IBIMA Publishing
Communications of International Proceedings
https://ibimapublishing.com/p-articles/40FIN/2022/4021622/
Vol. 2022 (12), Article ID 4021622

Predicting Corporate Bankruptcy Using Altman Z'-Score and Ratio Analysis in The Manufacturing Sector: Evidence from The Italian Case

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* Presented at the 40th IBIMA International Conference, 23-24 November 2022, Seville, Spain

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Abstract

Altman Z-score has been subjected to many revisions over the years. However, it is not free from criticalities and practical inefficiencies, especially in relation to the financial ratios which characterize the basic structure of the Score itself. The purposes of this study are to verify the effectiveness of the Z'-Score in the Italian manufacturing sector and to verify if the model is influenced by the unlawful practices that managers put in place to hide the signs of insolvency before its external manifestation. Using discriminant analysis and a sample of 30 "unhealthy" companies and a control sample of 30 "healthy" companies, this exploratory research aims to check if in the Italian case the situation arises for which a negative Z'-score does not often correspond to a situation of financial distress shown by the Net Working Capital to Total Assets ratio, that is the first variable in the Z'-Score formula. The results show that, in most of the cases, a high positive ratio does not correspond to a "healthy" business situation, especially due to the management's incentive to cheat. The main limitation of the research can be seen in the small number of companies considered. The study, however, lays the foundations for future research on the subject, offering food for thought for management and ideas for the academic world.

Keywords: Z-Score; Bankruptcy; Prediction models; Net Working Capital to Total Assets.

Introduction

The life of a company is often characterized by positive and negative phases, which, alternating in the entire business' life cycle, often highlight criticalities that management must opportunely consider to avoid an irreversible decline situation (Agarwal et al., 2007; La Rocca et al., 2011; Sancetta, 2015). Whenever delayed, these circumstances can prompt liquidation or insolvency (Ohlson, 1980; Hendel, 1996). Companies in distress need to combine a range of financing instruments to find the optimum solution (Yehning et al., 1995), and indeed, they should have used tools and methodologies capable of grasping early signs of bankruptcy (Ohlson, 1980; Zhang et al., 2021). One of the most used methodologies is certainly the Altman's model, which, based on a linear relationship, identifies five variables (ratios) for each subject in the sample. These, weighted by coefficients, give rise to a score that should ascertain the proximity of the single firm to the group of bankruptcy companies or to the "healthy" ones (Altman et al., 1968). One of the ratios is Net Working Capital to Total Assets (hereinafter referred to as NWC/TA). It compares the net liquid assets to the total assets of the firm. Working Capital is in fact the difference

between current assets and current liabilities, so, Net Working Capital to Total Assets ratio determines the short-term company's solvency. However, this financial ratio, often leads to situations of inefficiency, distorting the result of the Z-score and therefore casting doubts on the effective applicability of the model to certain sectors. This work pursues the objective of verifying the validity of the best-known forecasting model, alias the Z'-Score by Altman, and therefore its reliability in relation to Italian manufacturing companies, investigating the impact that the aforementioned ratio has on the calculation of the score and on the forecast of insolvency.

Literature Review

Predicting Insolvency

The issues of corporate insolvency and bankruptcy have monopolized scientific literature for years: the search for increasingly sophisticated methodologies capable of stealing early signs of insolvency has become a fundamental prerogative in accounting and banking & finance, but above all, the various models that generate more or less precise measures of financial distress are increasingly used by the academic world to test the health of entire economic sectors. First studies date back to the 1930s. These concerned the use of ratio analysis techniques to predict future bankruptcy studies right up to the mid-1960's focusing on univariate technique (Bellovary et al., 2007). Since Fitzpatrick (1932) compared 13 financial ratios of both failed and successful firms, numerous and different approaches to the prediction of bankruptcy can be found in literature, especially in relation to the manufacturing sector (Merwin, 1942; Altman, 1968; Bellovary et al., 2007). In his research, Merwin (1942) studied the insolvency forecast in five different manufacturing industries, during the period 1926-1936. Subsequently, there has been an entire line of studies based on statistical methodologies and economic-financial indicators (Beaver, 1966; Altman, 1968, 1983, 2002; Altman et al., 1995; Alberici, 1975; Taffler, 1976, 1982; Wilcox, 1976; Argenti, 1976; Appetites, 1984; Foreigners, 1986; Lawrence & Bear, 1986; Flagg et al., 1991; Kern & Rudolf, 2001). The fundamental matrix of these studies is to be found in the research carried out in the years immediately following the 1929 Wall Street crash (Smith, 1930; Ramser & Foster, 1931; Wall, 1936; Merwin, 1942).

