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DOES AUTOMATION INVESTMENT IMPROVE CREDITWORTHINESS IN EUROPEAN MANUFACTURING FIRMS? A MULTI-CASE ANALYSIS.

Relatore:

Prof. Francesco James Mazzocchini

Rapporto Finale di:

Francesco Freifer

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1. Introduction

Recently, Industry 4.0 or the fourth industrial revolution, has been a widely discussed topic. According to McKinsey & Co, this wave of change in the manufacturing sector began in the mid-2010s and holds significant potential for operations and the future of production. Before 2014, the Google search term “Industry 4.0” was practically non-existent, but by 2019, 68 percent of respondents to a McKinsey global survey regarded Industry 4.0 as a top strategic priority. 70 percent said their companies were already piloting or deploying new technology. (McKinsey&Company, 2022)

It is defined as the next phase in the digitisation of the manufacturing sector, driven by disruptive trends including the rise of data and connectivity, analytics, human-machine interaction, and improvements in robotics.

Driven by the need to reduce labour costs, reduce variable costs, increase efficiency, and increase production speed, across European manufacturing, firms ranging from Italian automotive suppliers to Danish pharmaceutical giants have committed billions to automation. Yet the financial consequences of these investments, particularly for creditworthiness and access to capital, remain poorly understood.

The question remains: Does automation investment improve the creditworthiness and financing profile of European manufacturing firms, and does this effect vary by sector and firm size? Widely accepted literature, taught in corporate finance classes, links automation to productivity and reduced labour costs, but rarely to creditworthiness at the firm level.

This thesis tests the academic link between automation investment in European manufacturing firms and the creditworthiness scores of these firms, using a case study of 6 European manufacturing firms, spread across different sectors, with one explicit SME comparator to the 5 large firms.

2. Literature Review:

2.1 Automation and Firm Financial Performance

According to Acemoglu and Pascual Restrepo's findings in their paper “Automation and New Tasks: How Technology Displaces and Reinstates Labour”, automation, by creating a displacement effect, shifts the task content of production against labour, while the introduction of new tasks in which labour has a comparative advantage improves it via the reinstatement effect. These technologies are qualitatively different from factor-augmenting ones, which do not impact the task content of production. The main implication of using this methodology is that the recent stagnation of labour demand is explained by an acceleration of automation, particularly in manufacturing, and a deceleration in the creation of new tasks. In addition, and perhaps reflecting this shift in the composition of technological advances, the economy also experienced a marked slowdown in productivity growth, contributing to sluggish labour demand.

Labour cost is defined as a variable cost; if production slows down, the firm may reduce working hours or downsize its workforce, and if production booms, the firm may increase overtime work or assume new employees. Automation flips the script by making it a fixed cost to the firm. Robotics and AI infrastructure require significant upfront investments, and once installed, the costs remain constant regardless of the amount of production output. This creates a higher operating leverage, defined as “the degree to which a company uses fixed costs in its operations to amplify the effects of changes in sales on its operating income.” (Investopedia, 2026)

Degree of operating Leverage = Contribution Margin / Profit

Contribution Margin = Price - Variable cost per unit

Although high operating leverage can be risky during a recession, it significantly enhances cash flow predictability during normal operations. By shifting the variable costs to fixed costs and by lowering the unpredictability and error of the human input, companies can forecast more predictable cash flows into the future. This added certainty creates a lower standard deviation of operating cash flows, lowering the risk of default and thus signalling that the firm can meet future interest payments, making the company a lower-risk borrower.

2.2 Credit-worthiness and Altman's Z-score

The Altman Z-score assesses a company's financial stability by analysing key financial ratios to predict the potential for bankruptcy. The Altman Z-score, a variation of the traditional Z-score in statistics, is based on five financial ratios that can be calculated from data found on a company's annual reports. It uses profitability, leverage, liquidity, solvency, and activity to predict whether a company has a high probability of becoming insolvent. This metric is aimed at manufacturing companies, which we will be analysing later on.

NYU Stern Finance Professor Edward Altman developed the Altman Z-score formula. Over the years, Altman has continued to reevaluate his Z-score. From 1969 until 1975, Altman looked at 86 companies in distress, then 110 from 1976 to 1995, and finally 120 from 1996 to 1999, finding that the Z-score had an accuracy of between 82% and 94%.

$$Altman\ Z\ score = 1.2a + 1.4b + 3.3c + 0.6d + e$$

Where:

A = working capital / total assets

B = retained earnings / total assets

C = earnings before interest and tax / total assets

D = market value of equity / total liabilities

E = sales / total assets

A score below 1.81 means it's likely the company is headed for bankruptcy, while companies with scores above 2.99 are not likely to go bankrupt. Scores between those 2 values indicate the company is in the financial grey, with a moderate risk of bankruptcy (Investopedia, 2026)

Some limitations of this metric include:

1. Past performance to predict future failure. A company could experience a catastrophic event (like a massive lawsuit or a supply chain collapse) that isn't yet reflected in the most recent balance sheet. A company could be trying to ‘hide’ debt, using aggressive accounting techniques, thus the Z-score could be artificially manipulated.
2. The biggest technical critique is that the Z-score focuses on accrual-based accounting rather than actual cash flow, where a company can show a profit on paper (high EBIT) but be completely out of cash to pay its immediate bills.

The cost of debt is the total interest a company pays to finance its operations through borrowed funds. The size of the cost of debt depends on the borrower's creditworthiness, so higher costs generally mean the borrower is considered by lenders to be relatively risky.

Cost of debt = Interest paid / Total debts

The interest coverage ratio reveals a company’s solvency and ability to pay interest on its debt. It shows how easily a company can pay interest on its outstanding debt. The ratio divides a company’s earnings before interest and taxes (EBIT) by its interest expense over a specific

period. It helps lenders, investors, and creditors determine a company's riskiness for future borrowing. (Investopedia, 2025)

Interest Coverage Ratio = EBIT / Interest Expense

Where:

EBIT=Earnings before interest and taxes

2.3 Capital Structure and Financing Theory

The Modigliani-Miller Theorem states that in a world of perfect markets, a firm's value is unaffected by its capital structure. Under this "Irrelevance Principle," the choice between debt and equity is unimportant. However, automation operates within the scope that the Modigliani-Miller baseline ignores. Tax Shields, and distress costs.

Automation requires heavy capital expenditure (CapEx), leading to significant depreciation tax shields.

Capital expenditures (CapEx) are funds companies use to acquire, upgrade, or maintain physical assets like buildings, technology, or equipment, with the goal of increasing operational scope or future economic benefits (Investopedia, 2026).

