Table of Contents

Introduction

This paper has the aim to deepen the Altman Z Score topic. The Z Score model, dating back to 1968 and developed by Edward I. Altman, aims to establish a standardized methodology that indicates the financial health of a company. Altman's methodology is widely adopted among practitioners due to its practicality and simplicity. “Approximately 30 minutes, a pocket calculator, and a preclassified balance sheet are sufficient to assess a company's insolvency status” (E.I. Altman and J.K. La Fleur 1968).

Altman's commitment to usability led him to develop various versions, updated in terms of parameters and financial indices used. These versions aim to describe the status of different companies while preserving the practicality that has facilitated its widespread adoption more accurately.

The paper will briefly describe the origins of the model. Then, it will dive into the model origination, as well as its evolution to different situations.

Chapter 1

Crisis Concept

1.1 How to define a crisis

A company crisis can be likened to a sudden storm that unexpectedly sweeps across the organizational landscape, disrupting normal operations and leaving behind a trail of chaos and uncertainty. It is characterized by its abrupt onset and the magnitude of its impact, which can range from financial losses and operational disruptions to irreparable damage to the organization's reputation.

At its core, a crisis represents a critical juncture where the very survival of the company is called into question. It is not merely a minor setback or a temporary inconvenience but a profound and existential threat that demands immediate attention and decisive action.

Crises can arise from various sources, including internal mismanagement, external factors beyond the company's control, or a combination of both. They may stem from governance failures, operational breakdowns, regulatory violations, ethical lapses, natural disasters, economic downturns, or unexpected market shifts.

What sets a crisis apart from other challenges is its potential for widespread impact and its ability to escalate rapidly, catching even the most prepared organizations off guard. Whether it's a product recall that shakes consumer confidence, a data breach that compromises sensitive information, or a public scandal that tarnishes the company's

reputation, a crisis has the power to upend the status quo and reshape the future trajectory of the organization.

In essence, a company crisis can be defined as a critical event or series of events that threaten the stability, viability, or reputation of the organization. It requires a coordinated and strategic response from organizational leaders and stakeholders to contain the crisis, mitigate its impact, and chart a path towards recovery and resilience.

1.2 Historical World Crises

1.2.1 The Great Depression (1929 – 1939)

The Great Depression was a watershed moment in history, marked by a prolonged period of economic turmoil and social upheaval. It began with the Wall Street stock market crash of October 1929, which triggered a chain reaction of events that reverberated throughout the global economy.

The crash wiped out billions of dollars in wealth and sent shockwaves through financial markets, leading to widespread panic and uncertainty. As stock prices plummeted, investors saw their fortunes evaporate, and confidence in the financial system collapsed.

The stock market crash was just the beginning. It exposed underlying weaknesses in the economy, including overproduction, underconsumption, and a fragile banking system. Industries had overexpanded during the prosperous 1920s, leading to excess production and declining demand for goods.

As businesses shuttered and industries contracted, unemployment soared to unprecedented levels. Millions of workers lost their jobs, and families struggled to make ends meet. Poverty and homelessness became widespread, with soup kitchens and breadlines becoming common sights in cities across the country.

The crisis deepened as bank failures swept through the country, wiping out the savings of millions of depositors and contributing to the contraction of the money supply. Deflationary pressures gripped the economy, as falling prices eroded the value of assets and made it harder for businesses and individuals to repay debts.

Initially, the government response to the crisis was limited, as policymakers grappled with how to address the unfolding disaster. President Herbert Hoover pursued a largely hands-off approach, hoping that the economy would self-correct.

However, as the crisis worsened, the government began to intervene more aggressively. President Franklin D. Roosevelt's New Deal programs aimed to stimulate economic recovery through government spending, public works projects, financial reforms, and social welfare programs.

While the Great Depression eventually gave way to recovery, its scars lingered for years, shaping the trajectory of economies and societies for decades to come. It shattered confidence in the capitalist system and led to a reevaluation of economic theories and policies.

In summary, the Great Depression was a defining moment in history, demonstrating the fragility of the global economy and the need for proactive government intervention during

times of crisis. It serves as a cautionary tale about the dangers of financial speculation, economic inequality, and the consequences of policy inaction in the face of economic turmoil.

The Great Depression had profound and far-reaching consequences, reshaping economies, societies, and politics worldwide.

The economic aftermath of the Great Depression was characterized by slow and uneven recovery. While economies eventually regained their pre-crisis levels of output and employment, the process took years and was marked by persistent unemployment and underutilization of resources.

The crisis prompted significant changes in economic policy, with governments adopting Keynesian principles of fiscal intervention to manage demand and stabilize economies. Financial regulation was also overhauled, with reforms aimed at preventing a recurrence of similar crises.

Socially, the Great Depression left a legacy of widespread unemployment, poverty, and homelessness. Millions of workers lost their jobs, and families struggled to make ends meet, leading to social unrest and discontent. Governments responded by expanding social safety nets, implementing welfare programs, and providing unemployment insurance to assist those in need.

Politically, the Great Depression fueled the rise of extremism and populist movements around the world. Economic hardship and social unrest paved the way for the emergence of authoritarian regimes and fascist ideologies in some countries. In the United States,

President Franklin D. Roosevelt's New Deal policies aimed to address the social and economic challenges of the Great Depression, ushering in an era of increased government intervention and social welfare.

Globally, the Great Depression had far-reaching effects on the global economy. It led to a decline in international trade and investment, exacerbating economic downturns in other countries. Protectionist trade policies were adopted, further hindering global economic recovery and contributing to the fragmentation of the world economy.

1.2.2 World War II (1939 – 1945)

The economic impact and consequences of World War II were profound and far-reaching, reshaping the global economic landscape in significant ways.

World War II caused widespread destruction of infrastructure, including factories, transportation networks, and urban areas, particularly in Europe and Asia. This destruction hindered economic activity and disrupted supply chains, leading to severe shortages of essential goods and services.

The war resulted in a massive loss of human capital, as millions of soldiers and civilians perished in the fighting. This loss of life not only had devastating social and emotional consequences but also led to a shortage of skilled labor and productive capacity, hindering post-war reconstruction efforts.

International trade and commerce were severely disrupted during World War II, as shipping lanes were blockaded, ports were bombed, and trade routes were cut off. This

disruption led to a decline in global trade volumes and a reorientation of trade patterns, as countries focused on self-sufficiency and wartime production.

Governments around the world engaged in massive economic mobilization efforts to support the war effort, diverting resources towards military production and defense spending. This led to the expansion of government intervention in the economy and the emergence of wartime command economies, with centralized planning and rationing of goods and services.

Financing the war effort required governments to borrow extensively, leading to a significant expansion of public debt. Central banks also engaged in monetary expansion to finance war spending, leading to inflationary pressures and currency devaluation in many countries.

After the war, countries faced the daunting task of rebuilding their economies and societies from the ruins of conflict. Post-war reconstruction efforts were extensive and required significant investment in infrastructure, housing, and industry. The Marshall Plan, initiated by the United States, provided aid to war-torn European countries to support their recovery and reconstruction efforts.

World War II resulted in significant shifts in economic power and influence, with the United States emerging as the dominant economic superpower. The war accelerated the decline of colonial empires and the rise of newly industrialized nations, particularly in Asia.

During World War II, the global economic landscape was significantly disrupted by the demands of war. The war effort required governments to mobilize resources, redirect production towards military needs, and implement strict regulations on industry and commerce. As a result, the failure rate of companies during this period varied depending on their ability to adapt to wartime conditions and contribute to the war effort.

For many companies, especially those in industries directly involved in military production, such as arms manufacturing, shipbuilding, and aircraft production, the war presented unprecedented opportunities for growth and profitability. These companies saw increased demand for their products and benefited from government contracts and subsidies. Additionally, some companies were able to pivot their operations to support the war effort by manufacturing military equipment or providing essential goods and services to the armed forces.

However, for other companies, particularly those in industries that were not directly involved in the war effort or faced significant disruptions to their supply chains, the war posed significant challenges. Many businesses struggled to obtain raw materials, labor, and transportation, as resources were diverted towards military needs. Additionally, government regulations and rationing imposed constraints on production and distribution, further complicating business operations.

As a result, the failure rate of companies during World War II varied depending on factors such as industry, location, and access to resources. Some businesses were able to adapt

and thrive in the wartime economy, while others faced insurmountable obstacles and were forced to close their doors.

The war reshaped the economic order, spurred technological progress, and laid the groundwork for the post-war economic boom of the 1950s and 1960s.

Overall, the economic conditions of World War II created a challenging environment for businesses, with both opportunities and risks depending on their ability to navigate the complexities of wartime production and supply chains. The war fundamentally reshaped the business landscape, leading to the rise of new industries, changes in consumer preferences, and long-term shifts in economic power and influence.

1.2.3 The Oil Crisis (1973)

The oil crisis of 1973 had profound economic ramifications, impacting firms worldwide in various ways.

At its core, the crisis was sparked by geopolitical tensions in the Middle East, leading to an oil embargo by the Organization of Arab Petroleum Exporting Countries (OAPEC) against nations that supported Israel during the Yom Kippur War. This embargo resulted in a sudden and significant increase in oil prices and disrupted oil supplies to Western nations.

For firms, the consequences were immediate and far-reaching. One of the most immediate impacts was the surge in production costs. Industries heavily reliant on oil, such as transportation, manufacturing, and agriculture, faced soaring expenses as the price of oil

skyrocketed. This placed immense pressure on profit margins and forced firms to reconsider their operations to cope with the new economic reality.

Supply chains also bore the brunt of the crisis. Disruptions in global supply chains occurred as firms struggled to obtain raw materials and components due to transportation and logistical challenges. This led to production delays and longer lead times, hindering firms' ability to meet customer demand and fulfill orders.

Furthermore, the oil crisis fueled inflationary pressures across economies. The higher energy costs rippled through the economy, causing prices of goods and services to rise. Inflation eroded consumers' purchasing power, dampening demand for goods and further straining firms' financial health and profitability.

The economic recession triggered by the oil crisis exacerbated these challenges. Reduced consumer spending and investment led to declines in economic activity, exacerbating firms' financial difficulties. Small and medium-sized enterprises (SMEs) were particularly vulnerable, with many facing insurmountable challenges and ultimately closing their doors.

In summary, the oil crisis of 1973 had a profound and lasting impact on firms worldwide. It highlighted the vulnerability of businesses to external shocks and underscored the importance of resilience, adaptability, and strategic planning in navigating turbulent economic conditions.

