nivel de endeudamiento son empresas financieramente estables y con baja probabilidad de insolvencia

Palabras clave: Liquidez, apalancamiento, rendimiento, estructura financiera, correlación, insolvencia financiera.

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Introduction

It is fundamental that the management of the organization monitors the financial health and the level of risk of the company considering the high degree of uncertainty and competitiveness at the global scale. The financial solidity of a company is determined by its capability to make timely payments, adequately finance its operation and face contingencies (Swalih *et al.*, 2021). Regardless of their size and economic activity, companies should overcome various challenges when pursuing their corporate purpose to guarantee their permanence in the market (Buele *et al.*, 2021). Some of these challenges include the deceleration of economic activity, which may lead to a decrease in sales and, thus, to loss of liquidity and also to an increase of the risk of financial difficulties. One of the options for monitoring the situation previously described, is to analyze the probabilities of financial bankruptcy in the short and medium term (Vavrek *et al.*, 2021).

Corporate bankruptcy is a sensitive issue in the financial world (Tung and Phung, 2019), since it refers to the financial health and stability of the organizations. The capability for predicting financial insolvency of a company is fundamental for its development and sustainability. However, the inability to precisely predict the risk of bankruptcy may produce devastating socioeconomical effects (Antunes *et al.*, 2017). At present, the literature identifies various traditional models of bankruptcy that are focused on the prediction of the financial difficulties of an organization; some of these models include Altman (1968, 1983, 1995), Beerman (1976, 1980), Taffler (1982), Zmijewski (1984), Almamy *et al.* (2016), among others. The aforementioned models are used to predict the bankruptcy probability of an organization in the years following the measurement; thus, they constitute an important financial tool for the finance managers to evaluate the financial health of the company (Sharma and Bodla, 2022).

Among the aforementioned models, the Altman Z-Score model stands out as a financial tool that has consolidated itself as a precise predictor of financial difficulties (Altman, 2018). This model incorporates the main dimensions of the financial

health of an organization, and for this reason it is not only a model to predict financial insolvency, but it has also become the prototype for many models of credit risk and default (Kacer *et al.*, 2019). Although this model has been widely applied in different economic sectors to predict the probability of company bankruptcy (Nafisa *et al.*, 2022) due to its level of reliability (between 75 % and 90 %) Ko *et al.* (2017), the following question arises: Which factors determine the behavior or outcome of the Z-score? To answer this question, the following research objective is posed: analyze the factors that determine the behavior of the Z-score in companies of the commercial sector in Colombia.

This document is structured in four sections. The first section presents a literature review about the Altman Z-Score model and the financial indicators that constitute it. The second section presents the applied research methodology, the data and the sample of financial information used in the research exercise, as well as the statistical tests carried out. The third section presents the results, making emphasis on the findings derived from the correlation tests applied. The fourth section describes the final considerations of the research, including its limitations and the future lines of analysis about the topic subject to study.

Literature review

The financial distress is defined by Hofer (1980) as a condition in which the company had net negative results along various consecutive years. Meanwhile, Hopwood *et al.* (1994) state that the financial difficulties occur when the working capital, the operating losses and the retained earnings are negative (an apocalyptic scenario according to these authors). From their point of view, Yuliastary and Wirakusuma (2014) identify the financial difficulties as the inability of the organization to fulfill its existing obligations such as taxes, accounts payable and short-term bank loans, among others. Bođa and Úradníček (2016) state that financial difficulties are represented by the combination of a low profitability indicator, a net negative result and a liquidity below one.

In summary, it could be stated that financial

difficulties are represented by the deterioration of the company liquidity, a gradual reduction of the operational income, earnings before interests and taxes and the profitability; these behaviors cause that the organization may fail to meet its obligations due to its inappropriate financial structure. The aforementioned situation generates concerns in the company actors (internal and external) Roque and Caicedo (2021). On one hand, there are the internal actors, which include shareholders, investors, managers and employees; on the other hand, the external actors are represented by clients, providers, financial institutions and the society in general Yuliastary and Wirakusuma (2014) and Muñoz *et al.* (2019).

Although a company may experience signals of financial difficulties, this process is not declared immediately. The bankruptcy process may vary considerably, with respect to its duration (Lukason and Hoffman, 2014). Hernández-Tinoco and Wilson (2013) state that there are various stages through a company may pass before it is defined as dead: financial difficulties, financial insolvency, bankruptcy declaration, economic failure, corporate failure, technical insolvency, etc. For Sormunen and Laitinen (2012), the process of financial distress consists of the following stages: a) initial stage, in which a reduction in the profitability of the company is experienced; b) late stage: the profitability drop is accompanied by a leverage increase in the financial statements; c) final stage: the profitability drop is accompanied by a leverage increase and a liquidity decrease.