The Italian context

In Italy, the first research concerning the study of the business crisis and insolvency occurred in correspondence with the economic boom that took place after the Second World War. In particular, some authors investigated the causes of crises (Argenti, 1976; Coda, 1977, 1990; Guatri, 1986; Confalonieri, 1993; Sciarelli, 1996; Piciocchi, 2003), while others analyzed and outlined specific tools capable of managing the crises themselves (Guatri, 1986; Caprio, 1997; Danovi et al., 2000; Falini, 2008). Among the most important Italian studies on bankruptcy prediction, must certainly be mentioned the contribution of Alberici (1975), author of a model for the prediction of insolvency characterized by five different versions of his Score to be applied each to a specific year of the five-year period preceding the instability. Other recent contributions are those of Resti (2002); Giannozzi et al. (2010); Altman, Danovi & Falini, (2013); Brogi et al., (2022).

Altman's studies

In 1968, Edward I. Altman developed one of the most famous descriptive strategy models: the so-called Altman Z-Score (Altman, 1968). Composed of five financial ratios weighted by different coefficients, for Teodori (1989) the model represents a real warning tool that all firms should implement in their organizational system. The model has a descriptive-comparative and non-probabilistic nature (Altman et al., 1970) and has been the subject of numerous revisions and improvements over the years (Altman, 1993; Altman, 2002). The first formulation of the Z-Score was intended for US publicly traded manufacturing firms (Altman, 1968). Subsequently, the model was updated and adapted to the situation of not listed companies (Scott, 1981; Altman, 1993; Danovi & Quagli, 2012). As can be observed from Figure 1, the models have a different classification of results.

Z-Score (*1968*)	**Z'-Score (*1993*)**
X_1 = net working capital / total assets	X_1 = net working capital / total assets
X_2 = retained earnings / total assets	X_2 = retained earnings / total assets
X_3 = earnings before interest and taxes / total assets	X_3 = earnings before interest and taxes / total assets
X_4 = market value of equity / total liabilities	X_4 = equity book value / total liabilities
X_5 = sales / total assets	X_5 = sales / total assets
$Z = 1{,}2X_1 + 1{,}4X_2 + 3{,}3X_3 + 0{,}6X_4 + 0{,}99X_5$	$Z' = 0{,}717X_1 + 0{,}847X_2 + 3{,}107X_3 + 0{,}420X_4 + 0{,}998X_5$
Zone of discrimination:	**Zone of discrimination:**
$Z > 2.99$ – "safe" zone	$Z' > 2.99$ – "safe" zone
$1.81 < Z < 2.99$ – "grey" zone	$1.23 < Z' < 2.99$ – "grey" zone
$Z < 1.81$ – "distress" zone	$Z' < 1.23$ – "distress" zone

Figure 1: Z-Score and Z'-Score formulas (*Source: Altman, 1968; Altman, 1993*)

Altman's model relies on specific ratios capable of summarizing various aspects of the company's economic and financial situation. Among these, the Net Working Capital (Current Assets − Current Liabilities) to Total Assets ratio is considered one of the most important. Subsequently its diffusion in the academic and managerial world, the model has broadened its scope by also being applied to non-manufacturing companies operating in the "emerging countries" (Altman et al., 1995; Xiaoa et al., 2012). In this regard, the new formulation of the Score adds a constant equal to +3.25 in order to standardize results equal to 0 which would be equivalent to a default situation (Altman et al., 1995; Altman & Hotchkiss, 2005). In the new version, weighting coefficients take on different values: $Z'' = 6.56X_1 + 3.26X_2 + 6.72X_3 + 1.05X_4$.

Financial ratios and Net Working Capital Management

Altman Z-Score has been considered, in the last twenty years an effective tool to predict the health of companies. In fact, numerous studies confirm its goodness both in Western countries and in emerging economies (Al Zaabi & Obaid Saif, 2011; Mizan & Hossain, 2014). Furthermore, most of the studies confirm that the ratio analysis underlying the model is useful and effective for predicting bankruptcy up to five years before full insolvency. In particular, the ratios relating to profitability, liquidity and solvency are considered to be the most significant in terms of forecasting insolvency (Scott, 1981). In the Italian context, there are numerous studies relating to the application of the Z-Score to manufacturing companies (Altman et al., 2013; Matozza et al., 2020). Equally numerous are the studies that analyze criticalities of financial ratios analysis (Altman et al., 2013; Matozza et al., 2020). For Celli (2015), Z-Score can be extended to non Anglo-Saxon firms and to Italian firms, taking into account certain critical points (Altman et al., 1994). Little, however, has been written in reference to the relationship between NWC/TA ratio and Z-score in the Italian case. Although part of the literature has highlighted critical issues regarding this relationship in Altman's approach (Gark, 1997; Farkas, 2003; Giannachi, 2017; Cenciarelli et al., 2020), there is a gap that this study aims to fill, at least in part, given the exploratory nature of the research.

