

Bankruptcy forecast analysis: empirical study of the manufacturing subsector of Norte de Santander, Colombia

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Abstract

The study "Bankruptcy Forecast Analysis in the Manufacturing Subsector of Norte de Santander, Colombia (2015 – 2022)" offers an empirical evaluation of financial stability in this region, using the capital structure theory of Modigliani and Miller and the Altman Z-Score model for bankruptcy risks as a theoretical foundation. Through a quantitative approach that includes time series analysis, the internal and external factors that affect the financial competitiveness of the subsector are analyzed. The research highlights the contributions and limitations of capital structure theory and the Z-Score model in real practices, and discusses the integration of advanced technologies such as artificial intelligence to fine-tune financial risk predictions. Using purposeful sampling and documentary analysis, patterns are identified and business solvency is assessed, providing a detailed view of the sector's resilience in the face of economic challenges. This study provides valuable insights for those interested in the financial sustainability of the manufacturing sector, highlighting the importance of adapting risk management strategies to regional particularities. Its contribution to the specialized literature lies in offering an updated perspective on bankruptcy forecasting and financial management adapted to the specific context of the Colombian emerging economy.

Keywords: bankruptcy forecast, Altman Z-Score model, capital structure, manufacturing sector.

Introduction

According to Bhuvneskumar et al., (2023), bankruptcy forecasting and financial analysis occupy a prominent place on the contemporary business research and practice agenda, especially in a globalized environment characterized by significant economic volatility. Therefore, the ability to anticipate financial difficulties before they

materialize into irreversible crises not only safeguards the sustainability of individual companies, but also protects the stability of the economic system as a whole. (Gómez & Rodríguez, 2015) . In this sense, meticulous financial analysis and bankruptcy forecasting become indispensable tools for managers, investors and regulators, providing a critical basis for making informed and strategic decisions. Furthermore, the relevance of these processes is magnified in sectors that are highly sensitive to economic fluctuations, such as manufacturing, where the ability to adapt to market changes and manage financial risks effectively is fundamental for success and operational continuity (Adesina & Onanaye, 2022).

Within the framework of these considerations, according to Gupta et al. , (2023) the study of bankruptcy forecasting takes on a strategic dimension, acting as a beacon that guides companies through financial turbulence towards safer waters. This field of research, enriched by the theoretical legacy of pioneers such as Modigliani and Miller as well as the methodological innovations introduced by Edward I. Altman, offers a deep understanding of the indicators and mechanisms that portend financial distress. On the other hand, Lord et al., (2021) refer to the ability of these models to synthesize a wide range of financial variables into understandable and actionable indicators allows organizations to evaluate their financial health with unprecedented precision. Thus, financial analysis and bankruptcy forecasting not only have the potential to anticipate the risk of insolvency, but also facilitate the identification of opportunities for strategic restructuring and operational improvement, underlining their cardinal importance in modern business management (Modigliani & Miller, 1958; Altman, 1968; Lukac et al., 2022).

In the context of Norte de Santander, the manufacturing sector constitutes a cornerstone of the regional economy, whose competitiveness and financial stability are influenced by both internal factors and a series of external variables, including the regulations imposed by the Superintendency of Companies. Colombia. This research focuses on the interaction between these factors and their impact on the solvency of companies in the sector, with the aim of offering a deeper understanding of the forces that shape their financial health (Calderón et al., 2022).

Likewise, this research is part of the intersection of economic and financial analysis, guided by the deep theorization of Modigliani and Miller on capital structure, as well as by the innovative contribution of Edward I. Altman through his Z indicator. -Score to evaluate the probability of business bankruptcy. This study aims to transcend traditional debates on the relevance of capital structure in corporate decisions, exploring the applicability of said theories in the diagnosis and prediction of financial vulnerabilities within the specific manufacturing context of Norte de Santander, Colombia, during the period between 2015 and 2022. Likewise, a rigorous quantitative

approach was adopted, supported by a retrospective and transversal methodological structure, with the analysis of time series as the central axis (Carrasco et al., 2022) .

The body of the article is organized around a logical and structured sequence, beginning with a literature review that places the theoretical contributions of Modigliani, Miller and Altman in the context of bankruptcy forecasting. Next, the methodology used to carry out the study is detailed, as well as the results obtained. The discussion of these findings allows for an in-depth interpretation of the practical implications, while the conclusion section projects the future directions of research in this field, emphasizing the relevance of the study for academics, financial professionals and policy makers interested in the strength and financial resilience of the manufacturing sector in emerging economies such as Colombia. This comprehensive approach ensures a significant contribution to the existing academic corpus, aligning with the publication standards of high-impact journals in the field of economic and financial analysis.

Literature review

The theory proposed by Modigliani and Miller has been fundamental in establishing a baseline for understanding financial management within corporations (Ahmeti & Prenaj, 2015). Although initially considered revolutionary, over time, academics and finance professionals have recognized its limitations in practical environments, marked by taxes, bankruptcy costs, and information asymmetries. These reflections have led to an enrichment of the original theory, inciting deeper discussions on the role of capital structure in business performance and survival. This academic debate has generated a favorable environment for the development of new theories and models that seek to overcome these limitations, adapting the notion of irrelevance of the capital structure to more realistic and complex contexts (Mang'ana et al, 2024) .