The analysis of financial reports, through the financial reasons that may be obtained from them, is a way to determine the condition (successful or failed) of a company at a particular moment Bağcı (2015) and Vavrek *et al.* (2021). In this sense, organizations may supervise their financial condition from the same information they generate (Roque and Caicedo, 2022). For this purpose, variables that come from the accounting process may be used to detect corporate bankruptcy Sun *et al.* (2014) and Rahayu *et al.* (2016). There are various ways to measure the financial health of organizations Muñoz *et al.* (2019). From the perspective of Kristanti (2019), the prediction of financial difficulties may be measured from the application

of two types of models: alternative and classical.

Alternative models are represented by non-parametric techniques that are applied to study corporate failure. Lestari *et al.* (2021) acknowledge as alternative models those based on: conditional probability Ohlson (1980) and Mora (1994); application of decision trees techniques Altman (1993), Frydman *et al.* (1985) and Bonsón *et al.* (1997); artificial neural networks Odom and Sharda (1990), Nasir *et al.* (2000), Boyacioglu *et al.* (2009), Tseng and Hu (2010) and Khediri *et al.* (2015). Another group of alternative models focus their prediction analyses of financial insolvency on the theory of real options and incidental prices (Delapedra-Silva, 2021). The proposals made by Black and Scholes (1973) and Merton (1974) give birth to a group of real options models used for predicting financial failures (Milanesi, 2019). From the original proposal of Merton, Bharath and Shumway (2008), they developed the naive model to measure insolvency probability or financial failure Schmidt and Milanesi (2019), which was modified by Milanesi (2016), who propose a version of the naive barrier option model for predicting financial failure.

Some strengths of alternative models include: a) they consider a wide range of analysis factors, both internal and external, that enable handling complex corporate and economic situations, b) in some cases they integrate uncertainty and future trends in financial predictions, b) they use artificial intelligence and machine learning techniques. Although alternative models enable a deeper exploration and explanation of financial information, these nonparametric techniques require precise data for their application. Likewise, the application of alternative models is complex and they require a large amount of data to be used effectively. Therefore, these techniques are not understood as a substitute instrument, but they are complementary of other classical methods for predicting financial insolvency (Romero, 2013).

Classical models to measure insolvency probability are represented by univariate and multivariate analyses Pérez *et al.* (2013). Scherger *et al.* (2018) and Shi and Li (2019) acknowledge the classical models proposed by Beaver (1966, 1968), Altman (1968, 1983, 1995), Deakin (1972),

Blum (1974), among others. Some strengths of these models for predicting financial insolvency include: a) simplicity and reliability, b) low application cost and accessibility to primary information. Although one of the strengths of prediction models is that it starts from financial statements; although contradictory, this could also be a limitation in their application, considering that financial information may be modifiable according to the convenience of the company in terms of corporate strategy (Grisales and Trujillo, 2016; Vega *et al.*, 2021; and Roque *et al.*, 2022).

Based on the above, from the statistical point of view, the models of discriminant analysis have the following limitations: a) they assume that variables are normally distributed, b) they set equal the variance and covariance matrices and c) they do not assign probabilities of occurrence to type I and type II errors for the cut-off point (Romero, 2013). Therefore, more than an exclusive tool for prediction, the models based on the discriminant approach that have been proposed for predicting corporate bankruptcy should be considered as an indicator that facilitates corporate diagnosis (Vera, 2017). Despite the limitations of classical models, they have had a high empirical development and are found in a large number of works (Romero, 2013). Authors such as Karas and Režnáková (2012) and Alaka *et al.* (2018) argue that the methods of multiple discriminant analysis are the techniques mostly used worldwide to predict the financial health of companies.

Altman (1968) is the founder and pioneer of the use of multiple discriminant analysis. The Z-score model proposed by this author is currently the best known and most widely used prediction model (Gavúrová *et al.*, 2017). The Altman Z-score model is applied worldwide as the main tool to analyze bankruptcies, both in research works and in practice (Altman *et al.*, 2017). The model is commonly accepted to anticipate financial failures and bankruptcy risks in various sectors (Alcalde *et al.*, 2022), which indicates its acceptability as a simple, reasonable and easy to implement measure (Apan *et al.*, 2018). The Z-score model is one of the best models to evaluate the financial solidity of any company, and it is accepted worldwide in the area of corporate

management (Divekar and Sukhari, 2021).

The first Altman Z-score model was formulated for organizations that were listed in the stock market and that belonged to the industrial sector. The author structures the first version of the model based on the following categories: liquidity, leverage, return, financial structure and activity (Hosaka, 2019). The first version of the model was structured as follows:

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

The financial indicators of the Z-score model are now presented (Altman *et al.*, 2017).

$$X_1 = \frac{(\text{urrent Assets}-\text{Current Liabilities})}{\text{Total Asset}}$$

The X_1 indicator enables to measure liquid assets with respect to the size of the company (Sareen and Sharma, 2022). The relationship between the working capital and the total assets of the company is related to the capacity of the organization to fulfill its short-term financial obligations Alcalde *et al.* (2022). A higher X_1 implies that the liquidity position is favorable (Divekar and Sukhari, 2021), since organizations with financial adversities experience operating losses; this may imply a reduction of the current assets with respect to the total assets (Laurens and Mulyani, 2022).