Methodology

Study objectives

To the author's own knowledge, previous studies hardly understood the relationship between NWC/TA ratio and Z'-Score in the Italian manufacturing sector (Shumway, 2001). Our study aims to:

- test the effectiveness of the Altman's model in the Italian context, considering the time-frame 2015-2019 (pre-covid pandemic situation). Based on the studies of Altman (1993) and Altman, Danovi & Falini (2013), we decided to apply the Z'-Score formula because considered companies are manufacturing ones, not listed on financial markets;

- confirm the critical issues concerning the first variable of the Altman's formula. In most cases, in fact, the NWC/TA ratio shows a situation of financial solidity and health for the company, when in reality it is in a over failure situation (Sue et al., 2021). This could be explained by virtue of managers' incentive to cheat by increasing the numerator of the ratio or decreasing the denominator, in order to avoid that, externally, worrying signals relating to the real economic and financial situation of the company are given. Therefore, the study intends to confirm whether the Z'-Score, applied to Italian companies, manages not to be influenced by such unfair practices.

Data Collection

This exploratory work concerns non-listed companies belonging to the Italian manufacturing sector. The choice of this sector has two reasons:

1. the manufacturing sector is Altman's favorite one in his studies (Altman, 1968; Altman et al., 1995). Therefore, the research makes it possible to compare the results with the original model's results (Alkhatib et al., 2011);
2. manufacturing companies are quite significant in the national production context and are generally characterized by a significant level of indebtedness (Istat, 2021).

Financial data were obtained from AIDA (Analisi Informatizzata Delle Aziende Italiane), a database provided by Bureau van Dijk, that contains comprehensive information on companies in Italy, with up to ten years of history. Search criteria are highlighted in Table 1.

Table 1: Search criteria (*Source: https://aida-r1-bvdinfo-com.ezproxy.uniroma1.it/, 2022*)



Aida - Società - Strategia di ricerca

	Risultato della ricerca	Risultato della ricerca
1.Eventi giuridici: Tipologia di procedura: nel e dopo l'anno 31/12/2018 fino a ed incluso l'anno 31/12/2019, Scioglimento e liquidazione, Fallita, Concordato preventivo, Liquidazione, Stato di insolvenza, ...	2.470	2.470
2.Forma giuridica: S.R.L.	1.491.216	1.766
3.Regione, provincia, comune: 01 - Piemonte, 02 - Valle d'Aosta/Vallée d'Aoste, 03 - Lombardia, 04 - Trentino-Alto Adige/Südtirol, 05 - Veneto, ...	2.218.928	1.766
4.NACE Rev. 2: 15 - Confezione di articoli in pelle e simili, 16 - Industria del legno e dei prodotti in legno e sughero, esclusi i mobili; fabbricazione di articoli in paglia e materiali da intreccio, 17 - Fabbricazione di carta e di prodotti di carta, 18 - Stampa e riproduzione su supporti registrati, 19 - Fabbricazione di coke e prodotti derivanti dalla raffinazione del petrolio, ...	184.547	210
5.Anni con bilanci disponibili: 2019, 2018, 2017, 2016, 2015	1.346.854	133
Ricerche Booleane : 1 E 2 E 3 E 4 E 5	Totale	133

Criteria can be described as follows (since the AIDA database contains only information from Italian companies, we considered it appropriate to keep the Italian language in Table 1):

1. legal events. We considered companies that, before the outbreak of the covid-19 pandemic (which could have distorted the results obtained due to the economic contingencies characterizing this period), from 2018/12/31 to 2019/12/31, have been subjected to dissolution, bankruptcy, arrangement with creditors, liquidation (Altman, 1968; Altman et al., 2013);
2. legal form. The chosen companies are all s.r.l, a kind of legal corporate entity in Italy, which literally means “limited liability company”, not listed on the financial market;
3. region. We considered the companies operating throughout the national territory;
4. NACE Rev. 2. NACE is the “statistical classification of economic activities in the European Community” (Eurostat, 2006). We considered all types of companies falling within the manufacturing sector;
5. availability of financial statements. For the effective application of the Altman’s model, we only considered companies that published their financial statements in the 5 years prior to 2019.