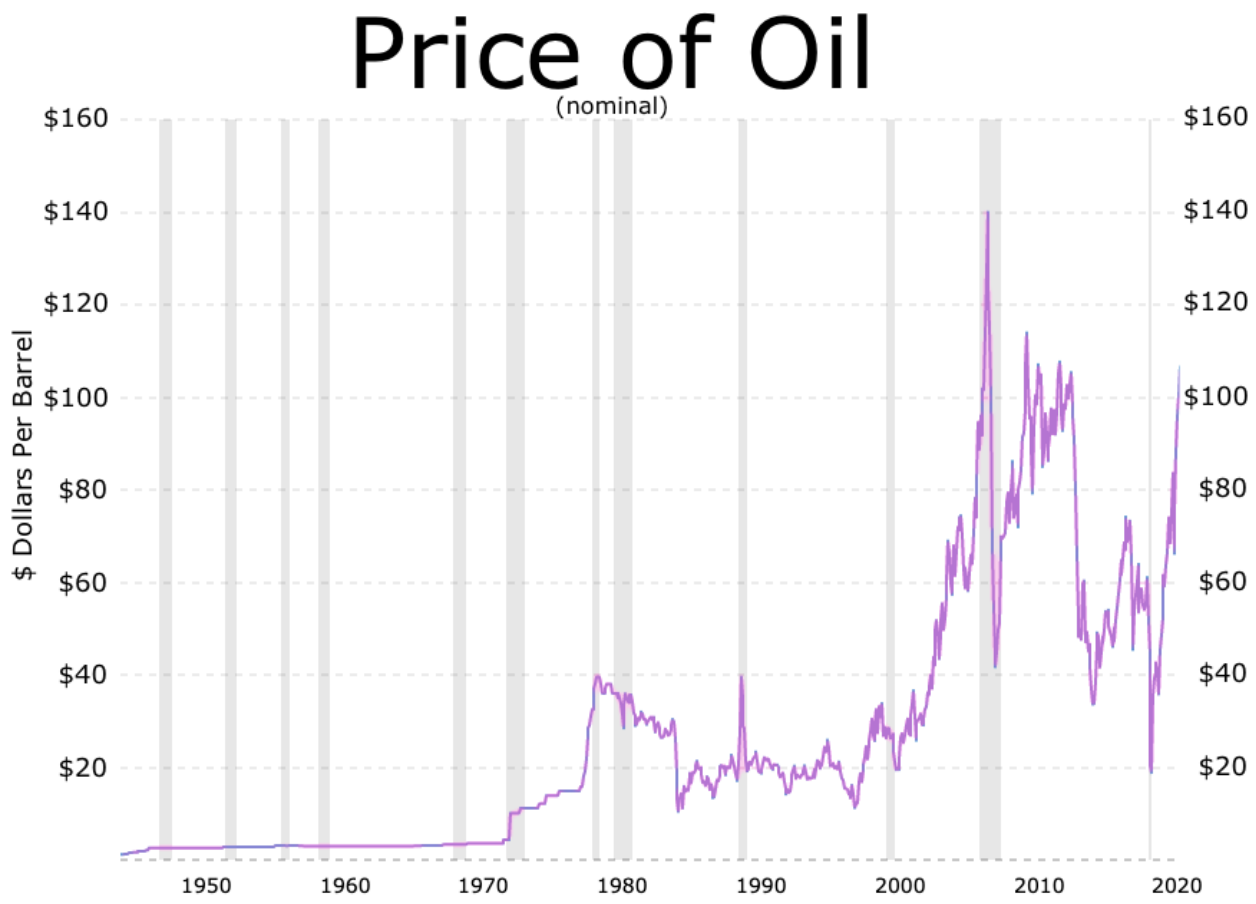


Figure 1 - Oil Price peak during 1973 crisis

1.2.4 The Dot-Com Bubble Burst (2000-2001)

The Dot-Com Bubble was a significant event in economic history, particularly in the technology sector. Here's a discussion of its economic impact on firms:

It was characterized by a speculative frenzy in the late 1990s, fueled by the rapid growth of internet-based businesses and the promise of new technologies. Investors poured billions of dollars into internet startups, many of which had little or no revenue or profit. Valuations soared to unsustainable levels, driven by speculation rather than fundamentals. When the bubble burst in 2000-2001, it had far-reaching economic consequences for firms in the technology sector and beyond. One of the most immediate impacts was the collapse

of stock prices for internet-related companies. Many dot-com startups went bankrupt as investor confidence evaporated and funding dried up. Firms that had relied heavily on venture capital and stock market investments faced severe financial strain and struggled to survive.

The bursting of the Dot-Com Bubble also had broader implications for the economy as a whole. It led to a decline in consumer and investor confidence, triggering a recession in the United States and other economies. The technology sector, which had been a major driver of economic growth in the late 1990s, experienced a significant contraction, with layoffs and bankruptcies becoming widespread.

The fallout from the Dot-Com Bubble Burst reverberated throughout the entire business ecosystem. Suppliers, service providers, and other businesses that relied on the technology sector for revenue saw declines in demand and revenue. The ripple effects of the downturn were felt across industries, contributing to job losses and economic hardship for many.

In the aftermath of the Dot-Com Bubble Burst, firms were forced to reassess their business models and strategies. There was a renewed focus on profitability and sustainability, as companies sought to rebuild investor confidence and weather future economic downturns. The technology sector underwent a period of consolidation, with stronger companies acquiring struggling startups and consolidating market share.

Overall, the Dot-Com Bubble Burst of 2000-2001 had a profound economic impact on firms, reshaping the technology sector and influencing business practices for years to

come. It served as a cautionary tale about the dangers of speculative bubbles and the importance of prudent investment and risk management.

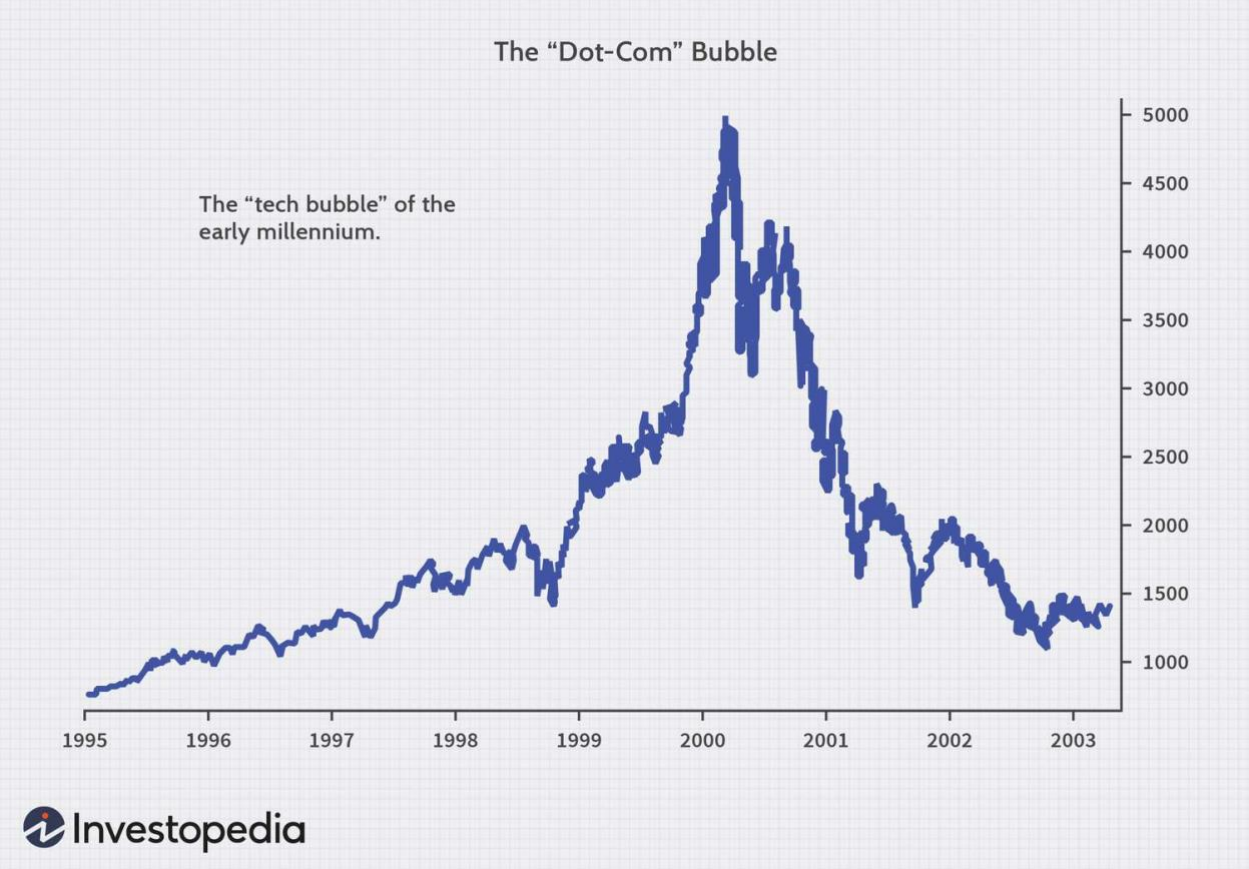


Figure 2 - Nasdaq Index price 1995-2005

1.2.5 The Global Financial Crisis (2007-2008)

The 2008 financial crisis was triggered by a combination of factors, including the proliferation of subprime mortgage lending, complex financial products, and lax regulation in the financial sector. When the housing bubble burst in the United States in 2007, it exposed widespread risks and vulnerabilities in the global financial system.

One of the immediate impacts of the crisis was the collapse of major financial institutions. Banks and investment firms faced massive losses on mortgage-backed securities and other

risky assets, leading to a wave of bankruptcies, mergers, and government bailouts. Firms that were heavily exposed to toxic assets suffered significant financial losses and struggled to stay afloat.

The financial crisis also had broader economic consequences, triggering a severe recession in many countries around the world. As financial markets seized up and credit dried up, businesses faced challenges accessing capital and financing their operations. Firms across industries saw declines in demand for their products and services, leading to layoffs, bankruptcies, and closures.

The impact of the financial crisis was felt across the entire business ecosystem. Suppliers, service providers, and other businesses that relied on credit and financing to support their operations saw declines in revenue and profitability. The crisis had a particularly pronounced impact on the automotive, construction, and manufacturing sectors, which experienced sharp declines in demand and production.

In response to the crisis, governments and central banks implemented unprecedented measures to stabilize financial markets and stimulate economic growth. These measures included monetary policy interventions such as interest rate cuts and quantitative easing, as well as fiscal stimulus packages aimed at boosting demand and supporting struggling industries.

The aftermath of the financial crisis reshaped the regulatory landscape and prompted firms to reevaluate their risk management practices. There was a renewed focus on financial stability and resilience, with increased scrutiny of banks' capital adequacy and liquidity.

Firms also faced pressure to improve transparency and accountability in their operations to rebuild investor confidence.

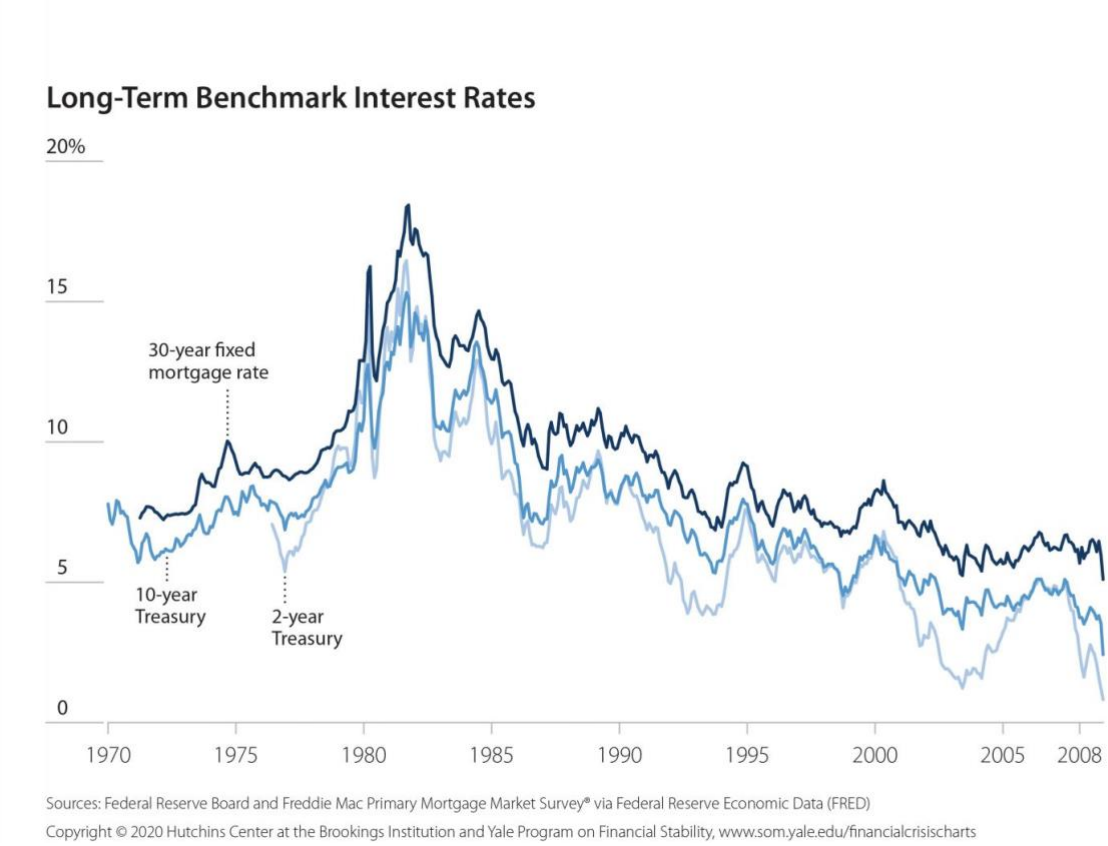


Figure 3 - Interest Rates 1970-2010

1.2.6 The COVID Pandemic (2020 – Present)

The COVID-19 pandemic brought about an unprecedented shock to the global economy. Governments around the world implemented strict measures such as lockdowns, travel restrictions, and social distancing protocols to contain the spread of the virus. These measures disrupted supply chains, halted economic activity, and led to widespread closures of businesses, particularly in sectors such as hospitality, tourism, and retail.