$$X_2 = \frac{(\text{Retained Earnings})}{\text{Total Assets}}$$

The X_2 indicator refers to the retained earnings with respect to the total assets. This indicator represents the seniority and the purchasing power of the company (Sareen and Sharma, 2022). When a company accumulates continuous losses, the reserves may become negative. Nevertheless, when it accumulates earnings, the reserves will be positive, which evidences the organic growth capability through the reinvestment to self-finance its projects (Alcalde *et al.*, 2022). This scenario is positive, because the company has not required to increase its level of indebtedness (Hernández, 2014).

$$X_3 = \frac{(\text{Earnings before interests and taxes})}{\text{Total Assets}}$$

The X_3 indicator represents the efficiency with which the management leads the company to maximize the profits generated by its main activity (Divekar and Sukhari, 2021). The companies should be able to consolidate their operations, to generate the amount of resources necessary to guarantee their sustainability in the long term (Sareen and Sharma, 2022). Companies in financial difficulties will exhibit continuous operating losses (Laurens and Mulyani, 2022). A higher value of this variable implies a lower bankruptcy probability (Alcalde *et al.*, 2022).

$$X_4 = \frac{\text{Market value of the wealth}}{\text{Total Liabilities}}$$

The X_4 indicator shows the weight of the value of the wealth with respect to the liabilities (Hernández, 2014). This indicator enables to establish the amount of value created for the company shareholders through market capitalization, and the total amount contributed by people external to the business (Divekar and Sukhari (2021). The index will show the sufficiency of the company wealth to face ordinary liabilities—short and long term— (Laurens and Mulyani, 2022). Authors such as Alcalde *et al.* (2022) state that a higher value of this financial indicator will imply a lower bankruptcy probability.

$$X_5 = \frac{\text{Sales}}{\text{Total Assets}}$$

The X_5 indicator represents a standard measure for asset turnover (Sareen and Sharma, 2022), showing the administrative and commercial capacity of the company to face the competitiveness of other companies of the same sector in which it operates (Alcalde *et al.*, 2022). This indicator focuses on the use of the total assets (current and noncurrent) to generate maximum sales (Divekar and Sukhari, 2021).

The Z-score model proposed by Altman was initially used as a tool for predicting financial insolvency, obtaining positive reactions and some criticism (Altman, 1970). Among the latter there is the theoretical limitation that it can be only applied to open capital companies that belong to the industrial sector. With the purpose of increasing

the group of companies to which the insolvency test may be applied, Altman (1983) proposed a new version of the model. The second version of the model has the following structure:

$$Z' = 0.717*(X_1) + 0.847*(X_2) + 3.107*(X_3) + 0.420*(X_4) + 0.998*(X_5)$$

The new version of Altman Z-score model was proposed for close capital companies that belong to the manufacturing sector. In this proposal, Altman (1983) adjusts the X_4 financial indicator, replacing the market value of the wealth by its book value. Nevertheless, the new version of the Z-score model inherited the limitation of the first proposal, since both models could only be used for companies of the manufacturing sector. In this sense, parameters and coefficients were adapted for different situations, which resulted in the third version of the model for nonmanufacturing companies that operate in emerging markets (Altman *et al.*, 1995; Altman and Hotchkiss, 2006). The proposal of the is presented below.

$$Z'' = 3.25 + 6.56*(X_1) + 3.26*(X_2) + 6.72*(X_3) + 1.05*(X_4)$$

In the third version of the model, the indicator of financial activity is eliminated and the constant 3.25. is added. The field of application is extended in this version. Its functionality and wide field of application have converted the Z-score Altman model in an effective tool for the analysis, foresight and prediction of the probability of corporate bankruptcy in different economies and with different aims (Roque and Caicedo, 2022).

The Z-score model has been the subject of a wide range of studies, through which different implementations and adaptations have been proposed in different sectors (Roque and Caicedo, 2022). This has given rise to a large number of applications and modifications of the Z-score Altman model, either for specific countries, private companies and emerging markets (Kapounek *et al.*, 2022). Research works have been recently published about the adaptation of Altman Z-score model in specific sectors of different economies, such as: European private companies (Kapounek

et al., 2022), companies in the areas of tourism, hotels and restaurants (Goh *et al.*, 2022; Lestari *et al.*, 2021), aviation companies (Divekar and Sukhari, 2021), wholesale and retail commercial companies (Buele *et al.*, 2021), automotive industries (Swalih *et al.*, 2021), Indian real estate companies (Sidhu and Katoch, 2019), Indian micro, small and medium companies (Prakash and Verma, 2019), Vietnamese multidisciplinary companies (Tung and Phung, 2019) and manufacturing companies (Siwi *et al.*, 2018), among others.