The Pecking Order Theory, also known as the Pecking Order Model, relates to a company's capital structure. Made popular by Stewart Myers and Nicolas Majluf in 1984, the theory states that managers follow a hierarchy when considering sources of financing. The Pecking Order Theory states that managers display the following preference of sources to fund investment opportunities: first, through the company's retained earnings, followed by debt, and choosing equity financing as a last resort. (CorporateFinanceInstitute, 2020)

Automation affects this theory in 2 main ways. Firstly, by lowering marginal costs and increasing margins, automation provides the company with a higher capability to retain

earnings, utilising more internal financing. Secondly, successful investment in automation signals to the market that the firm has a viable long-term strategy, reducing the "lemon premium". The lemon problem occurs when buyers have less information than sellers about a product's quality. This leads to a decline in the overall quality of goods and market failure.

An agency cost is an expense that arises when one person acts on behalf of another. Agency costs typically arise in the wake of core inefficiencies, dissatisfactions, and disruptions, such as conflicts of interest between shareholders and management. The payment of the agency cost is to the acting agent.

High operational uncertainty increases these costs because lenders demand higher interest rates (risk premiums) to compensate for the possibility of managerial missteps or volatile earnings. (Investopedia, 2026)

Automation stabilises this by lowering the variance in earnings because automated systems are less susceptible to the variance of human labour, making earnings more predictable, directly lowering the risk premiums demanded by lenders. Another way automation affects it is by securing the debt with tangible assets, providing higher liquidation to the lender if bankruptcy occurs, thus giving the lenders more security, which lowers the cost of debt.

2.4 SME vs Large Firm Financing Dynamics

Larger firms have easier access to financing than SMEs, as banks rely mostly on hard information, such as audited financial reports and stock price fluctuations, which most SMEs lack. And usually, banks that lend to SMEs use relationship lending, as opposed to transaction lending, which is used with large firms. Relationship lending is characterised by a long-term bilateral relationship between a lender and borrower. Over this time, the lender collects private information about the borrower, affording it a competitive advantage over other financial institutions. (ScienceDirect, 2021)

Moral hazard arises from asymmetric information when one party knows more about the other. Moral hazard occurs after an agreement, when one party changes their behaviour because they are protected from the consequences. (Investopedia, 2026)

Information asymmetry leads to credit rationing, and they fear that the company will take unnecessary additional risks, but in the case of automation investments, the information is physical for everyone to see, where you can see the machines but not see the efforts of manual labourers as easily.

Additionally, by automating the manufacturing, it digitises the SME, providing real-time data. This allows the bank to rely on hard information that is easily accessible, rather than the soft information banks usually rely on with SMEs. This moves the SME from relationship borrowing to transaction borrowing, which usually carries lower interest rates due to lower monitoring costs.

For these reasons and many others, I have included an SME in my study to compare it to 5 other large firms in the manufacturing sector.

2.5 Hypotheses

In the following chapters, we will discuss and analyse 3 hypotheses, which are the following:

H1: Automation investment is positively associated with Altman Z-score improvement across firms.

H2: Automation investment is associated with improved financing conditions (lower cost of debt, higher interest coverage).

H3: The creditworthiness effect of automation differs by sector and firm size, with the SME showing a disproportionate response.

3. Methodology

3.1 Research Design

This study uses a longitudinal multiple case study design to investigate whether automation investment improves the creditworthiness and financing profile of European manufacturing firms. The case study method is the right choice here because the relationship between a major capital investment and a firm's credit profile is not something you can capture cleanly in a regression. Firm size, sector dynamics, external shocks, and timing all shape the outcome, and removing that context to get a single coefficient means losing precisely the information that makes the findings useful.

The multiple case study design follows the replication logic described by Yin (2018), where cases are selected not to represent a statistical sample, but because each is expected to either confirm or contrast the findings from the others. Six firms across five different sectors, from automotive, pharmaceuticals, tyre manufacturing, aerospace, to food and dairy allow us to test whether the link between automation and creditworthiness holds broadly or only in specific contexts.

The design is longitudinal because each firm is observed across a five-year window centred on its automation investment event. All years before the investment are classified as the pre-automation period. The investment year itself and all years after it are classified as the post-automation period. This structure lets us see whether creditworthiness metrics move in the direction theory predicts after the investment happens.

The analysis is quantitative, relying on financial ratios computed from balance sheet and income statement data extracted from Orbis Europe. But it sits inside a case study frame because the unit of analysis is the individual firm, not a statistical observation in a dataset. This matters because some of the most important findings in this study require context to interpret correctly. Pirelli's distorted figures in 2016 are explained by the ChemChina acquisition that year. Airbus's low pre-automation reflects COVID-19 grounding commercial aviation in 2020. Novo Nordisk's exceptional revenue growth is driven by GLP-1 drug demand rather than automation per se. A pure regression would flag these as outliers. A case study frame asks why, and the why is what makes the analysis meaningful.

3.2 Sample Composition

The six firms were selected through purposive sampling, meaning they were deliberately chosen based on their relevance to the research question rather than for statistical representativeness of a broader population (Patton, 1990). This is the standard approach in case study research.

Four criteria guided the selection. First, all firms had to operate in manufacturing or a closely related industrial sector, because the Altman Z-score which is the primary creditworthiness measure in this study, it was developed and validated specifically for manufacturing firms (Altman, 1968). Second, each firm had to have a clearly identifiable automation investment event within a five-year observation window available in Orbis Europe. Third, five consecutive years of complete financial data had to be available for each firm. Fourth, the sample had to span different sectors and include at least one SME, in order to test H3, that the creditworthiness effect of automation differs by firm size.

The resulting sample is the following:

Firm	Company	Country	Sector	Size	Auto. Year	Data Window
1	Ferrari	Italy	Automotive / Luxury	Large	2024	2021–2025
2	Novo Nordisk	Denmark	Pharmaceuticals	Large	2024	2021–2025
3	Pirelli	Italy	Tyre Manufacturing	Large	2017	2014–2018
4	Brembo	Italy	Auto. Components	Large	2023	2020–2024
5	Centrale del Latte di Brescia	Italy	Food and Dairy	SME	2016	2015–2019
6	Airbus	France/Germany	Aerospace	Large	2023	2020–2024

Table 3.2: Firm profile and observation period

Four of the six firms are Italian, which reflects the focus on the Industria 4.0 incentive framework that the Italian government introduced in 2017 and which provided significant tax credits for automation investment in manufacturing. Ferrari (Firm 1), Pirelli (Firm 3), and Brembo (Firm 4) all operate within this context. Centrale del Latte di Brescia (Firm 5) is the explicit SME comparator in this study, with total assets ranging from €36 to €43 million across the observation window which is roughly 200 times smaller than Ferrari and over 1,500 times smaller than Airbus. Novo Nordisk and Airbus were included to extend the study beyond Italy and to cover other manufacturing sectors.