From a total of 2,470 companies (starting from the most important search criterion for us, “legal events”), research led to a sample of 133 companies. Following the example of Altman (1968), Altman et al. (2013), Celli (2015) and Matozza et al., (2020), we considered 30 firms in the above sample. For the control sample, we selected 30 “healthy” companies. The search criteria, in this case, are only deferred for criterion number 1: we considered "active" companies. Total sample from AIDA database was made up of 78,228 “healthy” firms. Beyond the objective non-comparability of the Italian and US markets, the choice of not using the original Z-Score is due to the fact that only the 6% of the total sample was listed on regulated markets (Gerantonis, Vergos & Christopoulos, 2009).

Multiple discriminant analysis: empirical results

The first methodological step concerns the calculation of the Z'-Score to verify its effective applicability to the Italian manufacturing sector and therefore its ability to predict insolvency at least 3 years before the event occurs. We first carried out the calculation of the score for the companies which, according to the AIDA, initiated proceedings related to insolvency in the 2018/12/31-2019/12/31 period. Analysis showed the following results:

Table 2: Z’-Score zones for “inactive” companies (*Source: our processing*)

Z'-Score	2019	2018	2017	2016	2015
Sample	30	30	30	30	30
Z'<1,23 - "distress" zone	93,30%	75%	70%	70%	70%
1,23 < Z' < 2,99 - "grey" zone	6,70%	20%	30%	30%	30%
Z' > 2,99 - "safe" zone	0%	5%	0%	0%	0%

Table 2 shows how, in most cases, companies are correctly classified in the “insolvency” area. The Z’-Score should be able to pre-see insolvency three years before it occurs (Altman, 1968): our exploratory research confirms this, and, in the four years preceding the "insolvency" event, the model correctly classifies companies with an average value of 71.25%. In 2018, there is a value equal to 5% of companies in "safe" zones, and therefore incorrectly classified. In 2019, on the other hand, a level of correctness of the model equal to 93.30% is reached for the "distress zone". 6.70% of companies is classified in the "grey" area. Further information is contained in Table 3.

Table 3: Z’-Score values for “inactive” companies (*Source: our processing*)

Z'-Score	2019	2018	2017	2016	2015	Tot. Avg.
Average Z'-Score	-6,57	-0,61	0,17	0,54	0,20	-1,254742275
Median Z'-Score	0,51	0,62	0,80	0,35	0,22	
Max Z'-Score	1,82	4,00	2,02	2,23	2,11	
Min Z'-Score	-105,63	-11,51	-8,65	-2,82	-3,25	
Adjusted Average V.	0,40	0,32	0,56	0,63	0,44	0,47

Table 3 shows how the score has always an average value of less than 1.23 in the last 5 years. Therefore, companies are placed in the "distress" zone. There is also a significant worsening of the average score in correspondence with the year 2019, in which the companies explicitly declared their insolvency. These considerations are confirmed by the total average value and by the adjusted average trend. With the approach of insolvency, performance naturally collapsed and in the most serious cases the Z'-Score took on clearly negative values. Altman's model, therefore, seems to confirm its forecasting effectiveness in the previous three years the declaration of insolvency and is therefore applicable, albeit with precise limits which will be discussed in the following paragraphs, to the Italian manufacturing sector. These considerations are summarized in Figure 2, which shows the average trend of the different areas of the Score.

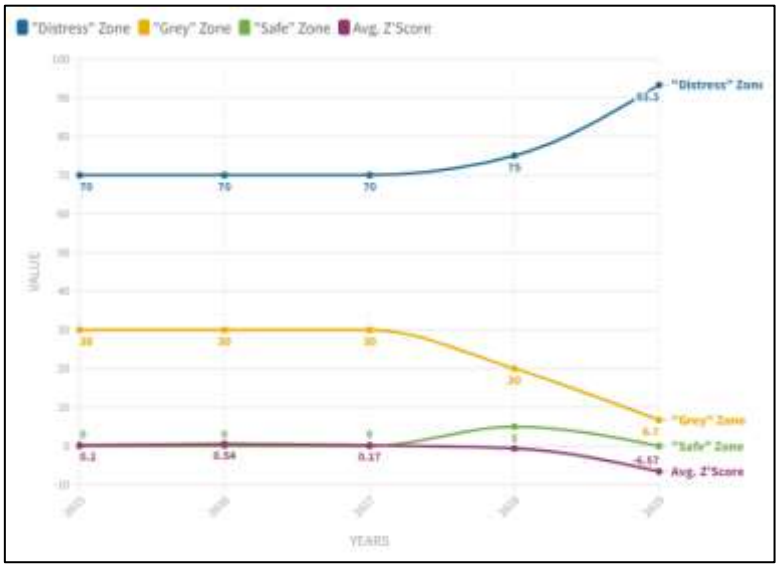


Figure 2: Average Z'-Score's trend (*Source: our processing*)