Similarly, the Z-score model has been considered a technique to associate the bankruptcy probability with other internal processes of the companies. Among the aspects analyzed, there is the relationship between the creation of added economic value and the probability of financial insolvency (Roque and Caicedo, 2021). Moreover, the analysis of financial difficulties and their relationship with aspects such as sustainable development (Pizzi *et al.*, 2022), corporate social responsibility (Bhuvanekumar *et al.*, 2022; Farooq and Noor, 2021) and integration of environmental, social and corporate governance factors (Brogi *et al.*, 2022). Similarly, the Z-score model has been also considered in studies focused on the association existing between the probability of financial insolvency and the impact of profitability and productivity (Milić *et al.*, 2022), sensitivity of cash flows (Gupta and Mahakud, 2022), and the prediction of the behavior of shares price (Sareen and Sharma, 2022). Other studies associate the insolvency probability with fraud in financial statements (Aviantara, 2021) and (Saleh *et al.*, 2021) or with issues such as the potential contribution of intellectual capital (IC) to financial stability (Festa *et al.*, 2020) and quality management practices (Kriemadis *et al.*, 2022). Based on the above, it is demonstrated that the Z-score model has not only exhibited longevity as a precise predictor of corporate problems, but it has also demonstrated that it can be successfully modified for a series of applications beyond its original approach (Altman, 2018, p. 34).

Although most of the studies focus on the applications of the Z-score model and the differ-

ent derivations and/or modifications that may arise from its application, other group of studies are focused on the determinants of bankruptcy probability (Habib *et al.*, 2018). With respect to such determinants, authors such as Kapounek *et al.* (2022) acknowledge that financial insolvency is influenced not only by the specific features of the company, but also by the macroeconomic development of the company. Authors such as Inekwe and Valenzuela (2019) and Tinoco *et al.* (2018) state that the inclusion of macroeconomic variables in the calculation of the Z-score enables more precise estimations of the financial insolvency of the companies. Meanwhile, authors such as Alfaro *et al.* (2019) state that the effect of the indebtedness of a company and its size may also have influence on the bankruptcy probability.

Materials and methods

The research was conducted under a quantitative approach that enables to identify the relationship between the Z-score and the financial variables that constitute the Z-score model. The study is established under a correlational research design, since the purpose of this research model is to show or examine the relationship between variables or results of variables (Salkind, 1998). The proposed methodology examines associations, but not causal relationships, where a change in the factor directly influences in the change of another (Bernal, 2016).

In order to identify the companies subject of study, it is considered as selection criterion the organizations that systematically report their financial statements in the Integrated System of Corporate Information (SIIS, Sistema Integrado de Información Societaria¹), of the Superintendency of Companies of Colombia, during the period 2016-2020. The companies are organized according to the International Standard Industrial Classification (ISIC), identifying the number of business units in every economic sector in Colombia.

1 <https://siis.ia.supersociedades.gov.co/#/massivereports>

Table 1
Companies by sector that systematically report in the SIIS (period 2016-2020)

Sector	Number of companies	Relative weight
Agricultural	578	6.40 %
Commercial	2684	29.70 %
Communications	157	1.74 %
Construction	794	8.79 %
Financial	325	3.60 %
Industrial	1763	19.51 %
Mining-Energy	174	1.93 %
Services	2427	26.86 %
Transportation	135	1.49 %
Total	9037	100 %

Based on the information obtained from the Integrated System of Corporate Information (SIIS), the companies that continuously reported financial information are identified during the observation window subject of study. The Colombian commercial economic sector is proposed for conducting the study, since the economic activity of the commercial and technology sectors are the main forces that drive the global economic transformation. According to the report jointly published by the World Bank and the World Trade Organization (2021), the trade and value chains have demonstrated to be robust and to be able to boost the recovery from COVID-19.

The Colombian wholesale and retail commercial sectors are characterized by exhibiting a large potential to generate jobs, increase earnings and, hence, contribute to the growth of the Colombian economy. During the health crisis caused by COVID-19, the commercial sector experienced a decrease of 6.6 % in its growth rate with respect to 2019; this situation arose due to the restrictions implemented by the National Government during 2020 with the purpose of limiting the propagation of the COVID-19 virus. During 2021, the Colombian commercial sector experienced a recovery in its contribution to the Gross Domestic Product, becoming the economic activity that mostly contributed to the added value dynamics of the Colombian economy. The scenario described above was repeated in 2022, where the commercial sector continued contributing significantly

to the GDP and to economic recovery.

Although the Colombian commercial sector only experienced a significant contraction during 2020, it is important to point out that the health crisis caused by COVID-19 had a negative impact on the performance of the business fabric, causing commercial losses, reduction of the employment rate and exports, and decrease in the internal and external demand; these consequences lead to a larger exposure of Colombian companies to the risk of financial insolvency (Ibáñez, 2022). The aforementioned bankruptcy risk materialized during 2021, where a total of 855 requests for financial insolvency were filed, and it became the second sector of the Colombian economy with a greater number of processes to adhere to the 2006 Law 1116 (Morales, 2021). Considering the importance of the commercial sector in Colombian economy and the scenario lived during the health crisis, it was established that the sample subject to study was constituted by 2684 companies of the commercial sector that systematically reported financial statements in the SIIS, of the Superintendency of Companies of Colombia, during the period 2016-2020.