One of the immediate impacts of the pandemic was a sharp decline in consumer demand. With people staying at home and prioritizing essential purchases, many businesses

experienced a sudden drop in revenue. Small and medium-sized enterprises (SMEs), which often operate with thin profit margins and limited cash reserves, were particularly vulnerable to the economic fallout from the pandemic.

The pandemic also exposed vulnerabilities in global supply chains. Firms faced disruptions in sourcing raw materials, components, and finished goods, as manufacturing plants shuttered, and transportation networks were disrupted. Just-in-time inventory management practices, which had become widespread in many industries, proved to be inadequate in the face of supply chain disruptions.

Businesses had to quickly adapt to remote work arrangements, implement new technologies for collaboration and communication, and ramp up their digital presence to reach customers online. Companies that were able to pivot to remote work and e-commerce were better positioned to weather the economic downturn.

Government responses to the pandemic varied widely, with many countries implementing fiscal stimulus measures and monetary policy interventions to support businesses and individuals affected by the crisis. These measures included financial assistance programs, loan guarantees, and tax relief measures aimed at providing liquidity and financial support to struggling firms.

Looking ahead, the long-term economic impact of the COVID-19 pandemic remains uncertain. Its effects are still present nowadays, such as high inflation and difficulty for companies to recover from that.

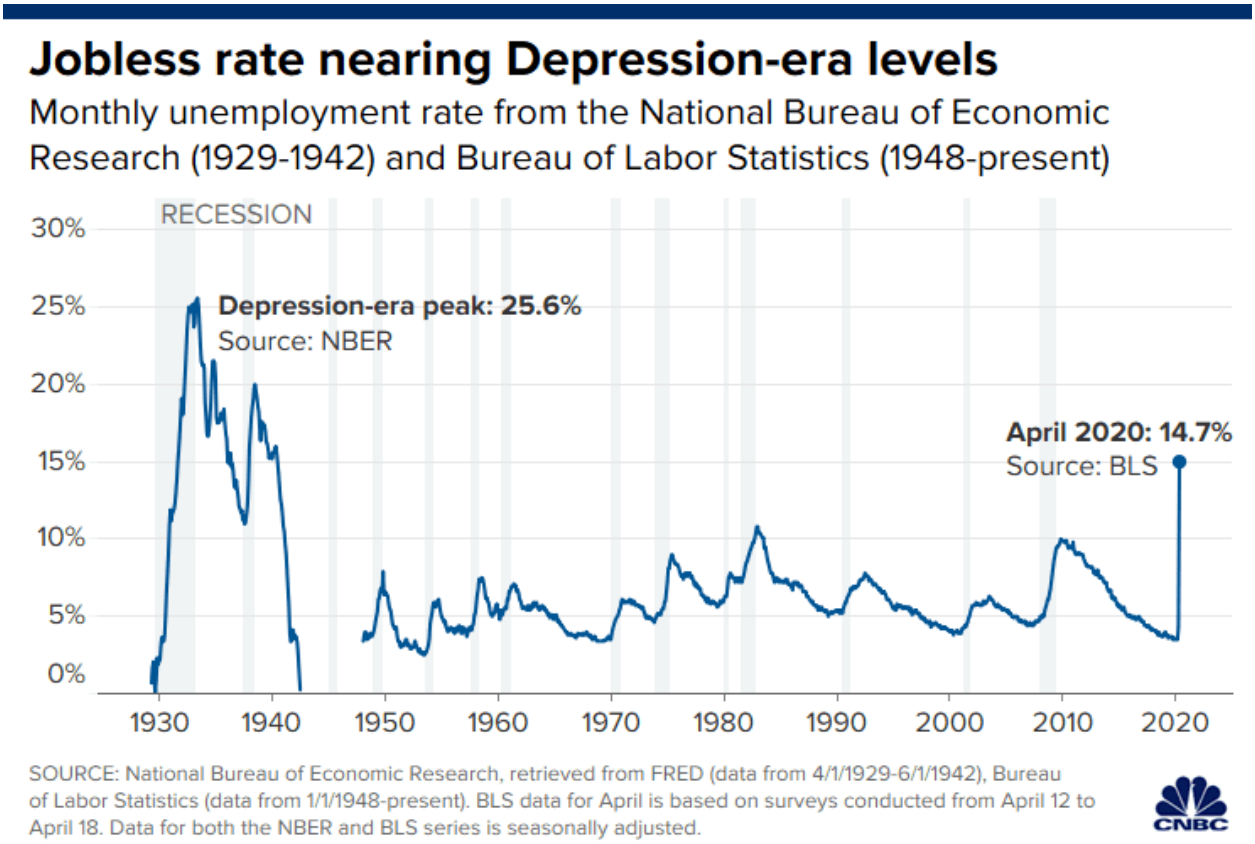


Figure 4 - Unemployment Rate during crisis periods

1.3 Type of Crisis

The literature defines three main types of crisis:

1. The Latent Crisis: The term "latent" refers to something that remains hidden, not externally apparent. This is precisely the case with the latent crisis: in this scenario, the state of equilibrium has just begun to alter, setting the stage for a decline, while still maintaining the appearance of intact health, especially to an external observer. This initial phase of crisis is challenging to identify, as the early difficulties are masked by the maintenance of the economic equation, i.e., the temporary preservation of the company's ability to maintain its corporate balance. It becomes crucial, therefore, for the

identification of the company's crisis state, for management not to limit itself to an analysis of the here and now but to adopt a prospective analysis aimed at projecting the company into the future, striving to maintain the second condition to be able to speak of a company's state of equilibrium: the ability to survive over time. An attentive management will be able to diagnose, even in this initial phase, the onset of a decline path, making it easier to reverse the course undertaken by the company. If this is not done, the crisis will continue its course. In this phase, the criticality of diagnosis is identified in two different factors: the first relates to the difficulty of unequivocally determining that it is not a simple negative phase experienced by the company, as often happens physiologically; the second consists in the management's awareness of the situation objectively and detachedly, without falling victim to the psychological distortions mentioned earlier.

2. The Manifest Crisis: The manifest crisis occurs when the imbalance is now evident. There is no longer the ability to maintain the economic equation: evident losses, a high level of indebtedness, and a state of illiquidity are apparent. In this case, the ability to reverse the process in progress will be strongly influenced by the speed of the decline characterizing the crisis. When it is particularly rapid, the interventions promoted by management may, in any case, not be able to stop the degeneration process. Then the only "solution" will be voluntary or compulsory liquidation. Obviously, if the pace of decline is slow, management may be able to reverse the aforementioned path, thus managing to "save" the company.

3. The Acute Crisis: In the case of an acute crisis, we are facing the most difficult situation experienced, and therefore, consequently, also the most difficult recovery of the activity carried out. In this case, indeed, the imbalance in which the company finds itself is maximum, and in the absence of prompt interventions by management (weighed against the actual convenience of keeping the corporate organism alive rather than facilitating its disappearance), there will be a traumatic closure of the company's life. This will clearly have particularly significant consequences for all stakeholders of the company, starting from the shareholders to end with the creditors - who may have difficulty seeing their credit reimbursed.

1.4 The main macro causes of a crisis

According to literature, 4 main causes led to a crisis in most of the companies:

1. Financial Mismanagement:
    a. Excessive Debt: Overleveraging occurs when a firm takes on too much debt relative to its equity, leading to increased financial risk and vulnerability to economic downturns. High levels of debt can strain cash flow, limit investment opportunities, and hinder the firm's ability to meet its financial obligations.
    b. Inadequate Cash Flow Management: Poor cash flow management, including delayed receivables, excessive inventory, or inefficient payment practices, can lead to liquidity problems and cash shortages. This can impair the firm's ability to cover operating expenses, service debt, or invest in growth opportunities.

c. Failure to Diversify Revenue Streams: Relying heavily on a single product, market, or customer segment exposes the firm to significant risks if demand declines or market conditions change. Failure to diversify revenue streams can leave the firm vulnerable to revenue fluctuations, competitive pressures, or disruptions in key markets.

2. Market Dynamics
    a. Shifts in Consumer Preferences: Changes in consumer tastes, preferences, or purchasing behaviors can disrupt demand for the firm's products or services. Failure to anticipate or respond to shifts in consumer preferences can result in declining sales, market share erosion, or loss of competitive advantage.
    b. Technological Advancements: Rapid advancements in technology can render existing products or services obsolete and disrupt traditional business models. Failure to innovate or adopt new technologies can leave the firm behind competitors and vulnerable to market disruption.
    c. Intense Competition: Increased competition within the industry can lead to pricing pressures, margin erosion, and loss of market share. Failure to differentiate products or services, build brand loyalty, or innovate can weaken the firm's competitive position and lead to financial underperformance.
3. Operational Issues
    a. Supply Chain Disruptions: Disruptions in the supply chain, such as raw material shortages, production delays, or transportation bottlenecks, can disrupt the

firm's ability to deliver products or services to customers. Inadequate supply chain management, lack of supplier diversification, or reliance on single-source suppliers can increase the firm's vulnerability to operational disruptions.

b. Production Delays: Delays in production due to equipment breakdowns, labor shortages, or quality control issues can impact the firm's ability to meet customer demand and fulfill orders on time. Poor production planning, inadequate maintenance practices, or lack of contingency plans can exacerbate production delays and lead to customer dissatisfaction.

c. Quality Control Issues: Product defects, recalls, or safety concerns can damage the firm's reputation, lead to costly recalls or litigation, and erode customer trust. Ineffective quality control processes, inadequate testing protocols, or outsourcing manufacturing to low-cost suppliers can increase the risk of quality control issues.

4. Strategic Missteps

a. Unsustainable Growth Strategies: Pursuing aggressive growth strategies, such as rapid expansion, acquisitions, or diversification into unrelated businesses, without sufficient planning or resources, can strain the firm's financial resources and lead to overextension. Failure to achieve growth targets or generate sufficient returns on investment can result in financial distress and operational challenges.

b. Poor Market Entry Decisions: Entering new markets without proper research, market analysis, or localization strategies can expose the firm to significant risks and uncertainties. Failure to understand local market dynamics, regulatory requirements, or cultural nuances can lead to market entry failures, loss of investment, or reputational damage.
c. Lack of Innovation: Failure to innovate or adapt to changing market conditions can leave the firm vulnerable to disruption by competitors or new market entrants. Lack of investment in research and development, reluctance to embrace new technologies, or resistance to change can inhibit the firm's ability to innovate and remain competitive.

1.5 Insolvency Outlook

In case of insolvency for a company, different scenarios may occur. Bankruptcy proceedings provide legal frameworks for addressing financial distress and insolvency in companies. In various jurisdictions, including the United States and Italy, different bankruptcy methods are employed to manage the affairs of financially troubled businesses. These methods include Chapter 7 and Chapter 11 bankruptcy in the United States, as well as Concordato Preventivo, Fallimento, and Amministrazione Straordinaria in Italy. Each method serves distinct purposes, ranging from liquidation to reorganization, and offers avenues for debtors and creditors to resolve financial challenges and achieve equitable outcomes.