Control sample of "healthy" firms: results

To confirm the previous results, we calculated the Z'-Score of the "healthy" companies. The analysis highlighted how the obtained score by the majority of the companies was to be placed in the area of uncertainty ("grey" zone) (Altman, 1995; Altman et al. 2013). Table 4 shows the results of the analysis. The tendency of the sample to present a score in the "grey" zone highlights how the Z'-Score, applied to the Italian manufacturing context, fails to provide a precise indication on the state of health of active companies. Therefore, there is no correspondence between the efficiency of the Z'-Score applied to "unhealthy" firms and that applied to "healthy" firms. Our study shows that, in the Italian case, Z'-Score cannot be used as a warning signal in the manufacturing sector.

Table 4: Z'-Score areas for "healthy" companies (*Source: our processing*)

Z'-Score	2019	2018	2017	2016	2015
Sample	30	30	30	30	30
Z'<1,23 - "distress" zone	30%	30%	40%	25%	20%
1,23 < Z' < 2,99 - "grey" zone	55%	50%	45%	55%	70%
Z' > 2,99 - "safe" zone	15%	25%	15%	20%	10%

Net Working Capital to Total Assets analysis and results

The second methodological step involves verifying the ability of the Z'-Score to predict insolvency even in the presence of inefficiencies relating to the ratios system present in its original formulation. Having previously verified the ability of the model to predict insolvency, but not to understand the state of "healthy" companies, the following paragraph shows how the Z'-Score does not feel the influence of managerial practices capable of tampering with the various balance sheet items and therefore the values of the financial stability ratios. In literature, one of the most used indices to understand the state of health of a company is the Net Working Capital to Total Assets ratio (Beaver, 1966; Altman, 1968; Ohlson, 1980; Taffler, 1982). This ratio represents the first variable considered by Altman in his model (Altman, 1968; Altman, 1993; Altman, 1995), and

it can be considered as the percentage of working capital to company total assets. It represents how strong the company's financial health is regarding the liquidation and shows the management risk tolerance toward the investment opportunity and risk of liquidation. The calculation is: current asset minus current liabilities divided by total assets. In this work, we then multiplied the result by 100 in order to arrive at the final ratio. Assets are listed on the balance sheet and comparing assets with total net working capital allows the analyst to compare the company's operational efficiency with its relative size in the market: a positive ratio is considered to be a sign of strength, and a negative ratio is considered to be a sign of weakness. We therefore calculated the NWC/TA ratio with the weighting coefficient predicted by Altman for the Z'-Score for the 30 "unhealthy" companies sample. Results are summarized in Table 5.

Table 5: NWC/TA for "unhealthy" companies (*Source: our processing*)

NWC/TA	2019	2018	2017	2016	2015	Tot. Avg.
Average Value	27.13%	20.15%	13.85%	15.71%	11.75%	17.72%
Median Value	42.52%	42.33%	25.95%	21.09%	19.84%	
Max Value	71.70%	71.48%	70.02%	71.19%	71.04%	
Min Value	-42.50%	-197.41%	-150.64%	-56.90%	-80.45%	
Adjusted Average Value	19.72%	29.16%	20.99%	17.83%	14.71%	20.48%

Results are not in line with the real situation shown by the AIDA database. The average value of the ratio grows steadily over the five-year period considered (except for 2017, in which it assumes a value of 13.85%). The total average value is equal to 17.72%. These values represent a satisfactory and very good solvency of companies, which, however, have ceased their activities or have requested an arrangement with creditors during 2019. To avoid value distortions, we calculated the adjusted average value by subtracting the maximum and minimum values from the calculated average. Although in the year 2019 there is a decrease in value compared to the previous year, from 2015 to 2017 there is a steady increase in value. The adjusted average value, on the other hand, is equal to 20.48%. It therefore represents a rather good short-term solvency. The result is confirmed by the graphical trend of the curves (Figure 3). We considered the calculation of the ratio in "healthy" companies to be negligible, since, in this case, management's incentives to cheat are minor and therefore negligible.