After the companies subject to analysis were defined, the Z-score model was applied with the purpose of identifying those companies that, according to their financial information, show signs of financial insolvency. The cut-off points defined by Altman Z-score model were used to analyze the Z-score results (Anjum, 2012).

- If the Z-score < 1.10, the company is in a state of difficulty (it is in the bankruptcy region).
- If $1.10 < \text{Z-score} < 2.60$ Z-Score, the company is in the ignorance region.
- If the Z-score > 2.60, the company is in the safe region.

Once the results of the Altman Z-score model (Z'') have been identified, correlations tests are carried out as a natural measure of the relationship between two random variables (Wooldridge, 2009). This enables to conclude which financial indicators have greater incidence on determining the Z-score. The correlation matrix and the variables subject to investigation are now presented.

Illustration 1

Correlation matrix

$$M_a = \begin{pmatrix} 1 & m_{12}(x_1, x_2) & m_{13}(x_1, x_3) & m_{14}(x_1, x_4) & m_{15}(x_1, x_5) \\ m_{21}(x_2, x_1) & 1 & m_{23}(x_2, x_3) & m_{24}(x_2, x_4) & m_{25}(x_2, x_5) \\ m_{31}(x_3, x_1) & m_{32}(x_3, x_2) & 1 & m_{34}(x_3, x_4) & m_{35}(x_3, x_5) \\ m_{41}(x_4, x_1) & m_{42}(x_4, x_2) & m_{43}(x_4, x_3) & 1 & m_{45}(x_4, x_5) \\ m_{51}(x_5, x_1) & m_{52}(x_5, x_2) & m_{53}(x_5, x_3) & m_{54}(x_5, x_4) & 1 \end{pmatrix}$$

where the correlation matrix is structured using the following study variables:

$$\text{Liquidity: } x_1 = \frac{(AC_{ca} - PC_{ca})}{AT_{ca}}$$

$$\text{Leverage: } x_2 = \frac{GA_{ca}}{AT_{ca}}$$

$$\text{Return: } x_3 = \frac{UAI_{ca}}{AT_{ca}}$$

$$\text{Financial structure: } \frac{Pat.T_{ca}}{PT_{ca}}$$

Altman Z-score model: Z''

The relationship Z'' between the score and the financial indicators of Altman model are analyzed using the scale of the relationship between variables defined by Martínez *et al.* (2009).

- If the range is between 0 and 0.25, the relationship is Poor.
- If the range is between 0.26 and 0.50 the relationship is Weak.
- If the range is between 0.51 and 0.75 the relationship is Moderate.
- If the range is between 0.76 and 1 the relationship is Strong.

Results

The Altman Z-score model is applied to the selected sample of 2684 companies of the Colombian commercial sector, during the period (2016-2020). The statistical test is focused on calculating the correlation between the explicative variables of the Z-score model, through the analysis of the panel data using the STATA 16 tool. The results of the descriptive statistics of the model are presented in table 2.

Table 2
Descriptive statistics of the variables of the Altman Z-score model

Variable		Mean	Std. Dev.	Min	Max	Observations		
Z	overall	7,83261	7,90095	-333,17190	439,92800	N	=	13.420
	between		5,55491	-59,77126	142,41020	n	=	2.684
	within		5,61935	-265,56800	350,45240	T	=	5
X1	overall	0,2728136	0,30993	-10,22944	9,68488	N	=	13.420
	between		0,26326	-5,13253	2,03198	n	=	2.684
	within		0,16361	-4,82410	7,92571	T	=	5
X2	overall	0,1859217	0,45556	-11,98908	15,25838	N	=	13.420
	between		0,39804	-6,61115	3,10893	n	=	2.684
	within		0,22169	-6,74004	12,33537	T	=	5
X3	overall	0,0805305	0,45177	-50,28133	2,66921	N	=	13.420
	between		0,21666	-10,05431	0,59836	n	=	2.684
	within		0,39644	-40,14649	10,18058	T	=	5
X4	overall	1,5673210	5,77438	-1,01424	412,99040	N	=	13.420
	between		3,83164	-0,81097	126,72560	n	=	2.684
	within		4,32046	-102,22090	328,26970	T	=	5

The average of the Altman Z-score model results obtained in this research work is greater than the theoretical limit (2.60). This result indicates that, in average, the companies of the sector have low probabilities of facing a financial insolvency process, with a low data dispersion because the standard deviation is close to the average.

Regarding the results of the financial indicators integrated in the Z-score model, their behavior is now described. Variable X1, which measures the relationship between working capital and assets, is low (0.25); this indicates that, in average within the group of companies analyzed, for every Colombian peso in assets the working capital is 0.25 Colombian pesos. A considerable dispersion occurs in this variable, since the standard deviation is slightly higher than the mean (0.30). Variable X2, which measures accumulated earnings with respect to assets, evidences that, in average, the companies have 0.18 Colombian

pesos of accumulated earnings for every Colombian peso in assets, with a high data dispersion because the standard deviation is more than twice the value of the mean (0.45). Variable X3 shows that, for every Colombian peso in assets, the companies obtained 0.08 Colombian pesos in earnings before interest and taxes, also with a high data dispersion. At last, variable X4, which measures the relationship between wealth and liability, is greater than 1 with a high dispersion, which indicates that, in average, the companies of the sector have a robust asset structure, but with a high variability between companies and through time.

