LUISS

Department
of Economics and Finance

Course of FINANCIAL MARKETS AND INSTITUTIONS

Credit rating forecasting model

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Academic Year 2021/2022

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INTRODUCTION

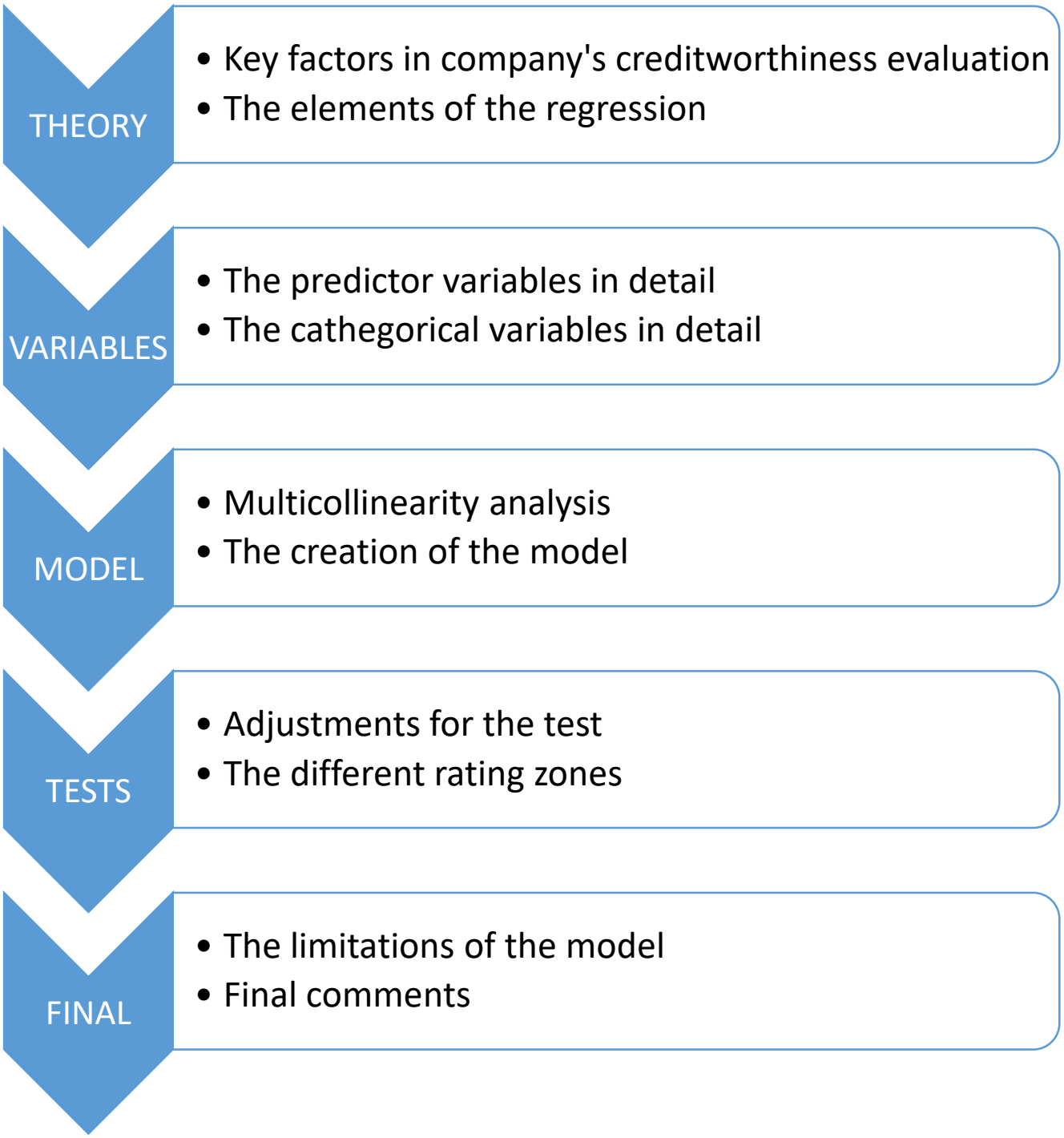
The purpose of this thesis is to create a quantitative model for credit rating evaluation. A model that is immediately applicable by collecting a small amount of data from a company's financial statement and that succeeds in giving investors valuable insights into firms' financial soundness.