On the other hand, the Altman Z-Score model has not only provided an analytical instrument for financial risk assessment, but has also inspired the development of other bankruptcy predictive models and risk analysis (Vinogradova et al., 2021) . The ability of this model to incorporate various financial variables into a single quantitative indicator has proven to be particularly valuable for financial researchers and professionals (Song et al., 2024) . The adaptability and accuracy of the Z-Score have been tested in multiple industries, highlighting its usefulness in volatile economic environments. Furthermore, recognition of the relevance of the model in different markets has encouraged research on its applicability and effectiveness in emerging economies, where market conditions and regulatory frameworks present unique challenges for insolvency prediction (Buele et al., 2021) .

The interplay between capital structure theory and bankruptcy prediction tools, such as the Altman Z-Score model, illustrates the complexity of financial management in the

corporate world (Loncarevic, 2015). This synergy has allowed companies to better evaluate their financial strategies and their position in the market, anticipating possible financial difficulties before they become irreversible crises. The continuous evolution of these theories and models reflects the dynamism of the financial field, driving academics and professionals to seek innovative solutions to complex financial problems and adapt their strategies to an ever-changing business environment (Forbring & Sandkuhl, 2021).

In addition to the theoretical bases and established models, it is crucial to consider the evolution of research in the analysis of bankruptcy forecasting in recent years. Technological advances and access to large volumes of data have allowed the development of more sophisticated predictive models, such as those based on artificial intelligence and machine learning . (Kythreotis & Soltani, 2023) (Ullah et al., 2021). These new methodologies have proven to be especially useful for detecting early signs of financial risk in complex and volatile environments. Recent studies have applied these techniques to the manufacturing sector, revealing patterns and correlations that were not evident with traditional methods (Falavigna et al., 2018) . The incorporation of these methodological advances can significantly enrich the predictive capacity of research on business bankruptcy.

Risk management has become an area of growing interest within the financial literature, especially with regard to its role in preventing bankruptcy (Góis et al., 2020) . Risk management strategies, including product and market diversification, capital structure optimization, and implementation of early warning systems, are essential for the financial stability of companies. The literature suggests that effective risk management can significantly mitigate the likelihood of facing financial difficulties (León & Espinoza, 2023). This aspect highlights the importance of integrating risk management into financial analysis and strategic planning, especially in sectors subject to high uncertainty and dynamism such as manufacturing.(Prakash & Verma, 2019) (McCay et al., 2019) .

In the regional context it plays a fundamental role in determining the financial strength and resilience of companies in the face of bankruptcy (Mohammed, 2016). The case of the manufacturing sector in Norte de Santander, Colombia, illustrates how specific regional factors, such as the economic, political and social environment, as well as infrastructure and access to markets, can influence the financial health of companies.(Bustamante & Bustamante , 2008) (Ospina & Martínez, 2019). Studies focused on regional contexts provide valuable insights into how local conditions can affect the application and effectiveness of financial models and risk management strategies. This regional perspective emphasizes the need to adapt financial analysis

tools and bankruptcy prevention strategies to the unique characteristics and challenges of each environment (López et al., 2017). (Martínez et al., 2018)

The manufacturing subsector in Norte de Santander, Colombia, offers an interesting case study due to its economic relevance and the specific dynamics it presents. Existing literature suggests that the financial competitiveness of this sector is not only influenced by internal factors, such as operational efficiency and capital structure, but also by external factors, including government policies and global market conditions (Contreras et al. ., 2016) (Gallego et al., 2017). This dual approach is essential to understand the financial vulnerabilities and resilience of the sector in the face of potential crises.

Finally, the review of empirical studies that have applied both the theory of Modigliani and Miller and the Altman Z-Score model to the manufacturing sector highlights the relevance and applicability of these approaches in the regional context (Ahmeti & Prenaj, 2015). These investigations show a diverse range of factors that can affect the financial stability of companies, from capital structure to macroeconomic and sector variables. (Mang'ana et al., 2024) (Valverde & Rossi , 2023) (Román, et al., 2023).

Method

The methodological conception of this study focuses on the positivist paradigm with a quantitative approach. This choice reflects a commitment to analytical rigor and objectivity, fundamental in research (Trejo, et al., 2023) (Hair et al., 2018) . The non-experimental nature of the study underscores its focus on exploration and descriptive analysis through retrospective data collection, allowing for an interpretation deeply rooted in the observed reality of the manufacturing subsector during the specific study period. The cross-sectional design was meticulously selected to capture a detailed and representative view at a given point in time, thereby revealing the contemporary financial status of the subsector and facilitating an accurate assessment of its bankruptcy potential.