In the United States, possible measures are the following:

1. **Bankruptcy**: Bankruptcy is a legal process governed by specific laws and regulations that vary by jurisdiction. In the United States, bankruptcy proceedings are typically categorized into chapters, such as Chapter 7, Chapter 11, and Chapter 13.
    - **Chapter 7 (Liquidation)**: In a Chapter 7 bankruptcy, a trustee is appointed to oversee the sale of the company's assets, which are then distributed to creditors according to a priority ranking. Any remaining debts that cannot be paid off through asset sales are typically discharged, relieving the company of further liability.
    - **Chapter 11 (Reorganization)**: Chapter 11 bankruptcy allows a company to restructure its debts and operations while remaining in business. The company develops a reorganization plan, which outlines how it will repay creditors and return to profitability. Creditors vote on the plan, and if approved by the court, the company continues operating under the supervision of a trustee or management team.
2. **Liquidation**: Liquidation occurs when a company sells off its assets to pay off its creditors. This process may be voluntary or involuntary, depending on the circumstances. Voluntary liquidation may be initiated by the company's management or board of directors when they determine that the company cannot continue operating profitably. Involuntary liquidation may occur through bankruptcy proceedings or creditor actions to recover debts owed.

3. **Restructuring**: Restructuring involves making significant changes to a company's operations, finances, or ownership structure to improve its financial stability and viability. This may include renegotiating debt agreements, reducing operating costs, divesting non-core assets, or implementing new business strategies. Restructuring efforts may be conducted internally by the company's management or with the assistance of external advisors, such as turnaround specialists or financial consultants.
4. **Acquisition or Merger**: Companies facing financial difficulties may seek to merge with or be acquired by a stronger competitor or investor. This can provide the company with access to additional capital, resources, and management expertise to help turn around its operations or mitigate its financial challenges. The acquiring company may benefit from synergies, economies of scale, or strategic advantages gained through the acquisition.
5. **Turnaround Management**: Turnaround management involves implementing strategic initiatives to improve a company's financial performance and restore profitability. This may include operational improvements, cost-cutting measures, restructuring of debt or equity, changes in management or leadership, and strategic repositioning. Turnaround efforts require careful planning, execution, and monitoring to ensure successful implementation and sustainable results.
6. **Debt-for-Equity Swap**: A debt-for-equity swap is a financial transaction in which a company's creditors agree to convert their debt claims into equity ownership in

the company. This can help reduce the company's debt burden, improve its financial position, and provide creditors with an ownership stake in the company's potential future success. Debt-for-equity swaps may be negotiated as part of a restructuring plan or bankruptcy proceedings.

7. **Government Intervention**: Governments may intervene to support financially distressed companies, particularly those deemed critical to the economy or national security. This may involve providing financial assistance, loan guarantees, tax incentives, or regulatory relief to help companies restructure their operations, preserve jobs, and avoid bankruptcy. Government intervention aims to prevent systemic risks, protect jobs, and promote economic stability, but it may also raise concerns about moral hazard and market distortions.

Chapter 7 and Chapter 11 bankruptcy proceedings are specific to the United States legal system and are not directly applicable in Italy. However, Italy does have its own bankruptcy laws and procedures for addressing insolvency situations.

In Italy, bankruptcy proceedings are governed by the Italian Bankruptcy Law (Legge Fallimentare) and are primarily regulated by the Italian Civil Code and the Italian Bankruptcy Law. The main types of bankruptcy proceedings in Italy include:

1. **Concordato Preventivo (Composition with Creditors)**: Concordato preventivo is a pre-bankruptcy agreement between a debtor and its creditors aimed at restructuring the debtor's debts and avoiding bankruptcy. It allows the debtor to

propose a plan for repaying its debts over time, often through a partial repayment and restructuring of debts.

2. **Fallimento (Bankruptcy)**: Fallimento is the formal declaration of bankruptcy by a court. It is initiated when a debtor is unable to pay its debts as they become due and seeks the court's protection from creditors. During bankruptcy proceedings, a trustee is appointed to liquidate the debtor's assets and distribute the proceeds to creditors according to a priority ranking.
3. **Amministrazione Straordinaria (Extraordinary Administration)**: Amministrazione straordinaria is a special insolvency procedure applicable to large companies of strategic importance to the national economy. It allows for the temporary suspension of the company's obligations and the appointment of a special commissioner to manage the company's affairs and develop a restructuring plan.

Chapter 2

Altman Z Score Model

2.1 Origins

Altman incorporated Linear Discriminant Analysis (LDA) into his research, a method originally proposed by Ronald Fisher in 1936 for classifying objects into predefined populations. Although not as widely recognized as linear regression, this technique, as elucidated by Altman, has found applications across diverse disciplines since its introduction. Initially employed in the realms of biology and behavioral sciences, its adoption in the financial sector came later.

Altman recognized the potential of LDA and leveraged it to formulate his own model, which sought a balance between precision and simplicity. This model aimed to ascertain whether a company falls within one of two predefined groups: the first comprising healthy companies and the second comprising those that have faced failure.

The fundamental principle of this statistical method is as follows: establish a criterion for categorizing companies into either the financially stable or financially distressed group, with the goal of minimizing estimation errors. Instead of relying on a single financial statement indicator to determine the parameter that distinguishes between these groups, a set of accounting ratios is employed. These ratios are appropriately weighted and condensed into a statistical index known as the "score."

To elaborate, the score's value is derived through the formulation of a function, referred to as the discriminant function. This function incorporates independent variables comprising various balance sheet indicators, each assigned specific weighting coefficients. Importantly, the discriminant analysis ensures the objective attribution of these coefficients.

The resulting discriminant function is configured as follows:

$$S_j = v_1 X_{1j} + v_2 X_{2j} + \ldots + v_n X_{nj}$$

Where:

S_j = score of the j-th company

v_i = coefficient of the variable X_i

X_{ij} = descriptive variable of the i-th characteristic for the j-th company, each of the measured parameters must be considered several times over a period of time.

It is important to consider that each of the objects has its own peculiarities, which vary over time. The parameters considered cannot be values considered only once or analyzed only once, abstract, but rather must be somehow contextualized with respect to the others and considered in their "changing" value with respect to the

others.

Let's examine two pre-defined samples, denoted as A and B, each with a known size. The size of the first sample is N_A, and the second sample has a size of N_B. Now, let's introduce:

- X_A e X_B, representing the matrices of observations on the variables, with dimensions $N_A \times n$ for the first sample and $N_B \times n$ for the second sample
- $\overline{X_A}$ and $\overline{X_B}$ the vectors containing the means of the variables for each sample
- $\bar{x} = \frac{N_A}{N} \cdot \bar{x}_A + \frac{N_B}{N} \cdot \bar{x}_B$ the column vector representing the combined observations, where it's evident that the sum of N_A and N_B equals N. The variable x serves as our reference point for analyzing the i-th variable, which will undergo examination for its variance and covariance.
- W the $n \times n$ variance and covariance matrix.

Now, we pinpoint our coefficient denoted by ai in the ultimate formula, and it will be determined as follows:

$$a_i = \pi \cdot r^2 \cdot i(\overline{x_A} - \overline{x_B})' V^{-1}$$

The final value of the score will then be:

$$S_j = (\overline{x_A} - \overline{x_B})' V^{-1}$$

while the average score of population A, denoted as the score of A or S_A, is expressed as:

$S_A = (\overline{x_A} - \overline{x_B})' V^{-1} \overline{x_j}$ as well as S_B.

The rule of linear classification can thus be articulated in terms of distances among scores: the j-th enterprise is assigned to population A if:

$$|S_j - S_A| < |S_j - S_B|$$

otherwise it is assigned to B population.

In geometric terms, the Linear Discriminant Analysis is represented in *Figure 1*, in 2 variables, 2 populations case.

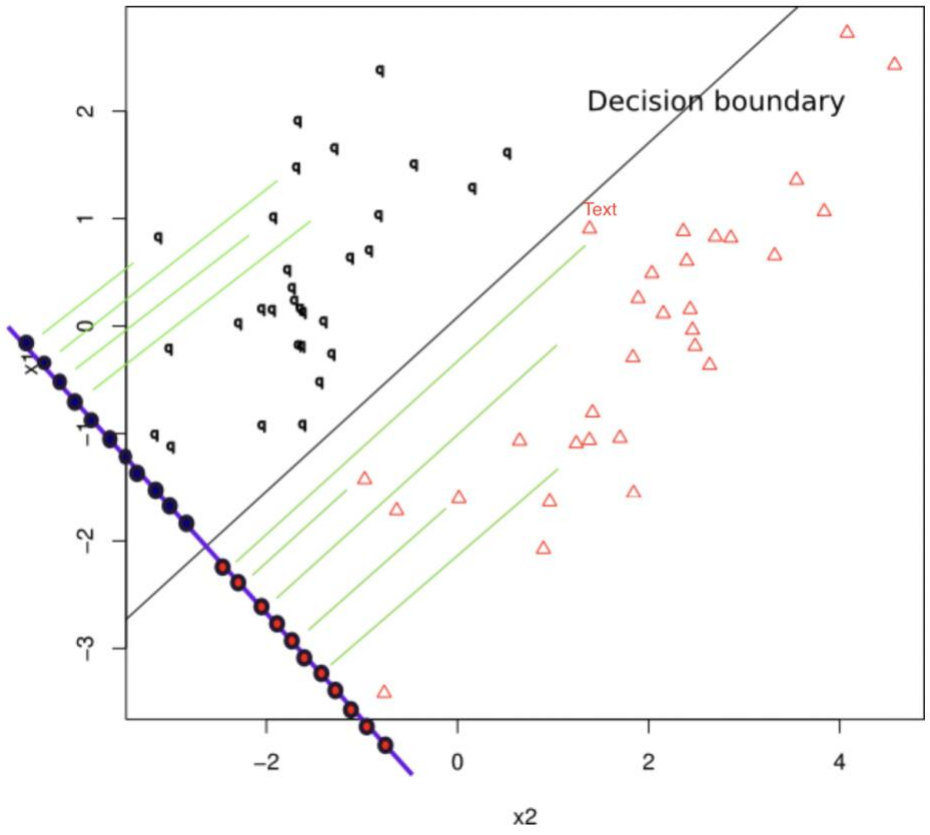


Figure 5 - Linear Discriminant Analysis – Source: R.A. Fisher, The use of multiple measurements in taxonomic problems, 1936

In the above figure, we observe our two populations, A and B, plotted on the X_1 and X_2 axes. Notably, there's a central line, referred to as Decision Boundary. For now, our focus will be on this line, as it divides the space into two portions, facilitating a classification of points in proximity with minimal attribution errors (which we will touch upon later). This implies that this line possesses the property of offering a clearer designation for points close to it between the two sets.

At the base of the axis, there's another line perpendicular to the first one. This represents the optimal discriminant function, considering the characteristics X1 and X2 of the two

groups. The businesses to be classified are represented by the points on the analyzed line, making their classification more straightforward compared to considering their 2 characteristics separately.