After the descriptive statistics of the variables subject to study have been calculated, the measurements and behavior of the Z-score for the business units analyzed are presented. The results of the Z' Altman model are shown in table 3.

Table 3*Results of the application of Altman Z-score model in companies of the Colombian commercial sector*

Region	2016		2017		2018		2019		2020	
	Number	Relative weight	Number	Relative weight	Number	Relative weight	Number	Relative weight	Number	Relative weight
Bankruptcy	62	2.3 %	64	2.4 %	64	2.4 %	70	2.6 %	84	3.1 %
Ignorance	48	1.8 %	54	2.0 %	62	2.3 %	68	2.5 %	56	2.1 %
Safe	2574	95.9 %	2566	95.6 %	2558	95.3 %	2546	94.9 %	2544	94.8 %

Table 3 evidences in a sustained manner, that more than 90 % of the companies in the commercial sector are in the safe region. This behavior enables to conclude that this economic sector has shown particular stability for this period of time. Nevertheless, it should be remarked that companies in the bankruptcy and ignorance regions have marginally increased their participation.

With the objective of identifying the behavior of the Liquidity, Leverage, Return and Financial Structure indicators for the 2684 companies of the Colombian commercial sector during the (2016-

2020) period, an individual analysis of the ratios previously described is carried out. Considering the atypical (extreme) observations obtained in the results of the variables (and in order to mitigate the possible distortion in the average, the deciles are used as a statistical measure to analyze the results. The decile analysis of the Liquidity, Leverage, Return and Financial Structure indicators enables to establish the range of the Pareto of the observations. In this sense, table 4 shows the decile distribution of the Liquidity (X1) variable of the Altman Z-score model.

Table 4*Decile distribution of variable X1 of Altman Z-score model*

Decile	2016	2017	2018	2019	2020
1	-0.02	-0.02	-0.01	-0.02	-0.01
2	0.06	0.06	0.07	0.06	0.09
3	0.13	0.13	0.13	0.13	0.16
4	0.19	0.20	0.19	0.20	0.24
5	0.25	0.25	0.25	0.26	0.30
6	0.31	0.31	0.32	0.33	0.37
7	0.38	0.39	0.39	0.41	0.44
8	0.48	0.48	0.48	0.50	0.54
9	0.60	0.61	0.60	0.62	0.65

The liquidity indicator is negative (although decreasing) for 10 % of the companies analyzed, which indicates that companies that are within this decile experienced a negative working capital. Nevertheless, for 70 % of the companies

subject to study it is evidenced that the ratio measured by variable X1 is positive, but smaller than 0.5. This means that the working capital is under 50 % of the total asset for most of the companies in the sample.

Table 5
Decile distribution of variable X2 of Altman Z-score model

Decile	2016	2017	2018	2019	2020
1	-0.04	-0.04	-0.05	-0.07	-0.08
2	0.03	0.03	0.03	0.04	0.04
3	0.08	0.08	0.08	0.09	0.10
4	0.12	0.13	0.13	0.14	0.16
5	0.18	0.18	0.18	0.20	0.22
6	0.24	0.25	0.25	0.26	0.29
7	0.31	0.32	0.32	0.34	0.36
8	0.41	0.41	0.41	0.43	0.46
9	0.52	0.56	0.55	0.56	0.60

The analysis of the accumulated earnings indicator shows that 10 % of the companies in the sample obtained negative accumulated results in every year. This indicates that for all companies in this decile, the losses are higher than the earn-

ings. For 70 % of the companies this indicator is positive, although lower than 0.5. In other words, for most of the companies, less than 50 % of the asset is represented by the results of previous exercises.

Table 6
Decile distribution of variable X3 of Altman Z-score model

Decile	2016	2017	2018	2019	2020
1	0.01	0.00	-0.01	0.00	-0.02
2	0.03	0.03	0.02	0.02	0.01
3	0.05	0.04	0.04	0.04	0.03
4	0.07	0.06	0.06	0.06	0.05
5	0.09	0.08	0.07	0.07	0.07
6	0.11	0.10	0.09	0.09	0.09
7	0.13	0.12	0.11	0.11	0.12
8	0.17	0.15	0.14	0.14	0.15
9	0.23	0.20	0.19	0.19	0.20

The analysis of the Return (X3) financial indicator shows that this ratio is close to 0 for the companies in the commercial economic sector that are in decile 10. This result implies that during the study period, a small percentage of the companies had operating losses. For 70 % of the companies,

this indicator was between 0.14 and 0.17. This enables to conclude that the operational earnings of a large percentage of the companies of the commercial sector may represent up to 17 % of the value of its assets, and in few cases, it is greater than 19 % (decile 9).