On the other hand, according to (Pardo et al., 2022) , time series analysis represents a robust approach to examine the financial evolution of the manufacturing sector and predict possible bankruptcy scenarios. This methodology allows capturing the temporal dynamics of financial variables and evaluating their impact on the solvency of companies. (Botero & Cano, 2008)The application of quantitative, retrospective and cross-sectional techniques facilitates a deep understanding of underlying trends and patterns, thus providing a solid basis for predictive analysis. .

For data collection, purposeful sampling was chosen, which allowed the precise selection of entities within the manufacturing subsector of Norte de Santander. This methodology ensures the inclusion of cases that are both representative and relevant to the research objective, thus maximizing the validity of the conclusions (Otzen & Manterola , 2017). Additionally, it was supported by a rigorous documentary analysis of official sources, including reports from the Superintendency of Companies of Colombia, guaranteeing the reliability and authenticity of the data corpus.

The research instrumentation was enriched with the use of panel data and graphical representations, establishing a solid basis for the systematization and visual analysis of relevant information. In terms of statistical procedures, time series analysis and K-means clustering techniques were implemented, using statistical software such as SPSS and R Studio. These advanced statistical methods were employed to understand longitudinal trends and identify cohesive patterns and segmentations within the subsector, respectively.

Results

Typification of the Manufacturing Sector of Norte de Santander – Colombia (2015-2022) according to Type of Company and Size of the Company

The classification of the manufacturing sector in Norte de Santander, Colombia, in the period 2015-2022, based on the type of company and size of the company, yielded significant results

Table 1.

Typification of the Manufacturing Sector of Norte de Santander – Colombia according to Type of Company and Size of the Company for the year 2022, last period of the time series

No	Business name	Assets	Income	Asset size	Income size
1	Mínercoque del Norte LTDA	\$468,723	\$260,468	Big	Big
2	Cerámica Italia SA	\$297,766	\$325,895	Big	Big
3	Yilcoque SAS	\$131,234	\$254,458	Big	Big
4	Palmicultores Del Norte SAS	\$123,298	\$365,814	Big	Big
5	Sigma SAS	\$98,827	\$26,233	Big	Median
6	Oils and Fats from Catatumbo SAS	\$95,941	\$275,454	Big	Big
7	Comercial Industrial SAS	\$40,659	\$41,931	Big	Median
8	Incolmine SAS	\$35,101	\$61,900	Big	Median
9	Arrocera Gelvez SAS	\$30,338	\$70,408	Big	Big
10	Export Coals From Colombia Y Cia LTDA	\$27,669	\$15,168	Big	Median
elev en	Mussi Shoes SAS	\$26,086	\$43,022	Big	Median
12	Pasteurizer La Mejor SA	\$24,073	\$64,760	Big	Median
13	Andina En Reorganización SA	\$15,027	\$18,128	Big	Median
14	Comercializadora Gómez Y Gómez SAS	\$6,497	\$9	Median	Micro
fifte en	Caroya SAS	\$1,925	\$1,140	Small	Small
16	Gameoru SAS	\$428	\$0	Micro	Micro

Note. The table demonstrates the classification of the manufacturing sector in the department of Norte de Santander - Colombia. The figures are expressed in millions, taking into account the financial information for the year 2022 as a reference, the last annual period of the time series under study.

In a first approximation, the companies under analysis exhibited a variety of legal forms. A marked preference for the Simplified Joint Stock Company (SAS) was evident, with 75% of the companies adopting this legal figure, while 12.5% chose to establish themselves as Public Limited Companies (SA), and another 12.5% as Limited Companies (LTDA). This discovery highlights the tendency of manufacturing

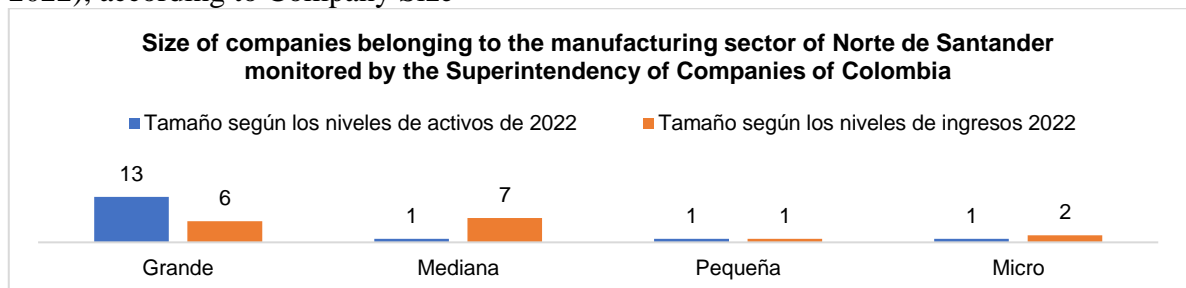
companies in the region towards an agile and flexible legal structure, consistent with the inherent characteristics of SAS in the Colombian business environment.

Continuing with the classification of companies, the results of the research revealed diversity in terms of business size. This classification was based on two key dimensions, considering the financial information for the year 2022, the last annual period of the time series under study. First, the size was evaluated according to asset levels, following the metrics of Law 590 of 2000, and then, the size according to income levels, applying the criteria of Decree 957 of 2019, both regulations belonging to the legislation. Colombian.