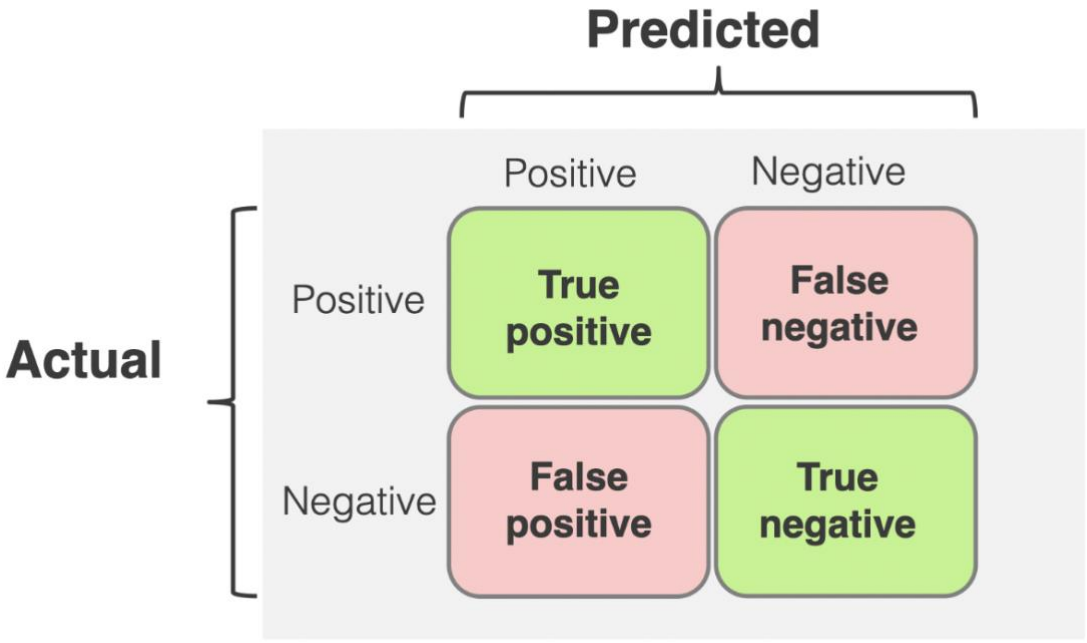
In this analysis, the only subjective aspect lies in the choice of variables X to observe in the businesses for classification, while the weights are determined by considering the characteristics of the two populations.

2.2 Classification Error

Being the Linear Discriminant Analysis a model, as we pointed out in the previous chapter, it will always be affected by errors. The concept and purpose of models is to minimize them, but they will always occur at some point. Taking as example the Figure 1, a classification error occurs if a point classified as *q* is in the reality a *triangle* point.

To summarize, when applying the linear discriminant model to predict business crises, two potential errors arise:

- Incorrectly classifying a healthy company as unhealthy (False Positive)
- Incorrectly classifying an unhealthy company as healthy (False Negative)



Considering the primary objective of the model, the error of the second type is decidedly more severe. In such a case, a bank making an evaluation mistake risks granting funding to a potentially insolvent business. Similarly, an entrepreneur aiming to assess their production process might erroneously perceive it as sound when urgent corrections are necessary.

Conversely, the error of incorrectly classifying a healthy company as abnormal would be less costly. This rationale leans towards preferring a more "cautious" model, one that more readily classifies a healthy company as unhealthy, rather than a model that, in moments of uncertainty, tends to categorize the subject among the healthy businesses.

Every classification model (e.g. a model where the aim is to classify a dataset among different groups) has to deal with classification errors, and they are also used to compute the efficiency of the model (e.g. the area under the ROC curve for the standard logistic regression).

2.3 The study

In his pursuit of creating a comprehensive model to determine a company's potential for failure, Altman aims to encapsulate all necessary information in a single value. The American economist's objective is clear – to develop a model that should be rapid and simple, catering to individuals with limited mathematical and statistical knowledge. This ingenious approach harmonized the demands of academics seeking precision and practitioners desiring an easily manageable tool.

Altman emphasized that his model is not probabilistic but descriptive comparative. Its purpose is to identify trends in financial indicators in the years preceding insolvency for both healthy and troubled companies.

During Altman's time, one widely-used method for analyzing a company's financial health was the ratio analysis. Despite its popularity among analysts, Altman notes that ratio analysis, focusing on individual balance sheet indices, did not receive favorable acknowledgment from academics. While it demonstrated effectiveness, particularly in stability analysis over a discrete time frame preceding financial distress, its limitations were evident: the methodology's univariate nature and emphasis on individual signals

of impending problems make it “susceptible to faulty interpretation and potentially confusing outcomes” (E. I. Altman, 1970).

Consider an enterprise with low profitability and/or solvency; it might be perceived as financially vulnerable. However, if it exhibits a high level of liquidity, the situation may not be as dire. Altman emphasizes the necessity of a model that can provide a holistic view of a company's situation, going beyond the limitations of ratio analysis.

Altman's goal is to evolve existing models by combining different measures into a unique and meaningful model. This task, however, presents challenges, especially in selecting the indices that will be part of the model and the method used to integrate these singular and separated values into a unified whole.

Altman's initial studies were published in 1968 in "The Journal of Finance" under the title "Financial Ratios, Discriminant Analysis, and the Prediction of Corporate Bankruptcy" and will be crucial for the purpose of this paper.

2.5 Multivariate Discriminant Analysis

Altman's exploration into predicting corporate bankruptcy involved the consideration of four potential tools (E. I. Altman and A. Saunders, 1997):

1. The linear probability model.
2. The *logit* model.
3. The *probit* model.

4. The discriminant analysis model.

Altman chose multivariate discriminant analysis as the appropriate statistical model. His decision was based on the success of this methodology in other scientific disciplines, from biology to behavioral sciences, but few had thought of adapting multivariate discriminant analysis in the business context at that time. He admired its early application in economics and recognized its success in providing a holistic view of variables and their interactions.

The linear discriminant analysis he chose classifies subjects into two or more groups based on predetermined criteria. Altman, in his case, opted for two groups: bankrupt and non-bankrupt companies. This reduced the need for multiple discriminant values, streamlining the analysis to a single discriminant value, called Z.

Altman's discriminant function, as introduced with Fisher's technique, aimed at combining individual financial indices into a unified value Z in the form of:

$$Z = a_1x_1 + a_2x_2 + \ \ldots\ldots\ + a_nx_n$$

where independent variables x_i assume the values of various financial indicators, assessing a company's potential for failure, and a_i the weights assigned to them by the model.

The economist's approach involved a thorough investigation to identify suitable predictive variables, ensuring the discrimination's feasibility. Altman grappled with the question of whether there were significant differences between healthy and distressed companies that would facilitate accurate discrimination and the construction of a precise yet user-friendly model (E. I. Altman, 1968).

Altman's unique approach involved customizing Fisher's technique through a meticulous analysis of a sample of companies. This approach tested the direct and immediate descriptive potential of various indices and their combinations, evaluating their ability to discern the lived health state of a company. The details of this analysis reveal Altman's commitment to creating a model that is not only precise but also accessible to a broad audience operating in the economic domain.

2.6 The Test

Altman embarked on developing a specialized application of Fisher's model, commencing with the creation of a company sample for testing and constructing his unique model. In this process, Altman stressed the importance of forming a sample with entities sharing similar characteristics, a crucial factor in identifying the descriptive power of discriminating variables. As previously mentioned, many of the indices considered in ratio analysis were interrelated, influencing each other. It is precisely this aspect that allowed Altman to choose a relatively low number of indices, ensuring

simplicity of use and interpretation for his method and avoiding the ambiguities that plagued older tools.

For the sample, Altman initially identified 66 companies in the manufacturing sector, their asset sizes ranging from 0.7 million to 25.9 million dollars, with an average of 6.4 million dollars. However, acknowledging the non-homogeneity of the group, further analysis was conducted by eliminating companies with assets at the extremes of the considered range.

Within this group, Altman distinguished between companies in optimal health conditions (forming G2, size = 33) and those facing bankruptcy and undergoing Chapter X bankruptcy proceedings between 1946 and 1965 (forming G1, size = 33).

Moving forward, Altman carefully considered which indices could best facilitate a clear separation of the two groups. These variables initially numbered 22 and were classified into five macro-categories:

- Liquidity
- Profitability
- Financial Leverage
- Solvency
- Assets

Altman's criteria for selecting ratios were based on their popularity in pre-study literature and their potential relevance. Additionally, Altman introduced new indices specifically developed for this study.

Each of the 22 indices underwent evaluation for its individual contribution and predictive ability within the model. Furthermore, each index was incorporated into a function to assess its contribution within a more complex context, considering its behavior in relation to other indices and the correlations between them.

Contrary to expectations, the study revealed that within this multivariate function, the most significant ratios were not the same as those accorded greater importance in univariate analysis. Altman attached crucial importance to the interaction these ratios would have with each other when selecting the optimal function through an iterative study.

The final function took the following form:

$$Z = 2.2X_1 + 2.4X_2 + 3.3X_3 + 0.6X_4 + 0.999X_5$$

Before delving into an analysis of individual variables, it is essential to draw the reader's attention to the values assumed by the different weights. These weights already provide

insights into which variables will have a greater impact on determining the final Z score, highlighting the variables with higher discriminatory power.

2.6 The five Independent Variables

$$X_1 = \frac{Working\ Capital}{Total\ Assets}$$

where: *Working Capital = Current Assets - Current Liabilities*

With *Current Assets* is meant all the resources on a company's balance sheet that are expected to be converted into cash or used up within one year, such as Cash and Cash Equivalents, Accounts Receivable, Inventory, Prepaid Expenses, Short-Term Investments, Notes Receivable (Short-Term). On the contrary, *Current Liabilities* are all the obligations that a company is expected to settle within one year or its normal operating cycle, whichever is longer, such as Accounts Payable, Short-Term Debt, Accrued Liabilities, Income Taxes Payable, Dividends Payable, Unearned Revenue, Notes Payable (Short-Term), Current Portion of Long-Term Debt.

X_1 is the ratio of working capital to total assets. It assesses the portion of a company's assets financed by its short-term liabilities, providing insights into its short-term liquidity position. A higher X_1 indicates a larger proportion of assets financed by working capital, which is generally considered favorable in terms of short-term financial strength.

To give some context, the table below summarize X_1 value in different industries:

Industry	X_1 value range	Comment
Retail	0.2 – 0.5	Lower X_1 ratios due to the nature of their operations, where inventory turnover is crucial.
Technology	0.5 – 0.8	Relatively higher X_1 ratios as they often have lower inventory levels and faster cash conversion cycles.
Manufacturing	0.3 – 0.6	Moderate X_1 ratios, as they typically require a balance between working capital and production needs.
Service	0.6 - 1	Higher X_1 ratios due to lower inventory requirements and faster cash turnover.
Healthcare	0.4 – 0.7	Moderate X_1 ratios, reflecting the need for a balance between liquidity and operational demands.

$$\boldsymbol{X_2 = \frac{Retained\ Earnings}{Total\ Assets}}$$

This ratio assesses the proportion of a company's total assets that is financed by its retained earnings, reflecting the contribution of internally generated profits to its asset base.

A higher X_2 is generally considered favorable, as it indicates a greater reliance on internally generated funds rather than external financing. This reliance on retained earnings can be seen as a sign of financial stability, suggesting that the company has accumulated profits over time.

When analyzing X_2, it's important to consider the historical context. Examining trends in retained earnings relative to total assets over time provides insights into the company's

financial trajectory. Consistent growth in retained earnings may signal financial strength and prudent financial management.

On the flip side, a declining X_2 ratio over time may raise concerns. It could indicate challenges in the company's ability to generate and retain earnings, potentially impacting its overall financial stability. In addition to this, the ratio tends to penalize young companies, since a lower amount of earning will be retained by them. It has its logic from the moment that younger companies have higher probability to fail compared to old ones (ISTAT, 2023). This ratio can be also seen as how age relates to failure for companies, across the different industries.

Industry	**X_2 value range**	**Comment**
Retail	0.1 – 0.3	Lower X_2 ratios as they typically operate with thinner profit margins and may rely more on external financing.
Technology	0.2 – 0.4	Moderate X_2 ratios, reflecting a mix of internal and external financing.
Manufacturing	0.3 – 0.5	Moderate to higher X_2 ratios, as they often need to reinvest profits for capital expenditures.
Service	0.4 – 0.6	Higher X_2 ratios, indicating a reliance on retained earnings for operational needs.
Healthcare	0.2– 0.4	Moderate X_2 ratios, reflecting a balance between internal and external financing.

$$\boldsymbol{X_3 = \frac{EBIT}{Total\ Assets}}$$

Where *EBIT* stands for *Earnings Before Interest and Taxes*, which is a measure of a company's operating profit, representing its profitability from core business operations before accounting for interest expenses and income taxes.