A credit rating is an essential tool for the smooth functioning of financial markets. It reduces uncertainty and asymmetric information between creditors and debtors by indicating the ability of an entity to repay its obligations with a letter tag rating. There are three main credit rating agencies: "Standard & Poor's", "Moody's", and "Fitch". All of them employ a meticulous combination of quantitative and qualitative approaches to determine the credit score of a company. The overall process takes several weeks of data collection, elaboration, and verification to obtain a result for the client.

This paper tries to approximate the same result, with just a few minutes of data and outcome analysis, through a credit rating forecasting model. The main advantage of an examination based on a purely quantitative pillar is that it provides an objective outcome not influenced by any human assessment, corruption, or misleading behavior. The main disadvantage is the lack of accuracy in the predictions. As the next chapters show, the quantitative approach explains approximately only one-third of the necessary elements for a perfect rating evaluation.

After a brief clarification on the theory utilized for choosing the regression's independent variables, and some descriptive statistics of the data set employed, the thesis describes the consequential steps towards the creation of a forecasting framework. It examines each variable individually and then attempts to add them together. Lastly, it tests the final model on some random UK companies and provides comments on the outcome. Table 0.0 will help visualize the structure of the thesis.

TABLE 0.0, thesis map, source: author's elaboration



CHAPTER 1: KEY FACTORS IN COMPANIES' CREDIT WORTHINESS EVALUATION

There are many elements to consider for evaluating a company's ability to repay its obligations. Several of them cannot be analyzed without a deep study of the qualitative aspects of the business, like the relationship with customers and suppliers. Moreover, other factors are difficult to measure, such as the ability of the management to deal with periods of crisis. This thesis focus on those components of credit rating that are easily quantifiable and generally not too difficult to collect. This chapter shows the basis on which the predictor variables of chapter 3 are built, and why they are logically sound.

1.1 LEVERAGE

The leverage refers to the capital structure of the company. It is a measure of the quantity of debt issued to fund the firm's activities, and of the amount of risk borne by the equity holders. Three main ratios quantify this value straightforwardly: the debt to equity ratio, the debt to assets ratio, and the equity multiplier, which is the ratio between total assets and total equity. The rationale behind the calculation of these ratios is that the higher the amount of debt is, the higher the probability of a business defaulting on its obligations due to a lack of resources. Moreover, the variability of the returns on equity increases as the value of debt rises.

1.2 PROFITABILITY

The main source of cash and funds to repay a company's liabilities is its net profit from operating activities. A firm that is not able to generate a cash inflow from its main operations cannot sustain creditors' pressure and its position in the market. Two metrics are useful to understand the profit and cash flow of the business: net profit after taxes and cash flow from operating activities. The difference is that not every income corresponds to an actual cash inflow for the firm, and a consequent increase in the liquid assets available to repay obligations. Based on these elements, many other ratios and indexes can be created. The economic value added is another example because it compares companies' profits to investors' average expectations, and it gives an intuition about the firms' ability to sustain growth.

1.3 LIQUIDITY

Liquidity is the ability of a company to generate enough cash to cover its short-term liabilities. To assess such ability, there are some easy-to-calculate ratios: the current ratio, which is the percentage of current liabilities covered by the current assets; the "acid" ratio, which is similar to the current ratio but it does not allow for inventory products to be sold off to repay current liabilities; and the cash ratio, which is a stricter measure because it allows only for cash and marketable securities to cover short-term obligations. These values provide an understanding of how a firm manages its short-run obligations and of its ability to continue operating in the near future.

1.4 FINANCIAL STRENGTH

In this thesis, financial strength denotes the capability of a firm to pay dividends and repurchase debt or equity when needed. The necessary information to assess financial strength is summarized in the cash flow from financing activities, which is a portion of the cash flow statement that is calculated by subtracting the dividend paid and the repurchase of debt and equity in the last year from the amount of debt and equity issued in the same period. A negative cash flow from financing activities signals a solid position to investors since it reflects the ability to pay off debt and/or distribute dividends to equity holders.