It was also observed that several outstanding companies in both dimensions showed great economic stature, without mentioning specific names, in the manufacturing sector of the region during the period examined, representing 37.5% of the total. On the other hand, some companies were classified as large in terms of assets, but medium in terms of income levels. This finding indicates a duality in the profitability and financial structure of these entities, crucial aspects for economic and financial analysis. In addition, companies with divergent classifications in assets and income were identified, highlighting the importance of evaluating both dimensions to obtain a comprehensive view of the companies' financial situation.

Figure 1

Typification of the manufacturing sector of Norte de Santander – Colombia (2015-2022), according to Company Size



Note. The figure demonstrates the typification of the Manufacturing Sector of Norte de Santander – Colombia (2015-2022) according to Company Size. Law 590 of 2000 determines asset levels at a general level as criteria, and decree 957 of 2019 establishes classification criteria according to income levels for each business sector.

Capital structure and indicators of solidity, debt and financial autonomy of the manufacturing sector of Norte de Santander – Colombia (2015-2022)

The detailed examination of the capital structure and the indicators of solidity, debt and financial autonomy revealed significant trends in the manufacturing sector of Norte de

Santander during the period 2015-2022. The research was based on the theory of Modigliani and Miller (1958) regarding the study of capital structure and its conditions and influences on the financial management of organizations.

Table 2.

Capital structure and indicators of solidity, debt and financial autonomy in the manufacturing sector of Norte de Santander – Colombia in the 2015-2022-time series

No	Business name	Asset	Passive	Heritage	Solidity	In debt I lie	Autonomy
1	Minercoque del Norte LTDA	\$114,171	\$35,369	\$78,803	\$4.0	27%	73%
2	Cerámica Italia SA	\$181,378	\$64,473	\$116,822	\$2.9	35%	65%
3	Yilcoque SAS	\$106,370	\$68,266	\$38,103	\$1.6	63%	37%
4	Palmicultores Del Norte SAS	\$65,789	\$47,286	\$18,503	\$1.4	74%	26%
5	Sigma SAS	\$46,958	\$10,538	\$36,420	\$4.4	26%	74%
6	Oils and Fats from Catatumbo SAS	\$80,832	\$74,673	\$6,159	\$1.1	93%	7%
7	Comercial Industrial SAS	\$42,099	\$6,898	\$35,201	\$6.2	16%	84%
8	Incolmine SAS	\$37,001	\$9,179	\$27,822	\$4.9	25%	75%
9	Arrocera Gelvez SAS	\$19,219	\$9,531	\$9,689	\$2.2	49%	51%
10	Export Coals From Colombia Y Cia LTDA	\$31,803	\$15,708	\$16,095	\$2.0	49%	51%
11	Mussi Shoes SAS	\$30,286	\$25,033	\$5,253	\$1.2	84%	16%
12	Pasteurizer La Mejor SA	\$17,721	\$7,460	\$10,261	\$2.4	42%	58%
13	Andina En Reorganización SA	\$10,638	\$6,177	\$4,461	\$2.2	53%	47%
14	Comercializadora Gómez Y Gómez SAS	\$11,372	\$8,553	\$2,819	\$1.3	76%	24%
15	Caroya SAS	\$1,699	\$85	\$1,615	\$22.8	5%	95%
16	Gameoru SAS	\$546	\$458	\$88	\$1.2	86%	14%

Note. The table demonstrates the capital structure and indicators of solidity, debt and financial autonomy in companies monitored by the Superintendence of Companies belonging to the manufacturing sector of Norte de Santander – Colombia. The capital structure figures are expressed in millions of pesos, taking into account the average in the 2015 – 2022 time series as a reference.

In a first review, the detailed analysis of the capital structure and the indicators of solidity, debt and financial autonomy of the companies under study, highlight three companies with higher levels within the sector, based on the average assets: First, Minercoque Del Norte Ltda , with a solid financial solidity of \$4.0, with a debt of 27% and an autonomy of 73%, therefore demonstrating a stable financial structure. Secondly, Cerámica Italia SA presented a financial solidity of \$2.9, with a debt of 35% and an autonomy of 65%, demonstrating the management of a balanced financial structure. Thirdly, Yilcoque SAS exhibited for the period 2016 – 2022 (no official reports from 2015 were found), a financial strength of \$1.6; Its debt was 63% and it

had a financial autonomy of 37%, indicating certain tensions in its financial structure with regard to the average levels of obligations with its external financing. These three companies are characterized by having average assets exceeding one hundred billion pesos within the department's manufacturing sector.