These six firms are not homogeneous, they differ enormously in size, sector, and national context. That is intentional as the variation is what allows us to test H3, but it also means that findings need to be interpreted carefully. A pattern that holds across the three Italian automotive firms does not automatically extend to an aerospace firm or a Danish pharmaceutical company.

The previous table shows the pre-automation and post-automation periods for each firm. Pre-automation is defined as all years before the investment year. Post-automation includes the investment year and all subsequent years in the window.

Centrale del Latte di Brescia only has one pre-automation year, this means the pre-automation baseline for this firm rests on a single data point rather than a three-year average. This makes the before-and-after comparison less robust for Firm 5.

3.3 Data Sources

All financial data in this study was extracted from Orbis Europe, the financial database maintained by Bureau van Dijk, a Moody's Analytics company. It is one of the most widely used databases in academic research on firm-level finance, because it standardises data across different national accounting formats, making cross-country comparison reliable (Kalemli-Ozcan et al., 2015).

For each of the six firms, five years of balance sheet and income statement data were extracted, centred on the automation investment year. All figures are in euros but for Novo Nordisk, which reports in Danish krone in its native accounts, Orbis Europe provides euro-converted figures at the prevailing rate for each year. For Airbus, the consolidated group-level financials are used.

Staff costs for Ferrari (Firm 1) were not available in Orbis Europe for any year of the observation window. This means the labour cost ratio, which is one of the operational metrics used to confirm that automation changed the firm's cost structure cannot be computed for Ferrari. This does not affect any of the creditworthiness metrics, all of which rely only on balance sheet and income statement data, but it is a limitation that applies specifically to section 3.4 and is noted throughout the analysis wherever relevant.

3.4 Metrics and Analytical Framework

For each firm, the pre-automation average and the post-automation average of every metric are computed and the change between the two is the primary basis for the analysis in Chapter 5. The following metrics are used:

Altman Z-Score

As described in section 2.2, the Altman Z-score is the primary creditworthiness measure in this study. The formula applied is:

$$Z = 1.2A + 1.4B + 3.3C + 0.6D + 1.0E$$

Where:

A = Working Capital / Total Assets

B = Retained Earnings / Total Assets

C = EBIT / Total Assets

D = Shareholders' Equity / Total Liabilities

E = Operating Revenue / Total Assets

A score below 1.81 signals distress, above 2.99 signals safety, and between the two is the grey zone. All inputs come directly from the Orbis data. For firms where the market value of equity is not available, the book value of shareholders' equity is used in D which is the standard practice when applying the model to non-listed or partially listed companies (Altman, 1968).

The previous table shows the computed Altman Z-score for every firm in every year of its observation window, calculated directly from the Orbis data used in this study.

Firm	Company	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
1	Ferrari	—	—	—	—	—	—	—	2.08	2.11	2.48	2.43	2.64
2	Novo Nordisk	—	—	—	—	—	—	—	2.48	2.50	2.48	2.08	2.08
3	Pirelli	1.84	1.79	1.02	1.25	1.28	—	—	—	—	—	—	—
4	Brembo	—	—	—	—	—	—	2.26	2.44	2.76	2.71	2.64	—
5	C. del Latte	—	2.91	2.86	2.89	3.02	3.34	—	—	—	—	—	—
6	Airbus	—	—	—	—	—	—	0.95	1.52	1.58	1.42	1.39	—

Table 3.4: Altman's Z-score for each company through the years

We notice that **Airbus** sits in the distress zone across the entire observation window which is a structural characteristic of aerospace firms, whose balance sheets carry enormous advance payments from airline customers that inflate current liabilities and compress the working capital component of the Z-score.

Centrale del Latte sits in or near the safe zone throughout, consistent with a conservative SME carrying very low leverage.

Pirelli's score collapses from 1.84 in 2014 to 1.02 in 2016, which is explained entirely by the ChemChina acquisition that year rather than any deterioration in operations where intangible assets jumped from €969 million to €6.5 billion in a single year, distorting the total asset base and all ratios that use it as a denominator.

Debt Metrics:

Cost of Debt

Cost of Debt = Interest Expenses / Total Debt

Total debt is the sum of short-term and long-term debt from the balance sheet. A falling cost of debt after the automation investment would suggest lenders are pricing the firm as less risky, consistent with the arguments in section 2.3 that automation lowers earnings variance and

provides tangible collateral. The cost of debt figures across the six firms range **from Centrale del Latte's** 0.17%–0.46%, reflecting its minimal debt position, to **Pirelli's** 15.74% in 2015, which reflected currency-denominated debt that normalised to 3.03% by 2018 after the ownership restructuring.

Interest Coverage Ratio

Interest Coverage Ratio = EBIT / Interest Expenses

A rising ICR after automation means the firm is generating more operating profit relative to its interest owed, a direct signal to lenders that it is a safer borrower. The figures in this sample range enormously. Novo Nordisk posted an ICR of 142.69x in 2021, meaning its EBIT was nearly 143 times its annual interest expense. Pirelli at its weakest recorded 1.70x in 2016, meaning only a modest drop in earnings would have made it unable to cover its interest. These extremes highlight why cross-case comparison needs to account for firm-specific context, not just the direction of the ratio.

Debt-to-Equity Ratio

The debt-to-equity ratio measures how much of a firm's financing comes from debt versus shareholders' equity. It is used here to track whether firms take on more leverage to fund automation which you would expect if the investment is debt-financed and whether that leverage then falls as improved earnings allow the firm to deleverage over time.

Debt-to-Equity Ratio = Total Debt / Shareholders' Equity

Operational Metrics

Three additional metrics are included to confirm that the automation investment actually changed each firm's operations in the way theory predicts. These are not creditworthiness

measures in themselves, but they validate the financial findings by showing the operational mechanism at work.

Labour Cost Ratio (staff costs / operating revenue). If automation is substituting labour, this ratio should fall after the investment. A declining labour cost ratio is evidence that the automation had real operational impact that it is the mechanism described in section 2.1 where variable labour costs shift to fixed capital costs. This metric cannot be calculated for Ferrari due to the missing staff cost data.