1.5 COMPANY'S AGE

The company's age is a proxy for its tradition and reputation in the eyes of investors and rating agencies. This data provides information on the firm's ability to survive financial instability and economic turmoil over the years. The idea behind the calculation of a variable based on the company's age is to verify if businesses generate a sort of inertia that contributes to stability in their market position.

1.6 ECONOMIC SECTOR

Different economic sectors are affected diversely by the elements previously described. It is important to analyze each area independently and capture the effect it has on credit rating. As an example, sectors characterized by the ownership of a large number of tangible assets are more likely to be in the condition to sell them off to pay their liabilities. It is not the same for those companies

that belong to economic sectors with high investments in research and development, and whose value is deeply linked to human capital.

1.7 RELIABILITY OF INFORMATION

The lack of reliability in accounting information is a source of uncertainty for investors and a reason for the credit score to decrease. It is not possible to measure this element without extensive analysis of the specific financial statements. In order to approximate such a value, it is reasonable to assign a “reliability score” to the auditing agencies and collect data on the identity of the financial documents’ auditor for each firm. The rationale behind this process is to verify whether a company whose financial report has been audited by a famous auditor is perceived as a less risky one or not.

1.8 CONCLUSIONS

The next chapter will explain in detail the various elements of regression outputs. Tables and regression summaries will be used extensively to give a clearer picture of the outcomes of the credit rating analysis, and that is why it is important to describe briefly each of the components.

CHAPTER 2: THE ELEMENTS OF THE REGRESSION

In this chapter, there is a general description of the various elements shown in the regression summary. Clarifying the meaning of the different labels is essential to understanding the implications of the regression results.

2.1 MULTIPLE R

The multiple R or coefficient of correlation measures the tendency of two variables to move together. It is a standardized measure of covariance and takes values between -1 and 1, with 0 indicating no relationship between the variables. It is calculated as the ratio between the covariance and the product of the standard deviations of the two elements.

2.2 R^2

The R-squared, or R^2, or coefficient of determination measures the percentage of the variation in the dependent variable attributable to the variation in input values. It is particularly important to consider this number when the objective is to obtain a forecast of the output values by knowing only the independent ones. The higher the R^2 is, the better the regression line fits the data, and the more the model is suitable for predicting the phenomenon. R^2 can be obtained by calculating the ratio between the Explained Sum of Squares (ESS= $\sum(\hat{y} - \bar{y})$^2) of the regression output and the Total Sum of Squares (TSS = $\sum(y - \bar{y})$^2). A more direct way to obtain the same value is to square the coefficient of correlation.

2.3 ADJUSTED R^2

When dealing with multivariable regressions, there is a chance that the R^2 statistic might be overestimated because of the addition of irrelevant variables in the model. To avoid such a misleading result, the adjusted R^2 "penalizes" the R^2 for the number of not statistically significant regressors. The formula for the Adjusted R^2 is $(1 - \frac{n-1}{n-k-1}\frac{SSR}{TSS})$ where "n" is the number of observations, "k" is the number of variables in the model, and SSR and TSS are respectively the Sum of Squares due to Regression and the Total Sum of Squares.

2.4 STANDARD ERROR

The standard error estimates the standard deviation of the regression model's error of prediction. The formula is $(\sqrt[2]{\frac{SSR}{n-k-1}})$ where "n" is the number of observations, "k" is the number of independent variables, and SSR is the Sum of Squares due to Regression (SSR = $\sum(y-\hat{y})$^2) . The higher the sample's size is, the lower the standard error of prediction.

2.5 OBSERVATIONS

It is the number representing the size of the sample. A higher number of observations makes all the regression statistics more reliable because of the greater amount of data analyzed by the model.

2.6 COEFFICIENTS

It represents the least-squares estimate for the coefficients of the regressors. It is an indicator of how much the dependent variable varies for a unit increase or decrease in the independent one. Such values are of the utmost importance since they are used to generate the final equation for the forecasting model.