This ratio provides insight into how effectively a company is utilizing its assets to generate earnings from its core business operations. A higher indicates that the company is more efficient in generating profits relative to its total asset base. This efficiency is a positive signal, suggesting that the company is effectively managing its resources to produce earnings.

On the other hand, a lower may imply lower profitability in relation to the total assets employed. This could be due to various factors such as operational inefficiencies, increased operating expenses, or lower-than-expected revenues.

Industry	**X_3 value range**	**Comment**
Retail	0.05 – 0.15	Lower X_3 ratios due to the nature of the industry, where profit margins tend to be thinner.
Technology	0.10 – 0.25	Moderate X_3 ratios, reflecting their potential for higher-profit margins.
Manufacturing	0.08 – 0.20	Moderate to higher X_3 ratios, indicating their ability to generate earnings from their asset base.
Service	0.15 – 0.30	Higher X_3 ratios, as their assets are often more human-capital-intensive.
Healthcare	0.10 – 0.20	Moderate X_3 ratios, reflecting the balance between profitability and asset utilization.

$$X_4 = \frac{\textbf{\textit{Market Value of Equity}}}{\textbf{\textit{Total Liabilities}}}$$

X_4 plays a significant role by examining the relationship between the market value of equity and the book value of total liabilities. This ratio, calculated as the market value of equity divided by the book value of total liabilities, offers insights into the market's perception of a company's financial position.

A higher X_4 is generally interpreted as a positive signal. It signifies that the market values the company's equity more favorably than its accounting liabilities. This optimism suggests that investors have confidence in the company's ability to generate future cash flows and view its financial position more optimistically.

In summary, X_4 adds a market-based dimension to the Altman Z-Score, capturing the market's perception of a company's financial strength in relation to its liabilities. For example, Altman explains that a company with a market value of equity worth $1,000 and a debt of $500 could withstand a two-thirds decline in equity value before becoming insolvent. Similarly, the same company but with an equity value of $250 would become insolvent with a one-third decline in equity value (E. I. Altman, 1968).

Industry	**X_4 value range**	**Comment**
Retail	0.6 – 2.2	Lower X_4 ratios reflecting potential volatility and lower market valuations compared to other sectors.
Technology	2.5 – 2.5	Higher X_4 ratios, due to the market's favorable perception of their innovative potential and growth prospects.

Manufacturing	0.8 – 2.5	Moderate X_4 ratios, reflecting a balance between market confidence and industry stability.
Service	1 – 2.8	Moderate X_4 ratios, influenced by factors like intellectual property and brand value.
Healthcare	2.2 – 2	Higher X_4 ratios, given the market's confidence in the sector's stability and long-term demand.

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

In the Altman Z-Score framework, X_5 flows as a measure of operational efficiency, encapsulating how well a company transforms its total assets into revenue. Emphasizing the crucial link between operations and financial performance, X_5 integrates seamlessly into a comprehensive evaluation of a company's health.

Ultimately, X_5 acts as a flowing metric, capturing the essence of operational effectiveness within the broader landscape of financial health assessment.

Industry	**X_5 value range**	**Comment**
Retail	0.2 – 0.6	Lower X_5 ratios due to potentially lower asset turnover in a sector with significant inventory and physical assets.
Technology	0.5 – 1	Higher X_5 ratios, indicating efficient utilization of assets to generate revenue, given the innovative and high-growth nature of the sector.
Manufacturing	0.3 – 0.7	Moderate X_5 ratios, due to the nature of the business where high assets are needed to produce.
Service	0.6 – 2.2	Higher X_5 ratios, particularly for those relying on intellectual capital and service-driven revenue streams.

Healthcare	0.4 – 0.8	Moderate X_5 ratios, considering the capital-intensive nature of the sector and the importance of efficient asset utilization.

Identifying the five indicators as independent variables in the function, Altman established the five weighting coefficients. These coefficients represent a weighted value assigned to each of the five variables, amplifying the distinctions between companies under normal balanced conditions and those in a distressed situation, as already highlighted by the financial indicators included in the model.

2.7 The Results

The average value assumed by the individual variables, respectively, for groups G1 and G2 is as follows:

Variable	Average Value Healthy Companies	Average Value Failed Companies
X_1	− 6,1%	41,4%
X_2	−62,6%	35,5%
X_3	−31,8%	15,3%
X_4	40,1%	247,7%
X_5	150,0%	190,0%

In the table above, we can discern the individual contributions of various selected variables to the model. It's apparent that the ratio values for financially stable companies consistently remain positive and notably higher than those associated with distressed

companies. Consequently, a company's potential for financial distress inversely correlates with its discriminatory score, indicating a lower score for higher risk.

Regarding a specific variable, its values are quite similar between the two groups (150.0% for one and 190.0% for the other). When conducting a sequential, univariate analysis, the contribution of this variable might go unnoticed.

This brings us to a segment of Altman's methodology in determining the array of variables applied in the final discriminant function. He initially assessed their significance individually before delving into a collective analysis. Notably, the index with comparatively weaker performance in univariate analysis is strategically assigned one of the higher weights in the ultimate formula.

Let’s consider the following table:

Variable	**Scale Vector**	**Importance Order**
X_1	3.29	5
X_2	6.04	4
X_3	9.89	1
X_4	7.42	3
X_5	8.41	2

As we previously highlighted, the true significance of a variable is not observable when considered in isolation. Altman, therefore, examines the coefficients for their corrected values based on the relative contribution of each variable. Upon observing the table, it becomes evident that, in terms of importance for discrimination, variables X_3, X_5, and finally X_4 are most useful.

The profitability index is undoubtedly the key contributor to distinguishing healthy companies from those on the verge of failure. This is not surprising, as the profit of a company on the brink of failure is likely to be negligible or even absent.

Let's shift our attention to variable X5. Its importance in a multivariate context is emphasized, making it the second most significant in the studied model. The reason for this result is likely the strongly negative correlation observed between X3 and X5 in the group of failed companies (equal to -0.78). This negative correlation is confirmed in studies conducted on groups after those used to develop the model.

This result underscored the greater significance of a negative correlation, rather than a positive one, as it carries additional information beyond a correlation greater than zero. This negative correlation can be attributed to the fact that failed companies tend to be characterized by assets whose value tends to deteriorate due to cost-cutting strategies, leading to a reluctance to renew and replace old company assets. Additionally, their financial size tends to shrink over time through cumulative losses, rendering any sales momentum ineffective.

Once the values of various ratios are calculated, it becomes possible to determine the Z score for each company in the two groups or any company under analysis. After establishing the average Z score for the two considered groups, it is suggested to identify a range of Z scores. Using this range, the health status of a given company can be classified by calculating its score, facilitating a determination of its overall health.

2.8 Altman's Analysis

To analyze the results, check the model and improve it, Altman applied a process constituted by 6 steps:

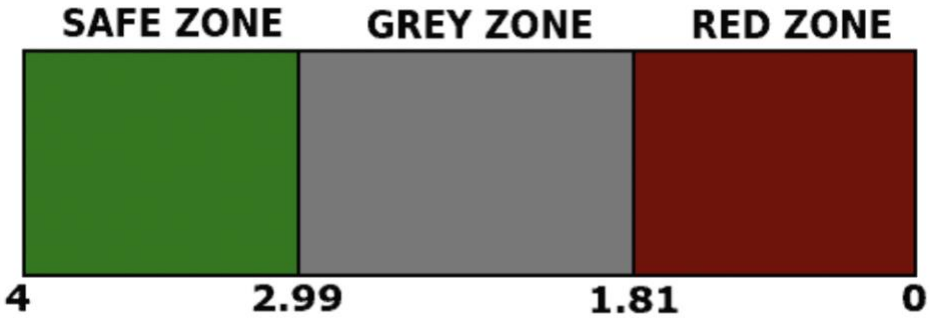
1. Control of outcomes on the initial sample, by looking at the confusion matrix, giving a 95% precision to the model.
2. Predictive ability two years before failure, by looking at the confusion matrix on a 2-year period (83% precision).
3. Potential errors or deviations and validation techniques, by executing a t-test on a subsample for 5 times, which confirmed the effectiveness of the model.
4. Examination of a secondary sample of failed companies, by testing the model on a sample of failed companies different from the first one (96% precision).
5. Examination of a secondary sample of healthy companies, same as previous point but tested on healthy companies (79% precision). This step will give to Altman the idea on how to define a gray area, that will be treated later.
6. Long-term accuracy, which shows a reliability of the model up to two years before bankruptcy.

As highlighted in point 5, once it was confirmed that his model could provide satisfactory answers, Altman contemplated the most appropriate way to develop the model to make it usable for anyone wanting to assess a company's health, whether it be banks, analysts, or others. It was necessary to identify a discriminant value that would serve as a dividing line between failed and healthy companies, known as the cutoff point or Z intermediate. Companies with a Z score below a certain threshold would be classified as insolvent, while those with a higher Z score would be considered healthy.

Analyzing the data from his samples, Altman observed that companies with a Z score above 2.99 could unquestionably be classified as healthy, while those with a Z score below 2.81 were certainly in crisis. Inevitably, there were intermediate results that couldn't unequivocally indicate a company's imminent failure or health. It became necessary to establish guidelines for companies classified in the gray zone. To do this, the situation of companies falling into the "overlap" area had to be reexamined. Within the range of uncertainty, the goal was to identify the values leading to the fewest misclassifications. The gray area, encompassing Z scores between 2.81 and 2.99, presented a zone of uncertainty where errors of Type 1 or 2 could occur.

Within this gray area, Altman identified a critical value for discrimination. After conducting additional tests on different samples, he found that the most critical value fell between 2.67 and 2.68. The selected critical value was 2.675, indicating that companies

with a Z score below this value could be considered potentially insolvent, while those with a Z score above it belonged to the group of healthy companies.



2.9 Z' and Z" scores

Altman, following criticism from the academic community regarding the lack of sophistication in financial ratios as a method to assess a company's health, combined various indices with linear discriminant analysis. The goal was to test the predictive capability of this technique in anticipating corporate failures. Altman aimed to determine if integrating these indices into a multivariate context would yield greater statistical relevance compared to their more commonly sequential use.

Results from this test were encouraging. The employed model demonstrated exceptional precision in predicting failures, accurately identifying critical conditions for 94% of the first group of companies and assigning the correct group membership for 95% of all companies. The model also performed satisfactorily for subsequent groups, which did not contribute to the model's creation, making their classification more challenging.

Notably, the model could identify companies destined for failure as early as two years preceding the event. However, beyond the two-year mark, the model's reliability

diminished, becoming less credible. Altman's test, building on prior studies by other authors, revealed a tendency to reverse classifications beyond the third year.

A significant limitation of the model is its applicability to specific types of companies - those in the manufacturing sector, publicly traded, with easily accessible financial information. Altman acknowledged this limitation and, in the concluding comments of his initial study, expressed the intent to develop a more versatile Z score applicable to a broader range of companies, particularly smaller ones not listed on the stock exchange and more prone to financial distress.

The subsequent models, Z' score and Z'' score, appear to have originated in Altman's mind at the conclusion of his first article, where he explicitly acknowledged the limitations of the initial model with the intention to address them. Although the process to develop these models paralleled that of the Z score, the results were more versatile in terms of applicability. This acknowledgment marked the study's conclusion with an awareness of the need to refine the model while recognizing the excellent starting point for subsequent model development.

The first pain point he addressed was about companies being publicly traded. In order to change the model, the variable $X_4 = \frac{Market\ Value\ of\ Equity}{Total\ Liabilities}$ needed to be changed. This model is applicable to private manufacturer companies.