Capital Intensity (tangible fixed assets / total assets). This is the primary indicator used to identify the automation investment event across all six firms. An increase in capital intensity in the investment year driven by new machinery and equipment purchases confirms that a significant capital event took place. The scale of this increase varies across the sample: Novo Nordisk shows a 79.4% jump in tangible fixed assets in 2024, the largest in the sample by a wide margin. At the other hand, Centrale del Latte shows a 1.0% decline in 2016, which creates a methodological challenge. The automation year for Firm 5 is therefore identified from annual report evidence rather than the balance sheet spike used for the other five firms.

EBITDA Margin (EBITDA / operating revenue). An improving EBITDA margin after automation is consistent with cost savings from labour substitution and productivity gains. Over time, higher margins strengthen debt-repayment capacity, which feeds back into improved creditworthiness.

It should be noted that this chapter does not include a separate limitations section, as they are discussed more in depth throughout Chapter 5 rather than listed abstractly in advance. The most important of these, including the Pirelli acquisition distortion, the Airbus COVID baseline, the single pre-automation year for Centrale del Latte, and the missing Ferrari staff costs, are all flagged explicitly at the points in the analysis where they matter.

4. Firm Profile

Before moving into the analysis in Chapter 5, this chapter introduces the six firms one by one. Each firm gets a short profile covering what the company does, what its automation investment looked like in the data, and any confounding factors that need to be flagged upfront so the reader is already prepared when they show up in the results.

4.1 Firm 1 – Ferrari

FIRM 1 — FINANCIAL DATA INPUT					
Company Name:	Company 1 — Ferrari				
Automation Investment Year (T=0):					2024
2024					
Variable	2021	2022	2023	2024	2025
BALANCE SHEET					
Total Assets (€)	6,863,505,000	7,765,823,000	8,051,312,000	9,497,146,000	9,628,352,000
Tangible Fixed Assets (€)	1,353,165,000	1,457,825,000	1,575,200,000	1,828,784,000	2,057,891,000
Intangible Fixed Assets (€)	1,923,355,000	2,092,570,000	2,204,881,000	2,330,846,000	2,423,639,000
Current Assets (€)	3,363,719,000	3,952,512,000	3,986,007,000	5,019,903,000	4,824,373,000
Current Liabilities (€)	2,190,156,000	2,912,942,000	2,797,210,000	3,485,922,000	3,207,537,000
Working Capital (€)	1,173,563,000	1,039,570,000	1,188,797,000	1,533,981,000	1,616,836,000
Total Debt — Short Term (€)	492,097,000	568,848,000	724,423,000	848,730,000	918,593,000
Total Debt — Long Term (€)	2,113,892,000	1,832,386,000	1,736,313,000	2,017,611,000	1,921,911,000
Total Debt (€)	2,605,989,000	2,401,234,000	2,460,736,000	2,866,341,000	2,840,504,000
Shareholders Equity (€)	2,211,416,000	2,602,487,000	3,070,622,000	3,543,238,000	3,914,742,000
Retained Earnings (€)	2,208,843,000	2,599,914,000	3,068,049,000	3,540,665,000	3,912,169,000
Total Liabilities (€)	4,652,089,000	5,163,336,000	4,980,690,000	5,953,908,000	5,713,610,000
INCOME STATEMENT					
Operating Revenue (€)	4,278,999,000	5,107,700,000	5,981,104,000	6,698,486,000	7,166,956,000
EBITDA (€)	1,734,401,000	2,041,995,000	2,273,537,000	2,546,283,000	2,759,080,000
EBIT (€)	1,068,592,000	1,221,207,000	1,611,232,000	1,879,506,000	2,097,144,000
Interest Expenses (€)	56,910,000	81,341,000	36,118,000	46,808,000	46,996,000
Staff Costs (€)	-	-	-	-	-
Depreciation (€)	665,809,000	820,788,000	662,305,000	666,777,000	661,936,000

Ferrari is the Italian luxury automotive manufacturer based in Maranello. Across the observation window from 2021 to 2025, the firm shows a consistent growth profile, with revenue rising from €4.28 billion to €7.17 billion, an increase of around 67% in five years.

The automation investment event in 2024 is visible in the balance sheet, where tangible fixed assets jumped from €1.58 billion in 2023 to €1.83 billion in 2024, a 16.1% increase. This corresponds to Ferrari's factory expansion in Maranello, including the new e-building facility built to support hybrid and electric vehicle production. Capital intensity stays around 19-21% across the window, with a small upward shift post-2024.

Ferrari does not report staff cost data in Orbis Europe for any of the five years, so the labour cost ratio cannot be computed for this firm. The cost of debt drops from 2.18% in 2021 to 1.47% by 2023, before stabilising around 1.65% after automation. The interest coverage ratio is consistently strong, ranging between 15x and 44x, reflecting Ferrari's high operating margins and modest debt load.

4.2 Firm 2 - Novo Nordisk

FIRM 2 — FINANCIAL DATA INPUT					
Company Name:	Company 2 — Novo Nordisk				
Automation Investment Year (T=0):					2024
2024					
Variable	2021	2022	2023	2024	2025
BALANCE SHEET					
Total Assets (€)	**26,174,447,747**	**32,442,080,530**	**42,196,476,548**	**62,769,217,832**	**72,731,964,890**
Tangible Fixed Assets (€)	7,449,923,788	8,965,318,938	12,204,784,007	21,896,423,678	27,916,164,206
Intangible Fixed Assets (€)	5,809,411,868	6,913,963,170	8,105,036,035	14,970,174,452	17,423,052,834
Current Assets (€)	11,518,301,843	14,548,960,075	18,737,143,034	21,682,025,014	23,103,332,722
Current Liabilities (€)	13,391,615,471	16,262,927,995	22,763,630,905	29,313,458,531	28,891,859,452
Working Capital (€)	(1,873,313,628)	(1,713,967,920)	(4,026,487,871)	(7,631,433,517)	(5,788,526,730)
Total Debt — Short Term (€)	1,730,806,686	64,546,101	711,669,555	866,758,143	1,331,114,645
Total Debt — Long Term (€)	1,744,128,865	3,270,066,835	2,754,365,125	12,084,214,815	15,934,390,804
Total Debt (€)	3,474,935,551	3,334,612,936	3,466,034,680	12,950,972,958	17,265,505,449
Shareholders Equity (€)	9,520,109,611	11,226,449,534	14,297,929,757	19,335,767,859	25,996,256,398
Retained Earnings (€)	9,457,939,444	11,165,130,738	14,237,416,376	19,275,666,159	25,936,506,284
Total Liabilities (€)	16,654,338,136	21,215,630,996	27,898,546,792	43,433,449,973	46,735,708,492
INCOME STATEMENT					
Operating Revenue (€)	18,994,466,286	23,949,830,723	31,244,896,470	39,133,887,581	41,404,953,374
EBITDA (€)	8,702,343,150	11,049,620,111	15,025,968,785	19,869,406,268	20,047,100,998
EBIT (€)	7,891,574,196	10,059,644,289	13,762,970,006	17,294,600,945	17,102,197,402
Interest Expenses (€)	55,307,227	75,169,313	99,156,071	259,946,589	904,557,778
Staff Costs (€)	4,916,018,493	5,995,929,356	7,448,646,996	9,086,002,452	10,379,237,836
Depreciation (€)	810,768,954	989,975,822	1,262,998,778	2,574,805,322	2,944,903,596