2.7 STANDARD ERROR OF THE COEFFICIENT

The standard error of the coefficients denotes the range of estimates for the slopes of the regression. The numbers associated with the regressor's coefficients are not perfectly accurate but they lie inside a possible interval calculated by the model. The formula for this standard error is the square root of $(\frac{1}{n-2} * \frac{SSR}{\sum(x-xm)^2})$, where "n" is the number of observations, SSR is the sum of squares due to regression, x is the observed predictor variable, and "xm" is the mean of the observed predictor variable. This error must be small compared to the dimension of the coefficient, if not, there is no certainty about the sign of the relationship among independent and dependent variables, moreover, the regressor might not be statistically significant.

2.8 T STAT

The "t stat" represents the distance, in terms of standard errors, of the coefficient estimation from the value 0. It is obtained by dividing the coefficient number by the value of its standard error. It verifies if the results obtained by the analysis of a specific sample can be extended to the entire

universe: a “t stat” sufficiently distant from zero means that the outcome of the regression is not due to the case.

2.9 P-VALUE

When dealing with a random variable with a sufficiently large number of observations, it is reasonable to assume that 68% of the values lie between $\pm$ 1 standard error from the mean, 95% of values lie between $\pm$ 2 standard errors from the mean, and 99.7% lie between $\pm$ 3 standard errors from the mean. The p-value is strictly related to the “t stat” and denotes the probability of observing a sample with a specific relationship between variables, if such a relationship does not hold in the universe. Therefore, the smaller the p-value is, the higher the chances that the coefficient estimate is significantly different from zero. For this study, a p-value smaller than 0.05 is considered to be acceptable.

2.10 CONCLUSIONS

The information contained in this section will be used thoroughly in the entire paper. The next chapter provides additional statistics for a comprehensive understanding of the dataset, making them the basis for further analysis.

The formulas and explanations of chapter 2 are based on information from “Introductory Statistics” fourth edition 2017, Sheldon M. Ross, and “Introduction to Econometrics” fourth edition 2020, James H. Stock and Mark W. Watson.

CHAPTER 3: THE DATA SET

This chapter describes the data collected from the Refinitiv database. The information analyzed in this paper belongs to 786 companies, which issued debt in the last 3 years, and whose country of incorporation and country of exchange is in the United Kingdom. All the monetary values reported are in Great Britain Pounds (GBP). In the following paragraphs, there is a brief description of the various elements used to derive the predictor variables and some descriptive statistics.

3.1 THE ECONOMIC SECTOR

It describes the macro-economic area of operations of the firms. The sample's distribution is as follows:

TABLE 3.1, economic sectors distribution, source: author's elaboration

Educational Services	3	Healthcare	57
Basic Materials	57	Industrials	143
Consumers' Cyclical	144	Real Estate	63
Consumers' NonCyclical	50	Technology	119
Energy	37	Utilities	12
Financials	101		

3.2 THE MOST RECENT FINANCIAL REPORT

The latest financial statements available on Refinitiv are dated differently among firms. In the following table, there is additional info on the period covered by the data collected.

TABLE 3.2, last financial report, source: author's elaboration

Last FS first half of 2021	398
Last FS 12/31/2020	386
Last FS 2018	1
Last FS 2016	1

Approximately all the companies' financial statements registered the effect of the first year of the COVID-19 pandemic. However, it is important to notice that some of the following statistics might be slightly biased because of the timing of the available data.

3.3 THE CREDIT RATING

The Thomson Reuters "StarMine" quantitative model for credit risk is used as a proxy for agency equivalent credit scores. It helped to collect additional data for those companies without an official rating reported on the Refinitiv database. The following table represents the sample's distribution of credit rating.

TABLE 3.3, rating distribution, source: author's elaboration

AAA	AAA-	AA+	AA	AA-	A+	A	A-		
5	0	2	6	6	23	48	73		
BBB+	BBB	BBB-	BB+	BB	BB-	B+	B	B-	
89	106	93	90	130	52	22	21	6	
CCC+	CCC	CCC-	CC+	CC	CC-	C+	C	C-	D
6	6	1	0	1	0	0	0	0	0

3.4 DATE OF INCORPORATION

It is the date on which the company was established and registered to the Companies House. Approximately half of the companies started their operations more than 20 years ago.