The new variable in the model is the following:

$$X_4^* = \frac{Book\ Value\ of\ Equity}{Total\ Liabilities}$$

And the coefficients for the variables in this model is slightly different than the Z-Score model (Altman, 1983):

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

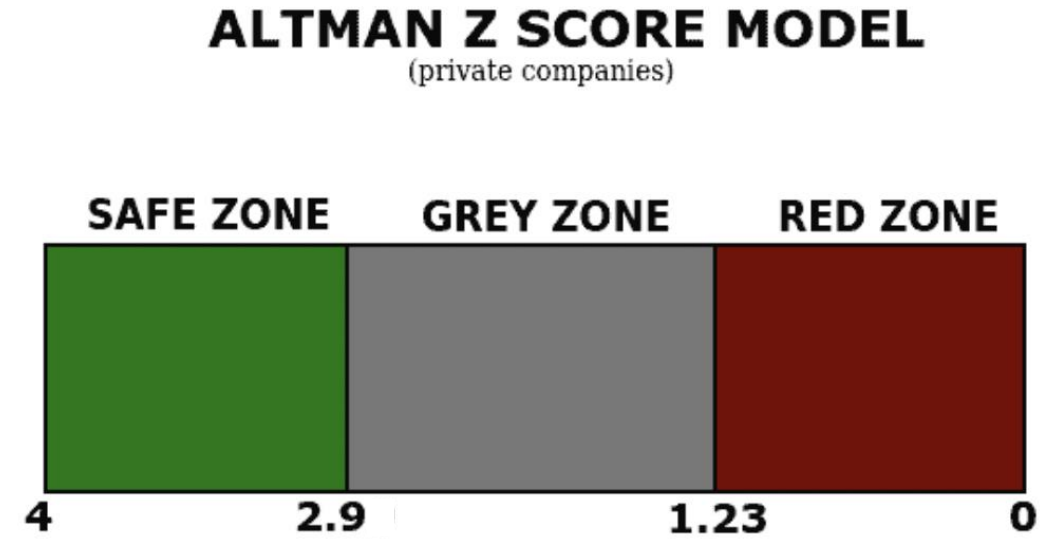
Where:

- X_1 = Working Capital/Total Assets
- X_2 = Retained Earnings/Total Assets
- X_3 = Earnings Before Interest and Taxes/Total Assets
- X_4^* = Book Value of Equity/Total Liabilities
- X_5 = Sales/Total Assets
- Z' = Overall Index

Looking at the weights, all of them have been decreased, so at first glance it seems more difficult for a company to be in the green zone using this index. However, also the range has been changed accordingly: firms with a Z' value exceeding 2.90 are categorized as non-bankrupt, while those with index values ranging from 2.23 to 2.90 fall into the gray area. If the index value is less than 2.23, it indicates that companies are facing a

challenging situation and are classified as being at high risk of bankruptcy. As can be seen, the gray area is now broader than before.

The model's accuracy in classifying bankrupt firms was 90.9%, and for non-bankrupt firms, it was 97.0% (E.I. Altman, 1983).



The last Altman's model, the so-called Z'' score, wants to have a more general application, for both private manufacturing and non-manufacturing companies. To do so, Altman removed the variable $X_5 = \frac{Total\ Sales}{Total\ Assets}$ to minimize the potential industry impact. The new model has the following form (E.I. Altman, J. Hartzell and M. Peck, 1995):

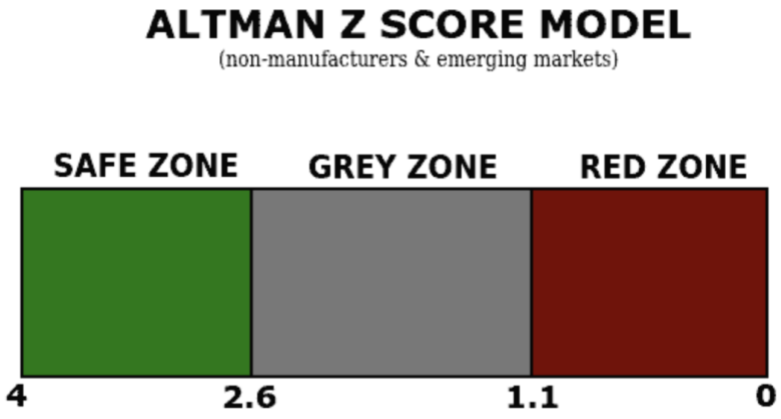
$$Z'' = 6.56X_1 + 3.26X_2 + 6.72X_3 + 2.05X_4^* + 0.998X_5$$

Where:

- X_1 = Working Capital/Total Assets
- X_2 = Retained Earnings/Total Assets
- X_3 = Earnings Before Interest and Taxes/Total Assets
- X_4^* = Book Value of Equity/Total Liabilities
- Z'' = Overall Index

When the Z'' value surpasses 2.60, companies are categorized as non-bankrupt. If their index value falls within the range of 2.10 to 2.60, they fall into the gray area classification. When index values dip below 2.10, companies face challenging circumstances and are labeled at a high risk of bankruptcy. The model exhibited a 97% accuracy in classifying non-bankrupt firms and a 90.9% accuracy for bankrupt firms.

A constant of 3.25 has been added to this last version for emerging market companies.



By applying the Z" score, Altman and Hotchkiss in 2006 outlined a correspondence between the results obtained through the model and the scores assigned by the U.S. rating agency Standard & Poor's. This procedure involved calculating the average Z" score for the population of companies in each Standard & Poor's rating class (taking into consideration the 3.25 constant in the model).

	Healthy Companies									
Rating	AAA	AA+	AA	AA-	A+	A	A-	BBB+	BBB	BBB-
Z" Score	>8.15	8.15	7.60	7.30	7.00	6.85	6.65	6.40	6.25	5.83
Rating	BB+	BB	BB-	B+	B	B-	CCC+	CCC	CCC-	D
Z" Score	5.65	5.25	4.95	4.75	4.50	4.15	3.75	3.20	2.5	<2.75
	Grey Area				Insolvent Companies					

Table 1 - Credit S&P Rating and Z" Score – Source Altman E.I. Hartzell J. Peck M.

2.10 Conclusion

Altman's initial model can be viewed as a preliminary attempt to test a novel idea and assess its validity. While the first model is reliable and accurate, Altman recognizes its limitations, particularly in excluding a significant number of companies from

investigation. The first Z-score, as previously mentioned, is tailored exclusively for publicly traded companies assumed to be larger and specific to manufacturing industries. This automatically leaves out a substantial portion of businesses in the market, especially the smaller enterprises that are more susceptible to financial distress.

The subsequent models, namely the Z' score or the Z" score, seem to have originated from Altman's desire to address the limitations explicitly mentioned in his initial article. The approach to developing these models mirrors that of the original Z-score but yields more broadly applicable results.

All the three models resulted in great results in terms of precision and reliability.

2.11 Other Bankruptcy Models

2.12.1 S Score

In 1978, Springate introduced a bankruptcy prediction model known as the S-Score, which utilizes the Multiple Discriminant Analysis (MDA) technique. By incorporating various financial ratios, Springate's model boasts an impressive 92.5% accuracy rate in foreseeing financial distress.

The S-Score is calculated using the following formula:

$$S\ Score = 2.03X_1 + 3.07X_2 + 0.66X_3 + 0.4X_4$$

Here's a breakdown of the components:

- X_1: Represents the ratio of working capital to total assets.
- X_2: Denotes the ratio of profit before interest and taxes to total assets.

- X_3: Reflects the ratio of profit before tax to current debt.
- X_4: Indicates the ratio of sales to total assets.

To interpret the S-Score effectively, a cutoff value of 0.862 is applied (as indicated by Rahayu, 2017). This cutoff delineates three distinct zones:

- **"Distress" Zone (S < 0.862):** Companies falling within this zone are in a precarious financial state, teetering on the brink of insolvency. The likelihood of bankruptcy looms large, necessitating urgent attention and strategic interventions.
- **"Grey" Zone (0.862 < S < 2.062):** Entities within this range are grappling with financial instability that demands proactive management. While not yet in imminent danger of bankruptcy, swift and effective measures are required to navigate through the uncertainty. Failure to address these challenges promptly may exacerbate the situation, potentially leading to insolvency.
- **"Safe" Zone (S > 2.062):** Companies positioned in this zone enjoy robust financial health, with minimal risk of bankruptcy. Their sound financial standing signifies effective management practices and prudent decision-making, mitigating the threat of insolvency.

The S-Score, with its nuanced categorization and high predictive accuracy, serves as a valuable tool for stakeholders in assessing the financial viability and risk exposure of companies.

Comparing the variables in the two models:

1. Working Capital to Total Assets: in both the S-Score and Altman Z-score models, the ratio of working capital to total assets serves as a measure of liquidity and short-term financial health. A higher ratio indicates a stronger ability to cover short-term obligations with current assets. Therefore, a higher value contributes positively to the overall score in both models.

2. Profit Before Interest and Taxes to Total Assets: this ratio in the S-Score model reflects profitability relative to total assets, capturing the efficiency of utilizing assets to generate profits before accounting for interest and taxes. Similarly, Altman's Z-score includes a profitability component, albeit in a slightly different form. Altman's model uses earnings before interest and taxes (EBIT) relative to total assets to assess operational profitability. Both ratios aim to evaluate the company's ability to generate profits from its asset base, with higher values indicating better financial performance.

3. Profit Before Tax to Current Debt: in the S-Score model, this ratio assesses the company's profitability in relation to its current debt obligations, providing insights into its ability to service debt with pre-tax earnings. Altman's Z-score does not directly include a ratio that specifically measures the relationship between profitability and current debt. However, it incorporates various ratios related to profitability and debt to assess overall financial health. While the specific formulation differs, both models seek to evaluate the company's ability to manage its debt obligations in light of its profitability.

4. Sales to Total Assets: this ratio in the S-Score model represents the efficiency of asset utilization in generating sales revenue. Altman's Z-score does not include a direct

measure of sales to total assets. Instead, it focuses on profitability, liquidity, and solvency ratios to assess financial health. However, the efficiency of asset utilization indirectly affects profitability, which is a key component of the Altman Z-score.

Comparing the two models, we find that while they share some common themes, such as assessing liquidity, profitability, and solvency, they differ in the specific variables used and their formulations. The Altman Z-score may offer a broader perspective by including additional ratios like market value of equity to total liabilities, which captures market sentiment, while the S-Score provides a focused analysis on profitability, liquidity, and debt management.

2.12.2 Model Zmijewski (X-Score)

Zmijewski employs ratio analysis to assess a company's performance, leverage, and liquidity. Central to this model is the profound consideration of debt levels as the foremost determinant of bankruptcy risk (Rudianto, 2013).

Zmijewski's approach offers formulas tailored for various business types, exemplified by the X-Score formula:

$$X\ Score = -4.3 - 4.5X_1 + 5.7X_2 - 0.004X_3$$

Here's a breakdown of the variables:

- X_1: Represents the ratio of earnings after taxes to total assets.
- X_2: Reflects the ratio of total debt to total assets.
- X_3: Denotes the ratio of current assets to current liabilities.

According to the evaluation standards cited by Fanny and Saputra (2000) in Peter & Yoseph (2011), a higher value correlates with an augmented likelihood of bankruptcy. Consequently, if the calculation yields a positive value using this model, it signals an elevated risk of bankruptcy for the company. Conversely, a negative value suggests a lower probability of bankruptcy (Rudianto, 2013).

Diving in deep in the variables and comparing them with Altman's ones:

1. Earnings After Taxes to Total Assets: this ratio assesses profitability relative to the total asset base, indicating how effectively the company generates earnings from its assets after accounting for taxes. Similarly, the Altman Z-score model includes a profitability component, where earnings before interest and taxes (EBIT) to total assets is used to gauge operational profitability. Both ratios aim to evaluate the company's ability to generate profits from its asset base, with higher values indicating better financial performance.

2. Total Debt to Total Assets: this ratio is a measure of the proportion of total debt relative to the total asset base, providing insights into the company's leverage level. In contrast, the Altman Z-score model also incorporates leverage metrics, such as the ratio of total liabilities to total assets, to assess the company's solvency and risk of bankruptcy. Both models consider the relationship between debt and assets as a critical factor in evaluating financial health, with higher leverage ratios indicating higher financial risk.