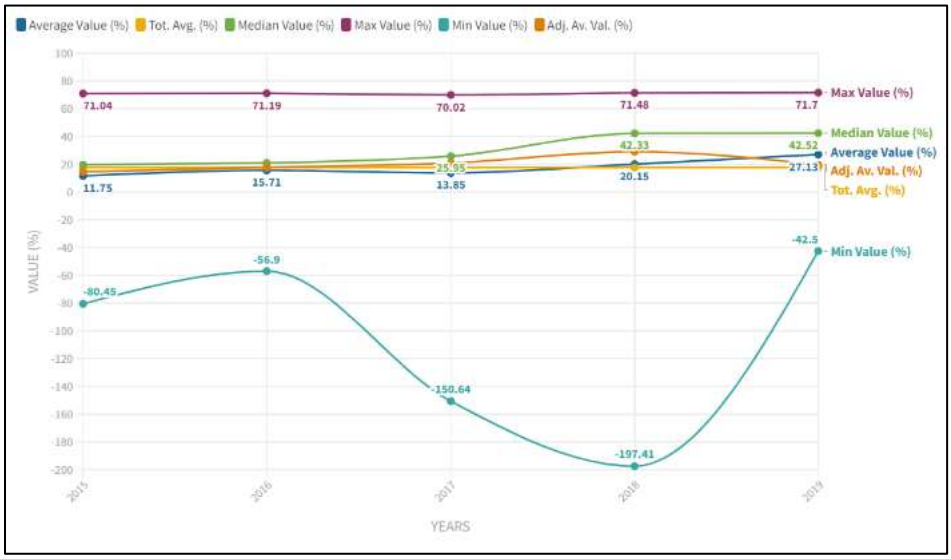


Figure 3: NWC/TA graphical trend (*Source: our processing*)

Table 6: US manufacturing NWC/TA values (*Source: our processing*)

Range	Significance
Ratio > 30%	Very Good
15% < Ratio < 30%	Satisfactory
0% < Ratio < 15%	Unsatisfactory
Ratio < 0%	Critical, no Net Current Assets

There is no optimal level of Net Working Capital to Total Assets for every company. It depends on the company operation, type of business, level of risk, and management behaviour toward risk. However, much of the literature presents reference

values for the US manufacturing sector (Taffler, 1982; Alkhatib et al., 2011) (Table 6). Given the lack of such indications for the Italian case, we considered these values as a benchmark for our study. The average results of the study are almost always positioned in the "Satisfactory" area of significance, except for 2017, where the average solvency is between 0% and 15%, and therefore unsatisfactory. The total mean value is “Satisfactory”, as is the adjusted mean value. The year 2018 marks the highest minimum values. However, this is an exception, as in the sample of companies, only 6% have a constant negative, and therefore critical, ratio values. For completeness of the survey, and to confirm this anomalous trend of the ratio, we then calculated average values and trends of the individual elements of the ratio, namely Net Working Capital and Total Assets. Results are shown in Figures 4, 5, 6 and in Tables 7, 8.

Table 7: Net working Capital values (*Source: our processing*)

Net Working Capital	2019	2018	2017	2016	2015	Tot. Avg.
Average Value (EURO'000)	248	668	565	576	577	527
Median Value (EURO'000)	23	146	139	96	113	
Max Value (EURO'000)	19.164	18.964	18.852	18.961	18.789	
Min Value (EURO'000)	-9.641	-3.904	-6.038	-3.969	-4.259	
Adjusted Average Value (EURO'000)	234	476	525	513	490	447

Table 8: Total assets values (*Source: our processing*)

Total Assets	2019	2018	2017	2016	2015	Tot. Avg.
Average Value (EURO'000)	4.239	3.803	4.080	3.566	4.105	3.959
Median Value (EURO'000)	392	400	598	317	634	
Max Value (EURO'000)	19.366	20.248	24.265	19.291	24.098	
Min Value (EURO'000)	8	17	68	2	54	
Adjusted Average Value (EURO'000)	3.401	3.100	3.182	2.894	3.219	3.159

The Net Working Capital ratio is the net amount of all elements of working capital. It is intended to reveal whether a business has a sufficient amount of net funds available in the short term to stay in operation. Understanding this formula is crucial in determining if the company is generating cash from its working capital or using cash. Some assumptions used to forecast NWC are:

- Accounts Receivable Days;
- Inventory Days;
- Percentage of sales;
- Accounts Payable Days;
- Percentage of sales, growth percentage.

In our study, the average values of the NWC remain quite stable in the 4 years preceding the insolvency, and then decrease in correspondence with the year 2019. This trend is also confirmed by the trend of the median and the adjusted average value. These positive values therefore show a stable situation for companies in the manufacturing sector during 2019, not in line with the Z’-Score results. The average values of Total Assets, on the other hand, are stable for the entire five-year period considered, as well as the median (which reaches 598 only in 2017) and the adjusted average value.