TABLE 3.4, date of incorporation, source: author's elaboration

Inc before 2002	399
Inc after 2002	387

3.5 TOTAL AND CURRENT ASSETS

It is the Pound (£) value of the total and current assets as reported on the last three balance sheets available on the Refinitiv database. Current assets are distinguished from other assets because they have convenient liquidity characteristics that allow the company to convert them into cash in less than 12 months.

TABLE 3.5, total assets statistics, source: author's elaboration

Values in millions of GBP	FY0	FY-1	FY-2
Average TA	4,026.0000	3,952.0000	3,847.0000
Median TA	201.7655	177.1495	158.5734
Sdev TA	32,360.0000	33,930.0000	32,860.0000
Average CA	1,810.0000	1,814.0000	1,737.0000
Median CA	58.6340	52.0765	47.9395
Sdev CA	27,260.0000	30,310.0000	28,730.0000

The total and current assets have steadily increased over the last 3 years. The result might seem inconsistent due to the economic conditions of the period considered but the average company of

this sample has constantly made profits over the 3 years. Moreover, UK companies have also issued a considerably high amount of equity.

3.6 CURRENT LIABILITIES

It is the pound (£) value of the liabilities due before 1 year as reported on the three most recent balance sheets on Refinitiv.

TABLE 3.6, current liabilities statistics, source: author's elaboration

Values in millions of GBP	FY0	FY-1	FY-2
Average CL	1,810.0000	1,814.0000	1,737.0000
Median CL	58.6340	52.0765	47.9395
Stdev CL	27,050.0000	30,220.0000	28,650.0000

The average of current liabilities has increased in the last 3 years and the median of the sample has gradually shifted toward higher amounts. This might reflect increasing liquidity issues for companies during the period between 2019 and 2021.

3.7 TOTAL DEBT

It is the sum of the short-term debt, long-term debt, and current portion of long-term debt. All the values are in Great Britain Pounds.

TABLE 3.7, total debt statistics, source: author's elaboration

Values in millions of GBP	FY0	FY-1	FY-2
Average TD	872.0912	921.3604	813.1260
Median TD	26.9265	28.9660	17.8870
Stdev TD	4,552.0000	5,079.0000	4,589.0000

The total debt issued decreases according to the most recent data. The increased economic uncertainty and financial risk of 2020 seem to have hampered the ability of the companies to issue debt. However, the last three years' trend is still increasing.

3.8 TOTAL CAPITAL

It represents the total amount of money invested in the company (GBP). It is the sum of equity and total debt.

TABLE 3.8, total capital statistics, source: author's elaboration

values in millions of GBP	FY0	FY-1	FY-2
Average TC	2133.2408	2,030	1,970
Median TC	146.3390	131	115
Stdev TC	10,890.0000	10,900	11,300

In FY0, the average total capital increased by around 5.1%. Since the average amount of total debt decreased in the same period, by applying the formula this should be due to UK companies raising a consistent amount of equity.

3.9 NET PROFIT AFTER TAXES

It is the bottom-line profit (GBP) registered on the three most recent income statements on Refinitiv.

TABLE 3.9, net profit statistics, source: author's elaboration

values in millions of GBP	FY0	FY-1	FY-2
Average NP	152.1677	1.9911	95.9045
Median NP	4.6400	0.6280	4.1688
Stdev NP	1,052.0000	965.8500	646.4745

The median of the sample is relatively small concerning its average. Some firms must have generated abnormal profits shifting the mean much higher than the median. The standard deviation constantly increased in the last three years reflecting the raising uncertainty for firms in light of the pandemic developments.

3.10 NET CASH FLOW FROM OPERATING ACTIVITIES

It measures the actual cash inflows or outflows (GBP) obtained from the company's main operating activities. It is the first section of the cash flow statement.