Table 7
Decile distribution of variable X4 of Altman Z-score model

Decile	2016	2017	2018	2019	2020
1	0.16	0.16	0.16	0.16	0.19
2	0.28	0.30	0.30	0.32	0.36
3	0.40	0.43	0.43	0.45	0.50
4	0.53	0.56	0.55	0.59	0.67
5	0.68	0.73	0.71	0.76	0.85
6	0.91	0.92	0.95	0.98	1.13
7	1.19	1.26	1.27	1.33	1.52
8	1.67	1.86	1.82	1.95	2.24
9	2.67	2.90	2.99	3.32	3.97

Taking into account that variable X4 measures the ratio between wealth and liabilities, it is evidenced that almost 60 % of the companies have a ratio similar or lower between liabilities and wealth (with the exception of 2020, in which it exceeds 1). From decile 7 and for every year this indicator is higher than 1, which implies a greater participation of the wealth with respect to the liabilities within the financial structure. It is also evident an increasing trend in the ratios. This en-

ables to conclude that there has been an increase of the wealth with respect to the liabilities for the group of companies subject to study.

Once the independent results of the financial variables that integrate the Altman Z-score (Z'') have been identified, the results of the correlation tests to identify the financial indicator that has greater incidence on a higher Z-score are presented. Table 8 shows the results.

Table 8
Correlation between the financial variables of Altman Z-score model and the Z-score. Safe region

	Z	X1	X2	X3	X4
Z	1.00				
X1	0.48	1.00			
	0.00				
X2	0.43	0.44	1.00		
	0.00	0.00			
X3	0.43	0.08	0.12	1.00	
	0.00	0.00	0.00		
X4	0.82	0.14	0.10	0.00	1.00
	0.00	0.00	0.00	0.66	

The results that measure the relationship between the explicative variables of the Altman Z-score model and the Z-score, show a weak relationship of the liquidity, leverage and return variables. For the case of the financial structure

variable (X4), there is a greater association (strong positive relationship) with the score of the model. This result enables to conclude that one of the characteristics of the companies that show a low bankruptcy probability is their financial solidity.

Table 9*Correlation between the financial variables of Altman Z-score model and the Z-score*

Variable	2016		2017		2018		2019		2020	
	r ²	Relationship	r	Relationship	r	Relationship	r	Relationship	r	Relationship
X ₁	0.30	Weak	0.44	Weak	0.66	Moderate	0.70	Moderate	0.51	Moderate
X ₂	0.23	Poor	0.39	Weak	0.53	Moderate	0.69	Moderate	0.46	Weak
X ₃	0.18	Poor	0.76	Strong	0.41	Weak	0.43	Weak	0.22	Poor
X ₄	0.96	Strong	0.56	Moderate	0.81	Strong	0.77	Strong	0.90	Strong

From the results obtained, it is seen that X₄ (Wealth/Liabilities) is the financial variable that may generate a larger impact on the result of Altman Z-score model. These results enable to conclude that the companies that maintain a sufficiently high proportion of wealth with respect to liabilities will obtain a good result in the evaluation of insolvency, which will indicate the financial solidity of the company or its capacity to face economic crises. Nevertheless, for the last three years (2018-2020) the ratio of the working

capital with respect to assets (X₁) had a positive moderate impact on Altman Z-score. Therefore, it may be concluded that, in addition to financial solidity, having a robust working capital also benefits companies in this economic sector.

After carrying out the correlation analysis for all companies in the sample, the process is repeated for organizations that are within the three regions identified by the model, namely, Bankruptcy, Ignorance and Safe regions.

Table 10*Correlation between the financial variables of Altman Z-score model and the Z-score. Bankruptcy region*

Variable	2016		2017		2018		2019		2020	
	r	Relationship	r	Relationship	r	Relationship	r	Relationship	R	Relationship
X ₁	0.19	Poor	0.03	Poor	0.68	Moderate	0.78	Strong	0.89	Strong
X ₂	0.59	Moderate	-0.09	Poor	0.72	Moderate	0.86	Strong	0.81	Strong
X ₃	0.59	Moderate	0.99	Strong	0.51	Moderate	0.44	Weak	0.30	Weak
X ₄	0.31	Weak	-0.13	Poor	0.26	Weak	0.31	Weak	0.35	Weak

For the companies that are in the bankruptcy region, according to the result of Altman Z-score model, there is a diversity of results, as opposed to what is shown by the correlation of the total sample. Between 2016 and 2018, the correlations of the financial variables with the results of the model (Z-score) show poor and weak relation-

ships. In 2019 and 2020 is it observed a strong relationship between variables X₁ and X₂ and the result of the model. Therefore, it may be concluded that high working capital and high retained earnings with respect to total assets considerably affect the insolvency probability, at least for the last two years of the study.