Novo Nordisk is a Danish pharmaceutical company specialising in diabetes care and obesity treatments. The firm experienced extraordinary growth across the observation window, with

revenue rising from €18.99 billion in 2021 to €41.40 billion in 2025, more than doubling in four years. This growth is driven almost entirely by global demand for the company's GLP-1 drugs, Ozempic and Wegovy. The automation event in 2024 is the largest in the entire sample. Tangible fixed assets jumped from €12.20 billion in 2023 to €21.90 billion in 2024, a 79.4% increase in a single year. This represents Novo Nordisk's massive scaling of manufacturing capacity to keep up with GLP-1 demand, including new production facilities in Denmark, the US, and France which lead a rise in Capital intensity from around 28% in the pre-period to 38% by 2025.

To fund this expansion Novo Nordisk took on significantly more debt, more than doubling the debt-to-equity ratio, from 0.24 in 2023 to 0.67 in 2024, and the interest coverage ratio falls from 138.80x in 2023 to 18.91x in 2025, not because operating profit fell but because interest expenses rose sharply alongside the new debt.

4.3 Firm 3 – Pirelli

FIRM 3 — FINANCIAL DATA INPUT					
Company Name:	Company 3 — Pirelli				
Automation Investment Year (T=0):					2017
2017					
Variable	2014	2015	2016	2017	2018
BALANCE SHEET					
Total Assets (€)	7,673,039,000	7,238,117,000	14,366,461,000	12,733,914,000	13,031,697,000
Tangible Fixed Assets (€)	2,522,464,000	2,419,453,000	3,556,635,000	2,980,294,000	3,092,927,000
Intangible Fixed Assets (€)	984,002,000	968,541,000	6,496,889,000	5,893,704,000	5,783,338,000
Current Assets (€)	3,369,272,000	3,180,137,000	3,680,540,000	3,269,117,000	3,677,818,000
Current Liabilities (€)	2,591,949,000	3,033,540,000	3,063,548,000	2,910,223,000	3,006,030,000
Working Capital (€)	777,323,000	146,597,000	616,992,000	358,894,000	671,788,000
Total Debt — Short Term (€)	529,103,000	613,094,000	641,987,000	559,064,000	799,942,000
Total Debt — Long Term (€)	1,781,726,000	1,275,688,000	5,945,999,000	3,897,089,000	3,929,079,000
Total Debt (€)	2,310,829,000	1,888,782,000	6,587,986,000	4,456,153,000	4,729,021,000
Shareholders Equity (€)	2,611,502,000	2,343,544,000	3,274,858,000	4,177,009,000	4,550,927,000
Retained Earnings (€)	1,268,217,000	1,000,259,000	1,932,577,000	2,272,634,000	2,646,552,000
Total Liabilities (€)	5,061,537,000	4,894,573,000	11,091,603,000	8,556,905,000	8,480,770,000
INCOME STATEMENT					
Operating Revenue (€)	6,222,139,000	6,478,268,000	6,257,147,000	6,367,939,000	5,686,514,000
EBITDA (€)	1,159,177,000	1,191,497,000	1,118,854,000	1,064,311,000	1,116,302,000
EBIT (€)	854,322,000	864,493,000	726,478,000	674,082,000	701,692,000
Interest Expenses (€)	200,497,000	297,207,000	427,467,000	311,428,000	143,491,000
Staff Costs (€)	1,239,770,000	1,295,130,000	1,217,846,000	1,106,205,000	1,070,106,000
Depreciation (€)	304,855,000	327,004,000	392,376,000	390,229,000	414,610,000

Pirelli is an Italian tire manufacturer, primarily known for high-performance and premium tyres. The observation window runs from 2014 to 2018, with the automation investment year identified as 2017.

Pirelli is the most complicated firm in the sample because of the ChemChina acquisition that completed in 2015 and the restructuring that ran through 2016 and 2017. Intangible assets jumped from €969 million in 2015 to €6.5 billion in 2016, mostly representing goodwill recognised on acquisition. This distorts the Altman Z-score in 2016, which collapses to 1.02 despite no operational distress.

Revenue stays in a tight range of €5.69 to €6.48 billion, showing operations were stable. What changed was the capital structure, the debt-to-equity ratio jumps from 0.81 in 2015 to 2.01 in 2016 before normalising to around 1.05 post-automation. The cost of debt peaks at 15.74% in 2015 due to currency-denominated debt, then falls to 3.03% by 2018 after refinancing.

4.4 Firm 4 – Brembo

FIRM 4 — FINANCIAL DATA INPUT					
Company Name:	Company 4 — Brembo				
Automation Investment Year (T=0):					2023
2023					
Variable	2020	2021	2022	2023	2024
BALANCE SHEET					
Total Assets (€)	3,172,746,000	3,683,289,000	3,845,112,000	4,173,868,000	4,630,090,000
Tangible Fixed Assets (€)	1,183,280,000	1,274,733,000	1,367,832,000	1,522,879,000	1,774,996,000
Intangible Fixed Assets (€)	219,567,000	297,319,000	300,422,000	300,732,000	311,425,000
Current Assets (€)	1,412,861,000	1,651,018,000	1,739,382,000	1,847,238,000	2,301,712,000
Current Liabilities (€)	844,248,000	1,056,332,000	1,195,305,000	1,340,901,000	1,482,373,000
Working Capital (€)	568,613,000	594,686,000	544,077,000	506,337,000	819,339,000
Total Debt — Short Term (€)	176,272,000	225,286,000	241,814,000	330,274,000	425,839,000
Total Debt — Long Term (€)	736,588,000	721,639,000	618,709,000	638,080,000	719,537,000
Total Debt (€)	912,860,000	946,925,000	860,523,000	968,354,000	1,145,376,000
Shareholders Equity (€)	1,481,041,000	1,796,120,000	1,947,013,000	2,099,419,000	2,329,817,000
Retained Earnings (€)	1,446,313,000	1,761,392,000	1,912,285,000	2,064,691,000	2,322,810,000
Total Liabilities (€)	1,691,705,000	1,887,169,000	1,898,099,000	2,074,449,000	2,300,273,000
INCOME STATEMENT					
Operating Revenue (€)	2,230,600,000	2,798,844,000	3,661,420,000	3,894,328,000	3,886,078,000
EBITDA (€)	376,578,000	485,037,000	624,187,000	665,717,000	658,565,000
EBIT (€)	169,028,000	270,322,000	381,827,000	414,011,000	390,842,000
Interest Expenses (€)	19,522,000	13,351,000	20,336,000	43,608,000	50,953,000
Staff Costs (€)	425,045,000	506,617,000	616,180,000	681,620,000	729,547,000
Depreciation (€)	207,550,000	214,715,000	242,360,000	251,706,000	267,723,000