In a second review, some companies characterized by having average asset levels between ten billion pesos and one hundred billion pesos in the department's manufacturing sector, had particularities in their financial metrics based on the time series averages. 2015 – 2022. In a first evaluation, various financial characteristics were detected in companies in the sector without mentioning their names. For example, one entity exhibited a financial strength of \$1.4 and a strong propensity for debt (74%), while another exhibited a robust financial strength of \$4.4, supported by autonomy of 74%. On the other hand, a third presented a financial strength of \$1.1 and a strong dependence on debt (93%), not reflecting income in the periods 2015 and 2016. In addition, another company was observed with a financial strength of \$6.2 and a solid financial autonomy of 84%, and another with a financial solidity of \$4.9 and a financial autonomy of 75%. Another pair of companies showed strength of \$2.2 and \$2.0, respectively, along with a weighted balance in their financing. In this same group, a company demonstrated a strength of \$1.2 and financing committed mainly to external sources (84%) and financial autonomy limited to 16%. In the period 2015-2022, other companies with different financial profiles were identified, such as one with a solidity of \$2.4, a debt of 42% and an autonomy of 58%, another with a solidity of \$2.2, and a relationship debt and autonomy of 53% and 47%, respectively, and finally one with a solidity of \$1.3, external financing of 76% and internal financing of 24%.

In the last review, companies with unique financial characteristics were grouped together. For example, one entity exhibited a financial structure with a solidity of \$22.8 and a financial autonomy of 95%, without reporting financial information in the periods from 2015 to 2017. On the other hand, another presented a financial solidity indicator of \$1.2, indicating a significant dependence on debt (86%), and a financial autonomy of 14%, without registering income in the period 2018 to 2022, which reflected losses in the same periods and added latent risks in its financial structure.

Economic Results and Profitability Margin Indicators, ROA and ROE of the Manufacturing Sector of Norte de Santander – Colombia (2015-2022)

The analysis of the economic results and the profitability margin indicators, ROA and ROE, offered a comprehensive vision of the financial performance of the manufacturing sector in Norte de Santander between 2015 and 2022. The research was based on the theory of Modigliani and Miller (1958) with regard to the influence of the capital structure on returns, supported by the behavior of the ROA and ROE indicators in the financial management of organizations.

Table 3.

Economic results and Profitability Margin Indicators, ROA and ROE in the manufacturing sector of Norte de Santander – Colombia in the 2015-2022-time series

No	Business name	Income	Profits or losses	Profitability margin	Roa	Roe
1	Minercoque del Norte LTDA	\$102,490	\$12,245	eleven%	17%	24%
2	Cerámica Italia SA	\$176,526	\$15,988	6%	7%	10%
3	Yilcoque SAS	\$115,022	\$9,098	8%	9%	14%
4	Palmicultores Del Norte SAS	\$151,497	\$1,522	1%	2%	7%
5	Sigma SAS	\$14,282	\$9,941	63%	16%	twenty%
6	Oils and Fats from Catatumbo SAS	\$104,292	\$782	-0.4%	1%	66%
7	Comercial Industrial SAS	\$30,410	\$1,804	5%	4%	5%
8	Incolmine SAS	\$62,201	\$1,386	2%	4%	4%
9	Arrocera Gelvez SAS	\$60,576	\$2,265	4%	12%	22%
10	Export Coals of Colombia y Cia LTDA	\$7,511	\$87	-1%	0%	1%
eleven	Mussi Shoes SAS	\$33,028	-\$441	-2%	-1%	twenty%
12	Pasteurizer La Mejor SA	\$42,186	\$1,432	3%	8%	13%
13	Andina En Reorganización SA	\$9,930	\$333	3%	4%	7%
14	Comercializadora Gómez y Gómez SAS	\$25,135	\$392	-654%	3%	46%
fifteen	Caroya SAS	\$2,389	\$148	6%	9%	9%
16	Gameoru SAS	\$13	-\$39	#DIV/0!	-7%	-13%

Note. The table demonstrates the *economic results and Profitability Margin Indicators, ROA and ROE* in companies monitored by the Superintendency of Companies belonging to the manufacturing sector of Norte de Santander – Colombia . The economic performance figures are expressed in millions of pesos, taking into account the average in the 2015 – 2022 time series as a reference.

In the retrospective analysis of the manufacturing sector in Norte de Santander, Colombia, between 2015 and 2022, notable results were observed in terms of economic profitability. In the first group of companies, Minercoque del Norte LTDA demonstrated solid profitability with a margin of 11% and returns on assets (ROA) and equity (ROE) of 17% and 24%, respectively. Cerámica Italia SA and Yilcoque SAS also showed moderate but consistent returns. In the second group, Palmicultores del Norte SAS exhibited moderate but constant profitability, while Sigma SAS stood out with efficient use of assets and generation of profits for shareholders. However, Aceites y Grasas del Catatumbo SAS showed certain limitations in its profitability despite the efficiency in generating profits with its own capital. Finally, in the third group, Caroya SAS stood out with solid profitability, while Gameoru SAS faced significant challenges in generating profits and financial profitability due to conditions and behaviors in its capital structure.

Regarding the economic performance and the financial indicators of profitability margin, ROA and ROE, these results contribute to an understanding of the economic

and financial dynamics of the manufacturing sector of the department of Norte de Santander, which offers reference information for make informed decisions in the business environment for the different interested users.