Table 11

Correlation between the financial variables of Altman Z-score model and the Z-score. Ignorance region

Variable	2016		2017		2018		2019		2020	
	r	Relationship	r	Relationship	r	Relationship	r	Relationship	r	Relationship
X ₁	0.14	Poor	0.16	Poor	0.24	Poor	0.09	Poor	-0.09	Poor
X ₂	0.12	Poor	0.13	Poor	0.16	Poor	0.15	Poor	0.23	Poor
X ₃	-0.01	Poor	0.01	Poor	0.05	Poor	0.27	Weak	0.33	Weak
X ₄	0.22	Poor	0.03	Poor	-0.10	Poor	-0.05	Poor	0.07	Poor

For the companies of the commercial economic sector that are in the gray or ignorance region, according to the results of Altman Z-score model, it is evident that in most of the years, with the exception of 2019 and 2020 (in variable X₃), all

relationships are poor. This implies that for the companies that are in such region, there is no trend about the particular impact of some of the financial variables on the result of the model.

Table 12

Correlation between the financial variables of Altman Z-score model and the Z-score. Safe region

Variable	2016		2017		2018		2019		2020	
	r	Relationship	r	Relationship	r	Relationship	r	Relationship	r	Relationship
X ₁	0.26	Weak	0.60	Moderate	0.59	Moderate	0.62	Moderate	0.39	Weak
X ₂	0.17	Poor	0.52	Moderate	0.37	Weak	0.57	Moderate	0.33	Weak
X ₃	0.13	Poor	0.35	Weak	0.28	Weak	0.25	Poor	0.10	Poor
X ₄	0.97	Strong	0.84	Strong	0.88	Strong	0.89	Strong	0.97	Strong

There is clear trend for the companies of the commercial economic sector that are in the safe region; specifically, the X₄ financial indicator shows a strong correlation with the results of the model in every year. This result enables to infer that for a company to have a low insolvency probability, the ratio of the wealth to the liabilities should be watched, seeking that the former is higher than the latter. With respect to the rest of financial variables under study, the magnitude of the relationship changes every year.

Conclusions and discussion

The financial solidity of a company is a concern that involves both internal and external parts, since the interconnection generated by the companies affects the entire corporate system. Altman Z-score model is considered a reliable tool to predict a potential corporate insolvency. From the

theoretical point of view, there is no consensus about which financial variable has the higher impact on the financial difficulties of a company. Therefore, the research study conducted enables to determine which variable affects considerably the behavior of the Z-score and its meaning with respect to financial insolvency.

The Z-score model is a simple linear model that does not take into account the complexity and the interaction of financial factors such as the management, the corporate strategy and the general economic conditions that may have influence on the bankruptcy probability of a company. Despite these limitations, it is a model easy to understand and easy to apply, which makes it accessible for a wide range of users. Similarly, Altman Z-score model has demonstrated to be a reliable and effective tool that may be applied to a wide variety of industries and companies to predict their bankruptcy probability; thus, such model has become a valuable tool for corporate

decision making.

Taking into account the results of Altman Z-score model, it is observed that during the 2016-2020 period there are signs of stability in the companies of the commercial sector. Due to the temporary situation that occurred in 2020, it may be stated that the companies of this sector adequately got around the pandemics. Only 10 % of the companies of the commercial sector exhibit liquidity problems, since they had an indicator below 1. This confirms the financial solidity of the companies of this sector. The accumulated earnings were positive for 90 % of the companies, and this indicator is greater than 50 % for those companies that are in decile 9. Therefore, it may be stated that one of the main features of the companies that are in this decile is the capitalization of earnings. For 30 % of the companies the wealth/liabilities ratio is greater than 1, with an increasing trend, which indicates for these companies it is important to increase the wealth with respect to the liabilities to increase their financial solidity.

With respect to the companies that are in the bankruptcy region, it can not be stated that there is a variable that is determinant when evaluating the insolvency probability. Nevertheless, the results obtained in the correlations of variables X1 and X2 for 2019 and 2020, might give an indication about what can negatively affect a company with a high insolvency probability. For the companies that are in the ignorance region, there is no evident trend of any particular variable that may explain the insolvency probability. For the companies that have low insolvency probability, a high wealth/liabilities ratio may explain the solidity. In this sense, a company that seeks to capitalize earnings and maintain a controlled level of indebtedness from the point of view of Altman model, will be a stable company.

In general terms, the correlation indicators show that there is a direct relationship between the wealth/liabilities ratio and the Altman Z-score, which enables to conclude that this variable considerably affects the score that a company may obtain regarding its insolvency. The companies that rely more heavily on their own capital tend to be more attractive, because their level of insolvency risk may be lower. If a com-

pany is able to strengthen its own resources and reduce its obligations through financial planning, the shareholders and/or investors will have less concerns when financial crises arise.

The results of this research work have academic and practical implications. With respect to the academic implications, the study is focused on determining the relationship between the Z-score and the financial variables that constitute Altman Z-score model in a particular scenario. The results obtained in this research process may motivate future research works where it is determined the relationship described previously, but in other sectors of the Colombian economy. Regarding the practical implications, the research represents a contribution to the literature, showing new evidence about the relationship between the Z-score and the financial variables that constitute Altman Z-score model.

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