Brembo is an Italian manufacturer of high-performance braking systems, supplying the premium automotive sector and motorsports. The observation window runs from 2020 to 2024, with the automation investment in 2023.

Brembo offers the cleanest automation story in the sample. Revenue grew from €2.23 billion in 2020 to €3.89 billion in 2024, a 74% increase, tangible fixed assets rose from €1.37 billion in 2022 to €1.52 billion in 2023, an 11.3% increase, reflecting investment in robotic production lines, the cost of debt rises from 1.41% in 2021 to 4.50% in 2023, consistent with new debt taken on to fund automation in a higher interest rate environment. The Altman Z-score is stable, moving from 2.49 pre-automation to 2.67 post-automation.

4.5 Firm 5 - Centrale del Latte di Brescia

FIRM 5 — FINANCIAL DATA INPUT					
Company Name:	Company 5 — Centrale del latte di brescia				
Automation Investment Year (T=0):					2016
2016					
Variable	2015	2016	2017	2018	2019
BALANCE SHEET					
Total Assets (€)	**36,451,271**	**38,768,567**	**40,835,868**	**43,448,169**	**39,767,892**
Tangible Fixed Assets (€)	18,146,024	17,966,692	17,861,170	20,182,994	19,888,791
Intangible Fixed Assets (€)	70,443	77,632	130,476	42,381	28,656
Current Assets (€)	17,751,521	20,240,960	22,840,267	23,216,839	19,844,490
Current Liabilities (€)	11,830,574	13,515,428	14,968,660	14,690,561	11,190,951
Working Capital (€)	5,920,947	6,725,532	7,871,607	8,526,278	8,653,539
Total Debt — Short Term (€)	1,507,616	1,909,338	3,855,337	3,247,860	1,342,724
Total Debt — Long Term (€)	8,471,671	8,053,058	7,617,102	8,917,670	7,940,259
Total Debt (€)	9,979,287	9,962,396	11,472,439	12,165,530	9,282,983
Shareholders Equity (€)	14,895,080	16,024,693	17,248,983	18,783,692	19,482,312
Retained Earnings (€)	7,238,648	8,368,261	9,592,551	11,127,260	11,825,880
Total Liabilities (€)	21,556,191	22,743,874	23,586,885	24,664,477	20,285,580
INCOME STATEMENT					
Operating Revenue (€)	58,452,346	60,259,129	65,842,877	71,024,280	71,105,625
EBITDA (€)	6,352,720	5,941,732	4,931,098	6,137,963	5,298,386
EBIT (€)	4,648,961	4,383,616	3,466,899	4,391,911	3,566,165
Interest Expenses (€)	45,928	37,961	33,767	38,573	16,091
Staff Costs (€)	5,459,076	5,746,010	6,118,821	6,325,180	6,268,223
Depreciation (€)	1,703,759	1,558,116	1,464,199	1,746,052	1,732,221

Centrale del Latte di Brescia is a regional Italian dairy producer based in Lombardy. With total assets between €36 million and €43 million, it is by far the smallest firm in the sample and the only SME. Revenue moves from €58 million in 2015 to €71 million in 2019.

The automation investment year is 2016, but it is the most methodologically challenging in the sample. Tangible fixed assets actually declined slightly in 2016 by 1.0%, rather than rising. The automation event for this firm is identified from annual report disclosures rather than the balance sheet spike used for the other five firms. Capital intensity sits around 46-50% throughout, which is high and reflects the asset-heavy nature of dairy production.

Centrale del Latte has the most conservative financing profile in the sample. The cost of debt ranges from 0.17% to 0.46%, an extremely low figure, reflecting minimal debt use. The interest coverage ratio is consistently very high, between 101x and 222x. The Altman Z-score sits in or near the safe zone throughout, rising from 2.91 in 2015 to 3.34 by 2019.

4.6 Firm 6 – Airbus

FIRM 6 — FINANCIAL DATA INPUT					
Company Name:	Company 6 — Airbus				
Automation Investment Year (T=0):					2023
2023					
Variable	2020	2021	2022	2023	2024
BALANCE SHEET					
Total Assets (€)	55,988,062,000	59,368,754,000	65,736,788,000	60,508,010,000	63,328,569,000
Tangible Fixed Assets (€)	2,372,742,000	2,398,330,000	2,489,416,000	2,554,315,000	2,620,466,000
Intangible Fixed Assets (€)	67,701,000	47,166,000	43,021,000	50,011,000	49,062,000
Current Assets (€)	37,397,615,000	40,710,072,000	46,931,991,000	41,442,824,000	44,253,466,000
Current Liabilities (€)	41,700,375,000	17,858,692,000	25,164,906,000	27,054,328,000	27,388,947,000
Working Capital (€)	(4,302,760,000)	22,851,380,000	21,767,085,000	14,388,496,000	16,864,519,000
Total Debt — Short Term (€)	0	48,413,000	251,799,000	274,374,000	253,369,000
Total Debt — Long Term (€)	1,622,822,000	1,509,962,000	1,566,194,000	1,627,750,000	687,224,000
Total Debt (€)	1,622,822,000	1,558,375,000	1,817,993,000	1,902,124,000	940,593,000
Shareholders Equity (€)	7,330,817,000	9,743,554,000	11,549,539,000	5,341,043,000	3,963,786,000
Retained Earnings (€)	8,438,088,000	9,739,977,000	11,545,962,000	5,337,462,000	3,960,205,000
Total Liabilities (€)	48,657,246,000	49,625,200,000	54,187,249,000	55,133,967,000	59,364,781,000
INCOME STATEMENT					
Operating Revenue (€)	39,996,441,000	41,058,634,000	50,939,077,000	55,052,123,000	57,955,086,000
EBITDA (€)	1,344,239,000	448,833,000	1,057,041,000	895,279,000	669,153,000
EBIT (€)	450,558,000	321,717,000	580,290,000	791,829,000	502,603,000
Interest Expenses (€)	231,992,000	19,273,000	70,222,000	56,106,000	62,120,000
Staff Costs (€)	1,193,866,000	1,327,086,000	1,200,597,000	1,419,298,000	1,497,099,000
Depreciation (€)	893,681,000	127,116,000	476,751,000	103,450,000	166,550,000

Airbus is the European aerospace firm headquartered across France and Germany, primarily manufacturing commercial aircraft and defence systems. The observation window runs from 2020 to 2024, with the automation investment year identified as 2023.