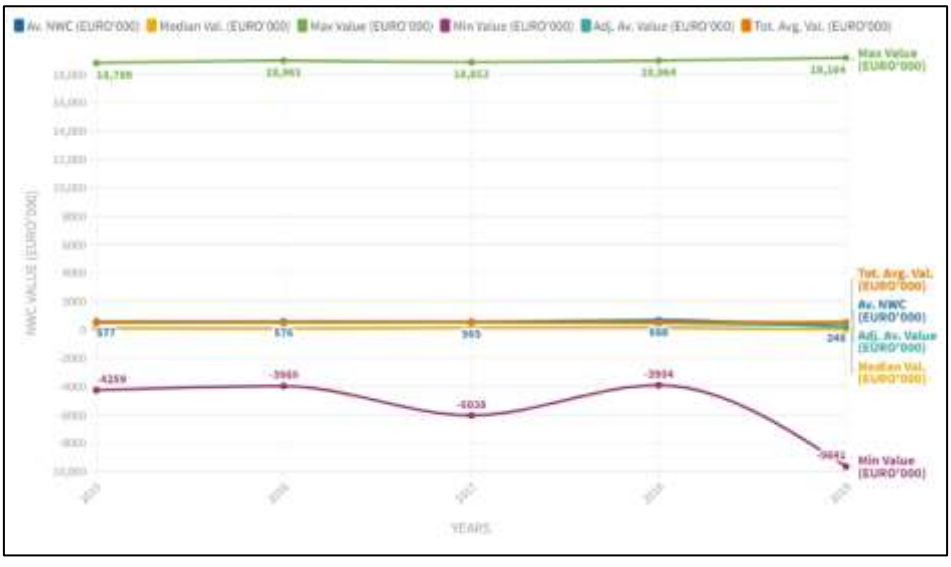


Figure 4: NWC graphical trend (*Source: our processing*)

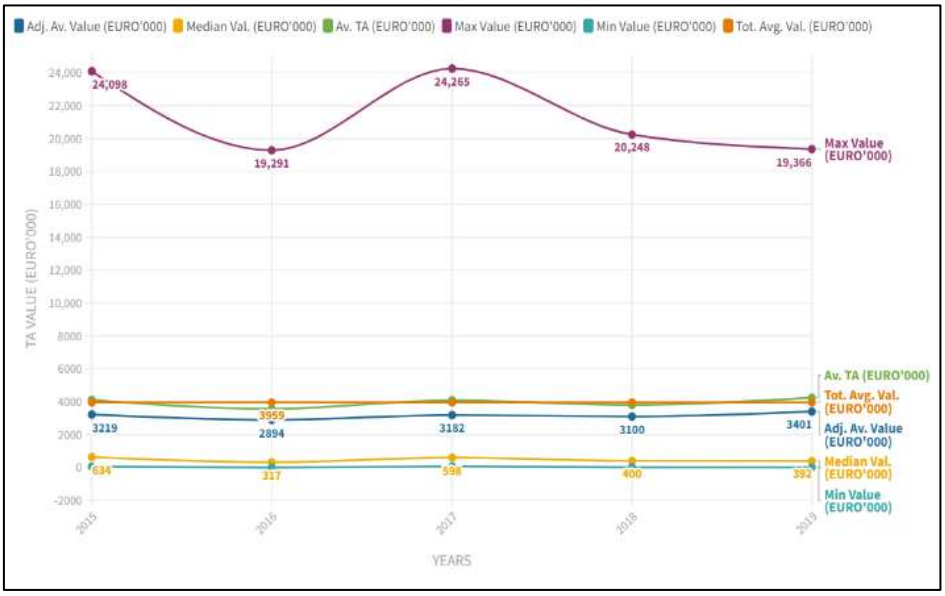


Figure 5: TA graphical trend (*Source: our processing*)