Metrics by cluster for the indicators of solidity, debt, autonomy, ROA and ROE of the Manufacturing Sector of Norte de Santander – Colombia (2015-2022)

The exhaustive research on the Manufacturing Sector of Norte de Santander - Colombia (2015-2022), in which an intentional "k-means clustering" analysis was implemented as a fundamental analysis tool. This method was based on the arithmetic means of key financial metrics, such as solidity, debt, autonomy, ROA and ROE, throughout the aforementioned time series. Its application enabled the efficient classification of companies in the sector, highlighting significant patterns and trends in their financial performance over the years.

This thorough analysis led to the identification and delineation of three different clusters, each characterized by a particular level of production assets and business returns. These clusters offered a significant and representative classification of manufacturing companies, allowing a more in-depth evaluation of the financial dynamics that influenced their operations during the study period. The cluster approach, supported by hard data and a solid analytical methodology, shed light on the key variations and similarities in the economic and financial performance of companies in the aforementioned regional and temporal context.

Thus, for cluster 1, the companies Minercoque del Norte Ltda , Cerámica Italia SA and Yilcoque SAS were characterized. For Cluster 2, the companies Palmicultores del Norte SAS, Sigma SAS, Aceites y Grasas del Catatumbo SAS, Comercial Industrial SAS, Incolmine SAS, Arroquera Gelvez SAS, Carbones de exporta de Colombia y CIA Ltda , Mussi Zapatos SAS, Pasteurizadora La Mejor were grouped together. SA, Andina in reorganization SA, Comercializadora Gómez y Gómez SAS. Finally, for cluster 3, the companies Caroya SAS and Gameoru SAS were identified.

Table 4.

Metrics by cluster for the indicators of solidity, debt, autonomy, ROA and ROE of the Manufacturing Sector of Norte de Santander – Colombia (2015-2022)

CLUSTER	SOLIDITY	INDEBTEDNESS	AUTONOMY	ROA	ROE
CLUSTER COMPANIES 1	\$2.8	42%	58%	eleven%	16%
CLUSTER COMPANIES 2	\$2.7	53%	47%	5%	19%
CLUSTER COMPANIES 3	\$12.0	46%	54%	1%	-2%

Note. The table shows the metrics by clusters for the indicators of solidity, debt, autonomy, ROA and ROE in companies monitored by the Superintendency of Companies belonging to the manufacturing sector of Norte de Santander – Colombia. The values took into account as a reference the average in the 2015 – 2022 time series

for each company, as well as the average for each cluster, becoming the key metric or pattern identified.

In the exhaustive retrospective analysis of the Manufacturing Sector of Norte de Santander – Colombia (2015-2022), the cluster-based results provide an insightful view of the different financial dynamics between companies. The companies included in Cluster 1 stood out for their solidity, evidencing an indicator of \$2.8, a debt of 42%, an autonomy of 58%, an ROA of 11%, and an ROE of 16%. On the contrary, the companies in Cluster 2 showed balance in their indicators, with \$2.7 in solidity, 53% debt, 47% autonomy, an ROA of 5%, and an ROE of 19%. On the other hand, Cluster 3 companies, although exhibiting the greatest strength at \$12.0, also presented significant challenges, such as a debt of 46%, autonomy of 54%, an ROA of 1%, and a surprisingly low ROE of -2%. This contrast between clusters highlights the diversity of financial situations within the region's manufacturing sector.

The comparative analysis highlights the importance of understanding the key variables that influence the financial health of manufacturing companies in the period studied. While Cluster 1 evidenced solid and balanced financial management, Cluster 2 also presented favorable figures, but with some variations. Cluster 3, despite having notable strength, faced significant challenges, underscoring the need to look beyond seemingly positive metrics and consider the interaction of multiple factors.

These results offer researchers and professionals a valuable perspective on financial trends and variations in the manufacturing sector of Norte de Santander – Colombia, contributing to a more holistic understanding of the economic reality in the region during the analyzed period.

Z-Altman Crisis Score Indicator of the Manufacturing Sector of Norte de Santander – Colombia (2015-2022)

Altman Score crisis indicator as described by Anaya (2018), highlighted crucial signals for the evaluation of the financial health of the companies under study. The methodology was established as a fundamental pillar for the identification of companies at risk of financial crisis, providing an effective tool in the bankruptcy forecast analysis, such as the Z- Altman Crisis Score indicator. This indicator is recognized for classifying companies in financial health zones, offering an objective measure of bankruptcy risk (Song et al., 2024) A detailed description of the indicator's application follows.

$$\text{Altman Z-score} = 1,2 * X1 + 1,4 * X2 + 3,3 * X3 + 0,6 * X4 + 1,0 * X5$$

X1: (Current assets – Current liabilities) / Total assets

X2: Retained earnings / Total assets

X3: Ebitda / Total assets

X4: Market or equity value of the shares / Total liabilities
 X5: Income / Total Assets