Airbus carries a major confounding event in 2020, the COVID-19 pandemic grounded commercial aviation globally, producing an unusually weak pre-automation baseline. The Altman Z-score for 2020 sits at 0.95, deep in the distress zone, and the cost of debt peaks at 14.30% that year before normalising. EBITDA margin was just 3.36% in 2020.

The automation investment in 2023 is modest in scale. Tangible fixed assets rose from €2.49 billion in 2022 to €2.55 billion in 2023, a 2.6% increase. Capital intensity sits around 4% throughout, which is structurally low because of Airbus's enormous advance payment balances from airline customers, which inflate current liabilities and dominate the balance sheet, which also explains why the Z-score stays in the distress zone across the entire window despite Airbus being a stable, globally significant manufacturer.

5. Results and Analysis

This chapter presents the results across all six firms, organised metric by metric rather than firm by firm, which makes patterns easier to see. The analysis follows the three hypotheses from section 2.5. H1 deals with the Altman Z-score, H2 with financing conditions, and H3 with the SME versus large firm comparison.

5.1 Altman's Z-Score Analysis

Firm	Company	Pre-Auto Avg	Post-Auto Avg	Change	Direction
1	Ferrari	2.22	2.54	+0.31	Improved
2	Novo Nordisk	2.49	2.08	-0.40	Worsened
3	Pirelli	1.55	1.27	-0.28	Worsened
4	Brembo	2.49	2.67	+0.19	Improved
5	Centrale del Latte	2.91	3.03	+0.12	Improved
6	Airbus	1.35	1.40	+0.06	Slight improvement

Four of the six firms show an improvement in the Altman Z-score after their automation investment. Ferrari, Brembo, Centrale del Latte, and Airbus all move in the direction H1 predicts. Novo Nordisk and Pirelli both deteriorate, but both have clear explanations that sit outside the automation event itself.

Ferrari shows the largest improvement at +0.31, moving from 2.22 to 2.54. The improvement is driven by stronger working capital management, lower leverage (Debt/Equity falling from 0.97 to 0.77), and revenue growing faster than the asset base.

Brembo improves by +0.19, from 2.49 to 2.67. The trajectory peaks at 2.76 in 2022 before settling slightly lower, but the post-automation average is still higher than pre-automation. Brembo is the cleanest case in the sample with no significant confounds.

Centrale del Latte improves by +0.12, moving from 2.91 to 3.03. This crossing of the 2.99 threshold is meaningful as the firm moves from the grey zone into the safe zone after automation. By 2019 the Z-score reaches 3.34. This is the most interesting result for H3, as it shows that even a small SME can produce a measurable shift in financial profile after automation.

Airbus shows a marginal improvement of +0.06, from 1.35 to 1.40. Both figures sit in the distress zone, but as noted in section 4.6, this is a structural feature of aerospace balance sheets, not real financial distress. The small improvement also reflects a partial recovery from the COVID-distorted 2020 baseline.

Novo Nordisk deteriorates by -0.40, from 2.49 to 2.08. This is explained almost entirely by the financing structure of the expansion. The firm doubled its debt, which directly reduced the X4 component of the Z-score (equity/liabilities) and increased the denominator in X3 (EBIT/total assets). EBITDA margin improved over the same period, confirming the underlying business strengthened even as the Z-score fell.

Pirelli deteriorates by -0.28, from 1.55 to 1.27. The pre-automation average is already depressed because it includes the acquisition-distorted 2016 figure of 1.02. Pirelli's result is the least informative for H1 and should be read with the ChemChina context in mind.

Overall, the Altman Z-score evidence partially supports H1. Of the four firms with relatively clean automation events, three improved and one (Airbus) improved only marginally from a distressed baseline. Both firms that deteriorated had identifiable non-automation explanations.

5.2 Financing Conditions

Firm	Company	CoD Pre	CoD Post	CoD Δ	ICR Pre	ICR Post
1	Ferrari	2.35%	1.64%	-0.70%	26.13x	42.39x
2	Novo Nordisk	2.24%	3.62%	+1.39%	138.44x	42.72x
3	Pirelli	10.30%	5.01%	-5.29%	2.96x	3.53x
4	Brembo	1.97%	4.48%	+2.51%	15.89x	8.58x
5	Centrale del Latte	0.46%	0.29%	-0.17%	101.22x	138.41x
6	Airbus	6.46%	4.78%	-1.69%	8.97x	11.10x

Four firms see a decline in their cost of debt after automation, Ferrari, Pirelli, Centrale del Latte, and Airbus. Two firms see an increase , Novo Nordisk and Brembo. Both increases are explainable: Novo Nordisk took on substantial new debt to fund its GLP-1 manufacturing expansion, and Brembo's increase reflects the general rise in European interest rates between 2021 and 2023 rather than any firm-specific risk repricing.

Pirelli's cost of debt fall from 10.30% to 5.01% is the largest in the sample, a 5.29 percentage point reduction. However, this is driven mostly by the post-acquisition debt refinancing rather than the automation event itself. Ferrari and Centrale del Latte show smaller but cleaner declines. Airbus's drop from 6.46% to 4.78% reflects partial normalisation away from its 2020 spike.

The interest coverage ratio results are more clearly aligned with H2. Four firms: Ferrari, Pirelli, Centrale del Latte, and Airbus show improvements, meaning operating profit covers their interest bill more comfortably after automation. Centrale del Latte goes from 101.22x to 138.41x and Ferrari from 26.13x to 42.39x, both substantial improvements. Brembo and Novo Nordisk show declining ICRs, but in both cases the cause is a rise in absolute interest expenses rather than weakening operating profitability.