TABLE 3.10, cash flow from operating, source: author's elaboration

Values in millions of GBP	**FY0**	**FY-1**	**FY-2**
Average CFO	255.6774	200.4415	228.0466
Median CFO	10.3120	9.5587	9.3210
Stdev CFO	1,678.0000	1,242.0000	1,476.0000

The cash flow from operating activities looks positive on average. However, there is a significant difference between the mean CFO and the median. It suggests the presents of some outliers companies that achieved much better results than the majority of firms in the sample. The high

standard deviation around the mean is an indicator that different companies had variable performances in the last three years.

3.11 NET CASH FLOW FROM FINANCING ACTIVITIES

It represents the sum of all cash (GBP) due to issuing and repurchasing debt or equity, and the payment of dividends.

TABLE 3.11, net cash flow from financing, source: author's elaboration

Values in millions of GBP	**FY0**	**FY-1**	**FY-2**
Average CFF	-155.3614	-41.5911	-103.4429
Median CFF	-2.5595	-0.6440	-1.3705
Stdev CFF	1,277.0000	832.4766	1,015.0000

The data reflects the troubles incurred by the companies in issuing debt and getting positive entries on the cash flow from financing activities. The considerable difference between the mean and the median is a strong indication of the presence of relatively few firms with a disproportionally low value for the CFF.

3.12 WACC

The weighted average cost of capital measures the average return that debt holders and stockholders require to bear the company's risk. The weights are the percentages of debt and equity over the firm's total capital. The metric has been collected directly from Refinitiv's database and any missing data, from one of the three years, is recreated as the simple average of the available WACCs for each business.

TABLE 3.12, WACC statistics, source: author's elaboration

	FY0	**FY-1**	**FY-2**
Average WACC	0.0919	0.0625	0.0583
Median WACC	0.0864	0.0593	0.0556
Stdev WACC	0.0577	0.0417	0.0416

It is possible to notice that in the most recent year the average WACC increased considerably alongside its standard deviation. The previous result might be due to the higher risk perceived by investors because of the COVID-19 pandemic.

3.13 AUDITOR

It is the data related to the companies' most common balance sheet auditor in the last three years. For companies that had a different auditor for each financial report, the latest one was considered.

TABLE 3.13, auditor's fame, source: author's elaboration

Companies with a well-known auditor	593
Companies without a well-known auditor	193

Which auditing firms are considered "well-known" is better explained in the "predictor variables" chapter, where a categorical variable called "Auditor" is created to investigate a possible connection to credit rating.

3.14 CONCLUSIONS

The data previously described is used to generate the predictor variables for the regression model. Often they are combined or calculated as a weighted average of the different periods' values. The next chapter explains, with the help of some simple regressions, the relationship between the variables and the credit rating.

CHAPTER 4: THE PREDICTOR VARIABLES

This chapter introduces and describes the set of variables correlated with the analyzed phenomenon, which are statistically significant at a 5% confidence level in explaining the variation in the numerical rating (NR). NR is an ad-hoc rating created for the model: it converts common "letter credit rating" (Standard & Poor's) to numbers according to the following table.

TABLE 4.0, numerical rating, source: author's elaboration

AAA	AAA-	AA+	AA	AA-	A+	A	A-		
27	26	25	24	23	22	21	20		
BBB+	BBB	BBB-	BB+	BB	BB-	B+	B	B-	
19	18	17	16	15	14	13	12	11	
CCC+	CCC	CCC-	CC+	CC	CC-	C+	C	C-	D
10	9	8	7	6	5	4	3	2	1

A weighted average of the three years of data available improves the regression's fit for some variables. The weights are 0.6, 0.3, 0.1 for fiscal year 0, -1, -2 respectively. These weights are chosen arbitrarily to reflect the stronger impact of recent developments on firms in light of credit rating evaluation. Not all the variables are included in the final model but examining them one by one provides valuable insights into understanding the elements of credit rating. All these variables predict the variation of the numerical rating. Following is the description of the predictor variables.