3. Current Assets to Current Liabilities: While the Altman Z-score model does not include a direct measure of current assets to current liabilities, it assesses liquidity through ratios such as working capital to total assets and current assets to total liabilities. Both

models aim to assess the company's ability to meet its short-term financial obligations, with higher ratios indicating better liquidity and lower risk of financial distress.

Comparing the two models, we find that while they share similar themes in assessing profitability, leverage, and liquidity, they differ in the specific variables used and their formulations. The Altman Z-score model offers a broader perspective by including additional ratios such as market value of equity to total liabilities, while Zmijewski's X-Score model provides a focused analysis on profitability, leverage, and liquidity.

2.12.3 Model Grover (G-Score)

The Grover model emerged from a comprehensive overhaul and reevaluation of the Altman model. In 1968, Jeffrey S. Grover embarked on this endeavor by augmenting the Altman model with thirteen additional financial ratios. His study spanned from 1982 to 1996, involving a sample of 70 companies, evenly split between those that declared bankruptcy (35) and those that did not (35). The outcome, as documented by Jeffrey S. Grover in 2001, is encapsulated in the following equation (J.S. Grover, 2001):

$$G\ Score = 0.057 + 2.650X_1 + 3.404X_2 - 0.016X_3$$

Where:

- X_1: Represents the ratio of working capital to total assets.
- X_2: Denotes the ratio of earnings before interest and taxes to total assets.
- X_3: Reflects the ratio of net income to total assets.

In Grover's model, companies deemed bankrupt are identified by a score equal to or lower than -0.02, while companies classified as non-bankrupt possess a score equal to or higher than 0.02.

1. Working Capital to Total Assets: this ratio assesses the efficiency of a company's working capital utilization relative to its total assets. Similarly, the Altman Z-score model incorporates a measure of liquidity, which evaluates the adequacy of a company's working capital to meet its short-term obligations.

2. Earnings Before Interest and Taxes to Total Assets: this ratio in the G-Score model reflects the profitability of a company in relation to its total asset base, measuring its ability to generate earnings before interest and taxes. Similarly, the Altman Z-score model includes a profitability component, which assesses operational profitability through the ratio of earnings before interest and taxes to total assets.

3. Net Income to Total Assets: in Grover's G-Score model, this ratio evaluates the profitability of a company by comparing its net income to its total assets. The Altman Z-score model does not include a direct measure of net income to total assets, but it assesses profitability through various ratios such as earnings before interest and taxes to total assets. Comparing the two models, we find that they share similar themes in assessing liquidity, profitability, and financial health. However, they differ in the specific variables used and their formulations. The Altman Z-score model incorporates additional ratios such as market value of equity to total liabilities, which capture market sentiment, while Grover's G-Score model provides a focused analysis on liquidity and profitability.

2.12.4 Taffler Model

In 1983, Taffler introduced the Taffler model, aiming to forecast the likelihood of manufacturing companies encountering bankruptcy within the London Stock Exchange during the period from 1969 to 1976, as referenced by Widiasmara and Rahayu in (2019). The Taffler model incorporates four key financial ratio elements: pre-tax earnings in relation to current obligations, the ratio of current assets to total liabilities, the proportion of total assets represented by current liabilities, and post-tax net income as a fraction of total assets. This model demonstrates an impressive accuracy rate of 95.7% in predicting companies prone to bankruptcy, achieving a flawless 100% accuracy rate for those deemed unlikely to face bankruptcy. Comparatively, the Taffler model surpasses other predictive models such as Altman, Springate, and Grover, exhibiting a 96% accuracy rate and a mere 4% error rate (Prakoso, 2022).

The formula for the Taffler model is outlined as follows:

$$Z_{Taffler} = 3.20 + 12.18X_1 + 2.50X_2 - 10.68X_3 + 0.0289X_4$$

Within the Taffler framework, when the T value falls below 0.2, the company is categorized into the distress zone, indicating a susceptibility to bankruptcy risk. Conversely, when the T value exceeds 0.2, the company is identified as financially stable and is considered not at risk of bankruptcy.

While both Altman and Taffler models evaluate liquidity, profitability, and financial stability, they differ in the specific variables used. The Taffler model emphasizes earnings

and liquidity ratios, while the Altman Z-score incorporates a broader set of metrics covering profitability, liquidity, solvency, and market valuation.

Chapter 3

Z' score application on Italian manufacturing companies

3.1 Introduction

The purpose of the following section is to test if the Altman model is resistant to this external macro geographical, cultural, and economic factors, which determines the difference between United States and Italy as countries, and to ordinary events, as Covid 19 pandemic.

The section will be structured as follows:

- A chapter to understand why Altman tailored its model to the manufacturing industry.
- A chapter describing the main difficulties and possible threats to apply the model to Italian companies, instead of US ones.
- A chapter introducing the Italian manufacturing industry, and its contribution in terms of value added to the economy of the country.
- A chapter containing a description of the sample of companies used for the study enhancing some key statistics as number of companies, average size, average revenues per year.
- A chapter showing and analyzing the results, looking on how the model performed during the not predicted Covid 19 pandemic.

Since most of the manufacturing Italian companies are not public, the model used for this analysis will be the Z' score, described in the section 2.9 of this paper.

3.2 Altman Choice

Before diving in deep on the empiric test, it is important to understand why Altman chose to tailor the Z score to the manufacturing sector in the late 20th century. Altman's choice was not arbitrary but rather based on several factors inherent to this sector, as:

- Capital Intensity: Manufacturing companies often require significant investments in fixed assets, such as machinery, equipment, and infrastructure. These capital-intensive nature exposes them to higher financial risk, particularly if they are unable to generate sufficient returns to cover their fixed costs.

- Cyclical Nature: The manufacturing sector is highly cyclical, meaning its performance is closely tied to economic cycles. During economic downturns, demand for manufactured goods typically decreases, leading to revenue declines and potential financial distress for companies operating in this sector.

- Operating Leverage: Manufacturing companies often exhibit high operating leverage, where a large portion of their costs is fixed. This means that small changes in revenue can lead to disproportionate changes in profitability, amplifying the impact of economic downturns or adverse market conditions.

- Working Capital Management: Effective management of working capital is crucial for manufacturing companies due to the need to finance inventory, receivables, and payables. Inefficient working capital management can strain liquidity and solvency, increasing the likelihood of financial distress.

- Competitive Pressures: Manufacturing is a highly competitive industry with thin profit margins, especially in commoditized markets. Companies must continuously innovate, optimize operational efficiencies, and manage costs to remain competitive, failing which they may face financial difficulties.

- Supply Chain Risks: Manufacturing companies are often part of complex supply chains, relying on suppliers for raw materials, components, and logistics services. Disruptions in the supply chain, whether due to natural disasters, geopolitical tensions, or unexpected events, can adversely impact manufacturing operations and financial stability.

Given these inherent characteristics of the manufacturing sector, Altman recognized the need for a robust financial tool to assess the creditworthiness and bankruptcy risk of companies operating in this industry.

2.3 Altman Z-Score Model in an Italian context

While the Altman Z-Score model has proven effective in assessing the financial health of US companies, its application to Italian manufacturing companies introduces several challenges and considerations. The decision to apply the model to Italian manufacturing companies necessitates a careful evaluation of the differences in financial reporting standards, business practices, and market dynamics between the two countries:

- Accounting Standards and Practices: One of the primary challenges lies in the differences between US Generally Accepted Accounting Principles (GAAP) and International Financial Reporting Standards (IFRS) adopted in Italy. Variations in accounting standards, terminology, and treatment of financial items can affect the calculation and interpretation of the financial ratios used in the Z-Score model.

- Cultural and Institutional Factors: Italy's business culture and institutional framework differ from those of the United States, influencing financial reporting practices, corporate governance norms, and investor behavior. Factors such as the prevalence of family-owned businesses, the role of government intervention, and the importance of relationships in business dealings may impact the relevance and reliability of financial data used in the Z-Score calculation.

- Market Structure and Dynamics: The Italian manufacturing sector exhibits unique characteristics in terms of market structure, competitive landscape, and industry dynamics compared to its US counterpart. Variations in sectoral composition, market concentration, supply chain relationships, and regulatory environments can affect the financial performance and risk profiles of Italian manufacturing companies, potentially influencing the predictive accuracy of the Z-Score model.

- Data Availability and Quality: Access to comprehensive and reliable financial data for Italian manufacturing companies may pose challenges due to differences in disclosure requirements, data availability, and transparency levels compared to US firms. Limited access to historical financial information, inconsistent reporting practices, and data gaps could impact the robustness and effectiveness of the Z-Score model in predicting bankruptcy risk for Italian companies.

- Economic and Financial Environment: Italy's macroeconomic conditions, including factors such as inflation rates, interest rates, exchange rates, and fiscal policies, may differ significantly from those of the United States. Variations in economic cycles, industry-specific trends, and external shocks could influence the financial stability and performance of Italian manufacturing firms, requiring adjustments or modifications to the Z-Score model to account for these contextual factors.

The Italian Manufacturing Industry

The Italian manufacturing sector holds a significant position in both the national economy and the global market. Renowned for its tradition of craftsmanship, innovation, and specialization in high-quality products, Italy's manufacturing industry plays a pivotal role in the country's economic landscape.

Italy has a rich industrial history that dates to the late 19th century when the country underwent rapid industrialization, particularly in the northern regions. The emergence of sectors such as textiles, automotive, machinery, fashion, and design propelled Italy into becoming one of the world's leading manufacturing hubs. Over the years, the sector has evolved, adapting to technological advancements, globalization, and changing market demands.

As of 2024 the Italian manufacturing sector continues to be a vital component of the national economy. It encompasses a diverse range of industries, each contributing uniquely to Italy's industrial prowess. Notable sectors include:

- Automotive: Italy is home to renowned automotive brands such as Fiat Chrysler Automobiles (FCA), Ferrari, Lamborghini, and Maserati. The automotive industry contributes significantly to both manufacturing output and exports.

- Fashion and Textiles: Italy is globally recognized for its luxury fashion brands, including Gucci, Prada, Armani, and Versace. The textile industry, particularly in

regions like Lombardy and Tuscany, is renowned for its craftsmanship and high-quality products.

- Machinery and Equipment: Italy's machinery sector is esteemed for its innovation and specialization in machinery and equipment for various industries, including agriculture, construction, and manufacturing.

- Design and Furniture: Italy is synonymous with design excellence, with companies like Alessi, Kartell, and Poltrona Frau leading the way in furniture and interior design.

- Food and Beverage: The food and beverage industry is another cornerstone of Italian manufacturing, encompassing renowned brands in wine, pasta, olive oil, and cheese.

According to the World Bank, the Italian manufacturing sector accounted for 14.92% of the country's GDP in 2022.

Italy's manufacturing output totaled 169.3 billion USD in 2022, reflecting its substantial contribution to the national economy.

Despite the big importance of the services industry, the Italian manufacturing sector remains a cornerstone of the country's economy, embodying a tradition of innovation, quality, and specialization.

As enhanced by figure 2, as of December 2023, the manufacturing industry occupies the 5th position in terms of market share, with over 275,000 existing companies out of 2,640,039 across all the sectors.

Italy: TOP Industries

2,640,039 registered companies

Industry	Number of Companies	Market Share
Services	661,510	25.1%
Retail Trade	517,819	19.6%
Finance, Insurance, and Real Estate	351,753	13.3%
Construction	339,366	12.9%
Manufacturing	275,643	10.4%
Wholesale Trade	211,075	8.0%
Transportation, Communications, Electric, Gas, and Sanitary...	122,343	4.6%
Agriculture, Forestry, and Fishing	121,340	4.6%
Unknown industry	22,398	0.8%
Public Sector	13,971	0.5%
Mining	2,821	0.1%

Source: HitHorizons.com, data accessed in December 2023

Figure 6 - Italian Industries Market Share Percentage

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