Reading both metrics together, H2 receives moderate support. Four out of six firms saw improved financing conditions after their automation investment, even in an environment of generally rising interest rates.

5.3 Operational Confirmation

Firm	Company	LCR Pre	LCR Post	CapInt Pre	CapInt Post	EBITDA Mgn Δ
1	Ferrari	N/A	N/A	19.35%	20.31%	-1.25 pp
2	Novo Nordisk	24.92%	24.14%	28.34%	36.63%	+2.92 pp
3	Pirelli	19.79%	18.09%	30.35%	23.57%	-0.13 pp
4	Brembo	18.00%	18.14%	35.83%	37.41%	-0.07 pp
5	Centrale del Latte	9.34%	9.14%	49.78%	46.64%	-2.51 pp
6	Airbus	2.86%	2.58%	4.02%	4.18%	-0.79 pp

The labour cost ratio falls in four of the five firms where it can be computed, Novo Nordisk, Pirelli, Centrale del Latte, and Airbus all show modest declines. Brembo shows a negligible increase of 0.14 percentage points, which is essentially flat. This is broadly consistent with the mechanism in section 2.1, where automation shifts variable labour costs into fixed capital costs.

Capital intensity rises in four of the six firms, Ferrari, Novo Nordisk, Brembo, and Airbus. Pirelli shows a drop in capital intensity, explained by the ChemChina acquisition expanding total assets through goodwill rather than by any reduction in machinery. Centrale del Latte's small decline is consistent with the methodological note that its 2016 automation event is not captured by the balance sheet spike used for the other firms.

EBITDA margin tells a more mixed story. Only Novo Nordisk shows a meaningful improvement, up 2.92 percentage points. The other five firms are either flat or slightly negative. This is worth noting but not surprising as automation generates higher depreciation from new equipment in the short term, which can offset labour savings. The longer-term margin effect simply falls outside the five-year window used here.

5.4 Cross-Case Patterns

Bringing the three hypotheses together, several patterns emerge from the six cases.

The Italian automotive cluster, Ferrari, Brembo, and Pirelli show the most internally consistent results. Ferrari and Brembo both improve on the Z-score with clean balance sheet signals, and Pirelli's post-acquisition financing conditions are visibly cleaner. The Industria 4.0 framework that ran in Italy from 2017 appears to have produced measurable balance sheet changes in firms that used it, which supports the broader argument that automation investment under structured fiscal incentives translates into observable financial improvements.

The SME comparator, Centrale del Latte, is the most interesting finding for H3. Despite its small scale and the methodological problem with identifying its automation event, the firm shows improvements across most metrics: Z-score up, cost of debt down, ICR up, labour cost ratio down. The improvements are smaller in absolute terms but consistent in direction. This is consistent with the argument in section 2.4 that automation can shift an SME from relationship lending toward transaction lending by making its operations more legible to creditors.

The two non-Italian large firms sit at opposite ends. Novo Nordisk is a case where automation was massively scaled and financed with new debt, and where the demand-driven revenue surge makes it impossible to isolate the automation effect cleanly. Airbus is a case where the pre-automation baseline was severely depressed by COVID-19. Both firms confirm that confounding factors are not exceptions in firm-level financial data, they are the rule, and the case study frame is what allows them to be dealt with.

Reading across all three hypotheses: H1 is partially supported, with four of six firms showing Z-score improvement and the two exceptions explained by confounds. H2 receives moderate support, with mixed cost-of-debt results but consistent ICR improvement in four firms. H3 is directionally supported by Centrale del Latte, but a single SME is not enough to draw a general conclusion. A larger study would need more SMEs in the sample.

6. Conclusion

This thesis asked whether automation investment improves the creditworthiness and financing profile of European manufacturing firms. The question was tested using a longitudinal multiple case study of six firms across automotive, pharmaceuticals, tire manufacturing, aerospace, and food and dairy, with one SME comparator to five large firms. Financial data came from Orbis Europe and covered five years per firm, centred on each firm's automation investment year.

The results give a qualified yes. Four of the six firms, Ferrari, Brembo, Centrale del Latte, and Airbus, saw an improvement in their Altman Z-score after their automation investment. The two that did not, Novo Nordisk and Pirelli, both had identifiable confounding factors. Novo Nordisk's deterioration reflects the scale of new debt taken on for its GLP-1 manufacturing expansion, not any weakness in the automation itself. Pirelli's pre-automation period was distorted by the ChemChina acquisition that completed in 2015 and 2016. Once these confounds are accounted for, the evidence on H1 leans positive.

The financing condition picture is less clean but broadly consistent. Four firms saw their cost of debt fall after automation, and the interest coverage ratio also improved in four firms, including the SME and the COVID-affected aerospace firm. The two firms with worsening cost of debt, Novo Nordisk and Brembo saw the increase explained by debt-financed expansion and the general rise in European interest rates between 2021 and 2023, not by lenders repricing firm-specific credit risk. H2 is therefore partially supported.

On H3, the SME comparator showed improvements across nearly every metric. The improvements are small in absolute terms but consistent in direction, which is suggestive evidence that automation can shift an SME's financial profile in ways lenders value. The mechanism described in section 2.4, where automation digitises an SME and gives lenders access to hard information about its operations would predict exactly this pattern, but a single case cannot prove a general claim.

Several limitations apply. The most obvious is sample size where six firms cannot be statistically generalised to European manufacturing as a whole. The five-year window also limits what can be seen, as some benefits of automation, particularly margin expansion, take longer than two years to appear, which is consistent with the flat EBITDA margin results in section 5.3. The automation event itself is proxied by tangible fixed asset growth, which is imperfect, as the Centrale del Latte case showed.

While this study provides valuable preliminary insights and lays the conceptual groundwork for understanding the effects of automation on a firm's ability to take more leverage, the findings are constrained by the current sample size. To definitively test the proposed research hypotheses, future research should build upon this foundation by employing a substantially larger sample. Doing so will allow for rigorous econometric analysis, providing the statistical power necessary to make robust inferences and generalize these findings to a broader population.

Despite these limitations, the broader picture is consistent. Automation investment is associated with improved creditworthiness and financing conditions across most of the firms studied here, and the cases where it is not are explainable through identifiable events. The mechanisms identified in the literature review, lower earnings variance, more predictable cash flows, tangible collateral, and digitisation that lowers information asymmetry, all appear in the data in one form or another across the six cases. For a future study, expanding the sample to include more SMEs and a longer post-investment window would strengthen the conclusions considerably.

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