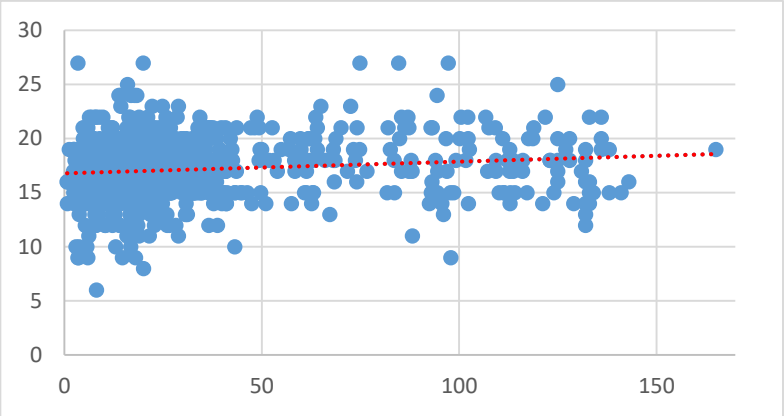
4.1 COMPANY'S AGE

The company's age is the difference, in years, between the 1st of January 2022 and the company's date of incorporation. A business that could continue its operations throughout the time has likely built a strong reputation of soundness and resilience among investors and credit rating agencies. Such qualities have a positive impact on the rating. For 31 companies, which date of incorporation preceded the 1/1/1900, the age in years was approximated to the first unit digit.

REGRESSION OUTPUT 4.1, company's age, source: author's elaboration

OUTPUT SUMMARY

Regression statistics	
Multiple R	0.1259
R^2	0.0158
Adjusted R^2	0.0146
Standard Error	2.8862
Observations	786



	Coefficients	*Standard error*	*t stat*	*P-value*
Intercept	16.7801	0.1442	116.3935	0
Company's age	0.0108	0.0030	3.5525	0.0004

As expected, the coefficient is positive (0.011) and statistically significant (p-value = 0.0004). The company's age can explain approximately 1.5% of the variation in the dependent variable, and it is a valuable element for credit rating prediction.

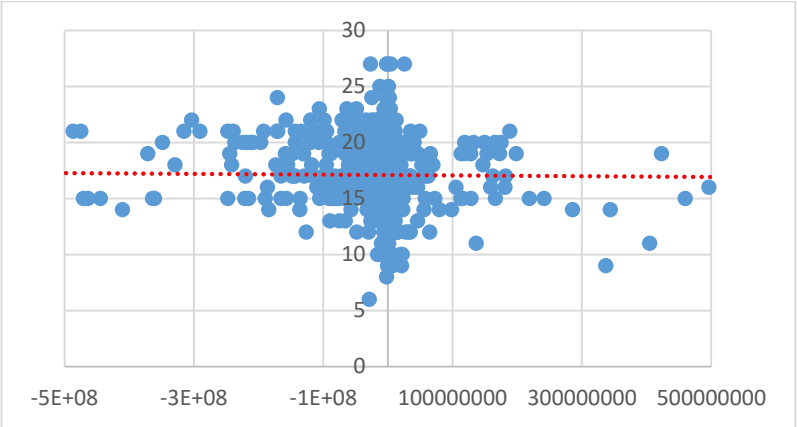
4.2 CASH FLOW FROM FINANCING ACTIVITIES WEIGHTED AVERAGE OF THE LAST 3 YEARS

The cash flow from financing activities is the last section of the cash flow statement. It reports all those transactions involving raising capital to support operations, repayment of the debt, and distribution of dividends to shareholders. The higher the cash flow from financing activities, the higher the debt issued by the firm. A company issuing, on average, a high amount of debt to fund its processes is more likely to be exposed to default risk. According to this line of thought, there should be a negative relationship between cash flow from financing activities and numerical rating. The following tables and graphs describe two variants of this variable: a “pure” one, where values represent pounds (£); a “normalized” one, where all values are divided by total assets.

REGRESSIONS OUTPUTS 4.2 and 4.2.1, cash flow from financing, source: author’s elaboration.