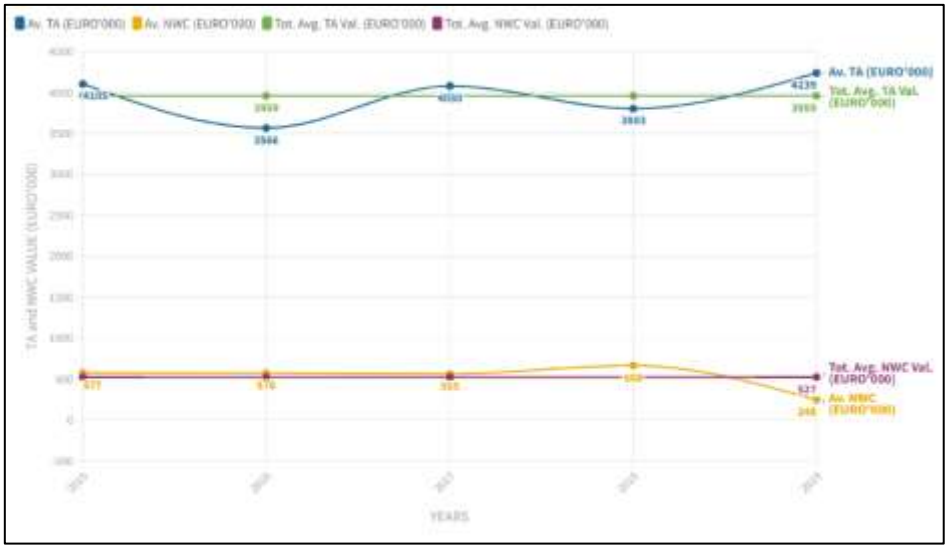


Figure 6: Total Average Values graphical trend (*Source: our processing*)

By only looking at immediate debts and offsetting them with the most liquid of assets, a company can better understand what sort of liquidity it has in the near future. NWC can be considered a measure of a company's operational efficiency and short-

term financial health. A positive NWC means that a company could have the potential to invest in expansion and grow the company; if current assets do not exceed its current liabilities, then it may have trouble growing or paying back creditors and it might even go bankrupt. Figure 6 shows how average Total Assets remain around the Total Average throughout the considered period, while the Average Value of the NWC decreases in correspondence with the last year, while maintaining positive and satisfactory values.

Discussion

Results and conclusions

The first phase of our research shows how the Altman's model has a good predictive capacity if applied to a sample of 30 Italian manufacturing companies not listed on the financial markets. However, the same model fails to correctly locate "healthy" firms in the correct area. The latter, in fact, although they are still in business, are classified, in most cases, in the area of uncertainty and, in the considered five years, 29% of companies are classified as "insolvent", while only the 17% as "healthy". This demonstrates the limits of the model compared to the Italian case and the impossibility of using the Z'-Score as a support element in business processes to predict critical situations of instability. The second methodological step analyzed one of the most objections raised by the literature towards the Altman model. In fact, if the model becomes the recognized standard for crisis prediction, it is possible that incentives will be generated to "cheat the model". For example, some companies, aware that their state of crisis can be soon intercepted, could apply budgetary policies aimed at manipulating the model indicators. Or, even, they could generate behaviours that really modify the indices but worsening the business situation. One of the indices on which the model is based is the ratio between Net Working Capital and Total Assets. A company could increase the value of this index (and all else being equal its Z-Score) by combining policies to increase trade receivables and inventory (to increase the numerator) with policies for the sale of corporate assets (to reduce the denominator). In this way, the improvement in the score could be accompanied by a worse financial situation, due to greater investments in working capital and less availability of company assets. The case of the Italian manufacturing sector shows how such attempts to cheat are possible, given the anomalous trend of the NWC/TA ratio. Most of the considered companies, in fact, despite presenting an objective critical situation in the last year under investigation (2019), present a satisfactory financial solidity. This obviously collides with the circumstantial situation that can be found in reality. However, the study shows that, even in such a situation, the Z'-Score manages not to be affected by the influence of these tampered indices but proves capable of reading the real situation of "unhealthy" companies. This could be due to the robustness of the other variables considered in the model, which partially mitigate the errors due to the NWC/TA ratio.

Research Limits

The main limitation of this research is the low statistical significance of the sample. Another limit, strictly connected with the purpose of the research, is that of the truthfulness of the data present in the AIDA database: in "unhealthy" companies, management is often incentivized to cheat to hide the critical situation until it becomes unmanageable and therefore visible from the outside. Therefore, attempts to improperly modify the items in the financial statements could distort the results of the Z'-Score, making it ineffective and unable to place companies in the correct area of belonging. Italian companies, however, proved to be solid with regard to this possible flaw in the Altman's model.

Developments and managerial implications

The possible developments of the research involve considering a statistically significant sample of companies on which to test the validity of the Altman's model and on which to find any critical elements related to the NWC/TA ratio or to the other ratios in the formula. It will be useful to combine multivariate analysis with a statistical model capable of refining the results and avoiding errors. This exploratory research, therefore, lays the foundations for a line of studies that is currently very interesting and offers food for thought for the academic world and management, which have always been attentive to these issues.

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