- When the model is applied, the results are interpreted as follows:
- Less than 1.8; negative zone with high probability of bankruptcy.
 - Between 1.8 and 3.0; sickly gray area with risks.
 - More than 3.0; healthy company with low possibility of bankruptcy

Table 5.
 Z-Altman Crisis Score Indicator of the Manufacturing Sector of Norte de Santander – Colombia (2015-2022)

No	BUSINESS NAME	INDICATOR	OBSERVATION
1	Minercoque del Norte LTDA	4.03	Healthy zone. Low chance of bankruptcy
2	Cerámica Italia SA	2.17	Gray zone. Sick with risks
3	Yilcoque SAS	2.14	Gray zone. Sick with risks
4	Palmicultores Del Norte SAS	2.41	Gray zone. Sick with risks
5	Sigma SAS	2.60	Gray zone. Sick with risks
6	Oils and Fats from Catatumbo SAS	1.06	Negative zone. High probability of bankruptcy
7	Comercial Industrial SAS	2.50	Gray zone. Sick with risks
8	Incolmine SAS	3.79	Healthy zone. Low chance of bankruptcy
9	Arrocera Gelvez SAS	4.91	Healthy zone. Low chance of bankruptcy
10	Export Coals of Colombia y Cia LTDA	0.82	Negative zone. High probability of bankruptcy
eleven	Mussi Shoes SAS	1.53	Negative zone. High probability of bankruptcy
12	Pasteurizer La Mejor SA	3.40	Healthy zone. Low chance of bankruptcy
13	Andina in Reorganization SA	2.09	Gray zone. Sick with risks
14	Comercializadora Gómez y Gómez SAS	2.83	Gray zone. Sick with risks
fifteen	Caroya SAS	4.22	Healthy zone. Low chance of bankruptcy
16	Gameoru SAS	-0.11	Negative zone. High probability of bankruptcy

Note. The table demonstrates the crisis indicator in companies monitored by the Superintendency of Companies belonging to the manufacturing sector of Norte de Santander – Colombia in the 2015-2022 time series . The indicator figures are referenced to the average in the 2015 – 2022 time series.

In the retrospective analysis of the manufacturing sector in the department of Norte de Santander, Colombia, during the period from 2015 to 2022, the results obtained through

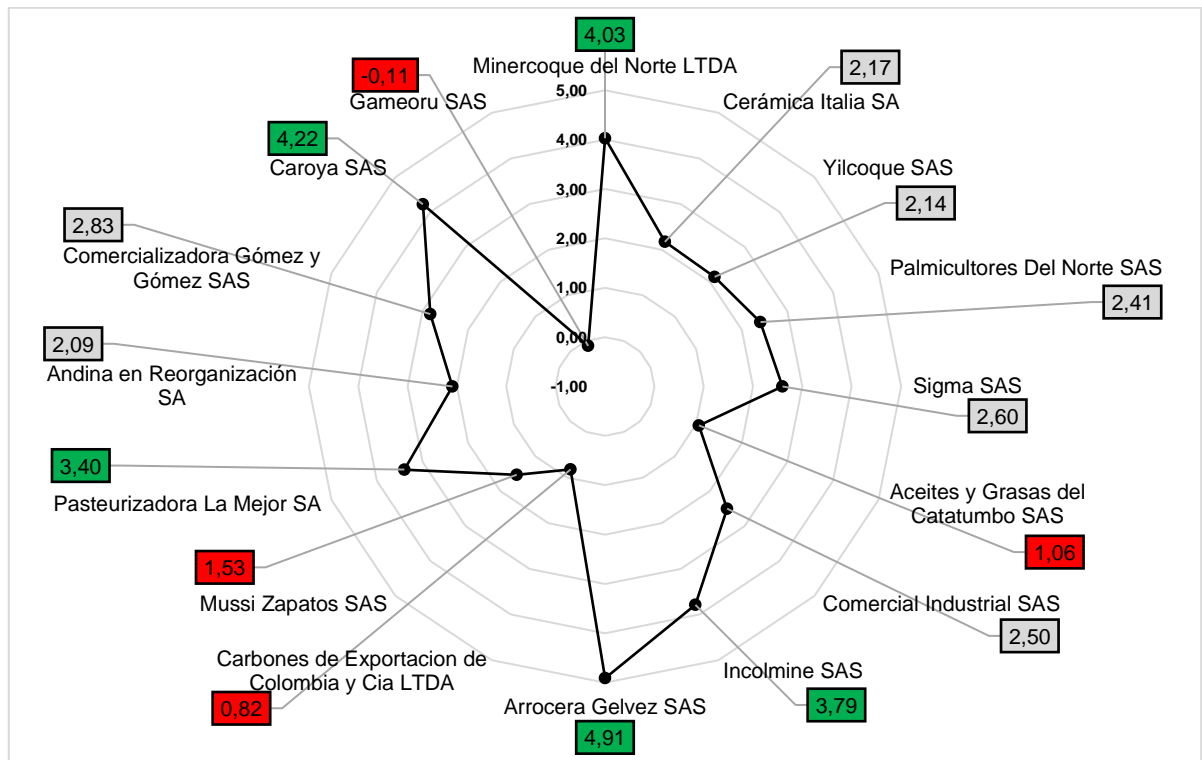
the Z Altman Score bankruptcy indicator reveal different levels of financial health and risk. A varied distribution of companies is observed in different risk zones: 25% of the companies were located in the healthy zone, indicating a low possibility of bankruptcy. 50% of the companies were found in the gray zone, evidencing an unhealthy condition with risks of bankruptcy. 25% of the companies were in the negative zone, with a high probability of bankruptcy.

In addition, companies with solid financial health were identified, representing 25% of the total and being located in the healthy zone with a low possibility of bankruptcy. In the gray zone, indicating an unhealthy condition with risks of bankruptcy. These results offer a clear retrospective view on financial stability and bankruptcy risk in the context of the regional manufacturing sector.

The data provided in the previous table, referring to the Z-Altman Crisis Score indicator of the Manufacturing Sector of Norte de Santander – Colombia (2015-2022), is detailed more clearly in the following illustration. In it, it is observed that 5 companies in this study were classified in a healthy area, indicating a low possibility of bankruptcy. In addition, 7 companies were located in a gray area, indicating that they are companies with bankruptcy risks. On the other hand, 4 companies were identified with a high probability of bankruptcy, that is, they are categorized in a negative zone.

Figure 2.

Z-Altman Crisis Score Indicator of the Manufacturing Sector of Norte de Santander – Colombia (2015-2022)



Note. The graph represents the crisis indicator in companies monitored by the Superintendency of Companies belonging to the manufacturing sector of Norte de Santander – Colombia in the 2015-2022 time series . The indicator figures are referenced to the average in the 2015 – 2022 time series.

In this way, taking into account the results of the research, in the comparison of the capital structure with the Z-Altman Crisis Score indicator, it was established that the majority of companies located in a healthy area with a low possibility of bankruptcy, showed greater financial autonomy, except for the company Arrocera Gelvez SA, which showed a balanced indicator in its financing sources. On the other hand, the companies identified in a negative zone with a high probability of bankruptcy, for the most part, presented a high debt of more than 80%, except for the company Carbones de exporta de Colombia y Cia Ltda.

Discussion.

The discussion of the results of the financial analysis of the manufacturing subsector of Norte de Santander – Colombia (2015-2022), based on the postulates of Modigliani and Miller and the Altman Z score crisis indicator by Edward I. Altman, reveals key parameters to understand financial health and the probability of bankruptcy in the sector. The capital structure highlights notable differences between companies,

highlighting the influence of solidity, debt and financial autonomy. Companies such as Minercoque del Norte LTDA and Sigma SAS exhibit solid structures, while others, such as Aceites y Grasas Del Catatumbo SAS, face risks according to the behavior of their financial indicators.

The results reveal a diverse distribution of companies in different risk zones, highlighting the significant presence of companies in precarious financial conditions, with 50% located in the gray zone and 25% in the negative zone, indicating a high probability bankruptcy. This situation highlights the financial challenges facing manufacturing companies in the region, possibly influenced by economic and structural factors. However, it is encouraging to note that 25% of companies exhibit solid financial health and a low probability of bankruptcy, which suggests the existence of effective business practices and adequate financial management in certain sectors, which coincides with what was stated by (Bhuvneskumar et al., 2023) .

The analysis of economic results, including profitability margins, ROA and ROE, offers a complete view of financial performance according to (Gupta et al. , 2023) companies such as Sigma SAS and Arrocera Gelvez SAS stand out for their efficiency, unlike cases such as Comercializadora Gómez y Gómez SAS, which faces financial difficulties evidenced by negative margins.

Finally, clustering reveals specific patterns in asset levels and returns, providing a valuable tool for understanding financial dynamics. The Crisis Score Z-Altman indicator validates categories of healthy, gray and negative zones, highlighting the usefulness of this indicator in the evaluation of financial risk. It was identified

Conclusions.

In the investigation of the bankruptcy forecast analysis in the manufacturing subsector of Norte de Santander, Colombia (2015-2022), the significant influence of the financial theories of Modigliani and Miller was highlighted, specifically on the capital structure. The differentiation between companies, highlighting solidity, indebtedness and financial autonomy, underlined the relevance of these postulates in the understanding of financial dynamics.

The evaluation of the financial results of the subsector, based on the aforementioned theories and on the Altman Z score crisis indicator by Edward I. Altman, revealed key patterns to understand financial health and the probability of bankruptcy. Capital structure, economic performance and cluster classification provided a comprehensive and nuanced view of financial performance. These analytical approaches facilitated informed decision making and risk management in a dynamic business environment.

Ultimately, potential areas for future research were identified, focusing on the exploration of theories of organizations and behavioral finance. The application of inferential statistics is proposed to obtain a deeper understanding of causal relationships in financial analysis. These new lines of research have the potential to enrich the understanding of financial complexities and contribute to the continued development of effective business strategies in the manufacturing sector.

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