OUTPUT
SUMMARY

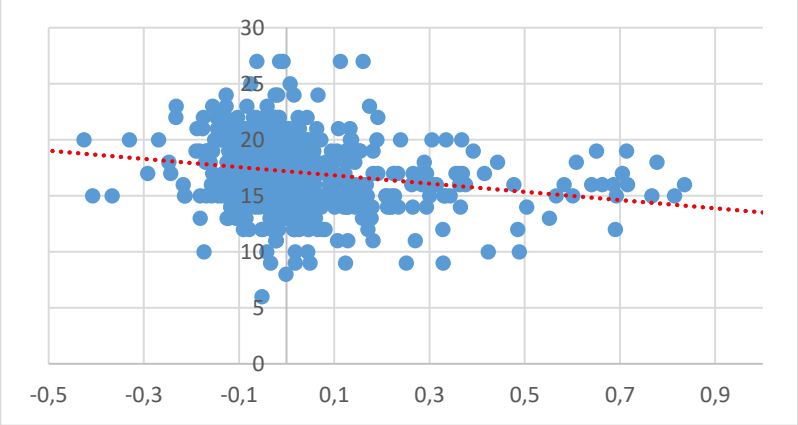
Regression statistics	
Multiple R	0.1168
R^2	0.0136
Adjusted R^2	0.0124
Standard Error	2.8894
Observations	786



	Coefficients	*Standard Error*	*t stat*	*p-value*
Intercept	17.0987	0.1038	164.7671	0
CFF PURE W	-3.4553E-10	1.0495E-10	-3,2924	0,0010

OUTPUT
SUMMARY

Regression statistics	
Multiple R	0.2263
R^2	0.0512
Adjusted R^2	0.0500
Standard Error	2.8339
Observations	786



	Coefficients	*Standard Error*	*t stat*	*p-value*
Intercept	17.1863	0.1013	169.5807	0
CFF/TA W	-3.6680	0.5640	-6.5037	1.3952E-10

The first regression's coefficient is indeed negative (-3.4553*10^(-10)) and statistically relevant (p-value = 0.001). Furthermore, the weighted average of the last three years' cash flow from financing activities explains roughly 1.24% of the variation in the numerical rating value, so it is a candidate variable to add to the final model. When divided by total assets, the variable explains a greater portion of the numerical rating (approximately 5%). The coefficient is still negative and statistically

significant. When used together with the dimension of the company, the CFF is a more powerful metric. For each additional pound of debt issued by the company the NR decreases by 3.455*10^(-10), and for each 1% increase in the CFF/TA ratio, the NR decreases by 0.03668.

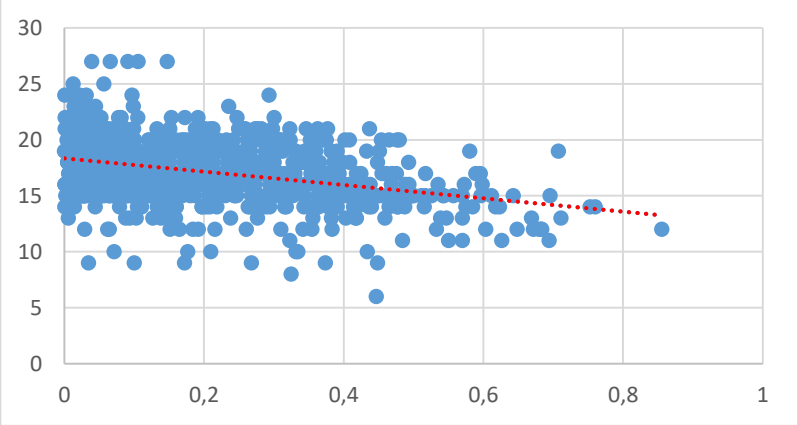
4.3 DEBT TO ASSETS WEIGHTED AVERAGE OF THE LAST 3 YEARS

The ratio of debt to assets is one of the most straightforward measures of a firm's leverage. It is the sum of the long-term, short-term, and current portion of long-term debt divided by the total assets. It is a powerful tool for predicting the company's credit rating since it concerns some of the most relevant entries on the balance sheet. The rationale behind the choice of this variable is that the higher the leverage is, the lower the credit rating because of greater indebtedness and exposure to default risk.

REGRESSION OUTPUT 4.3, debt to assets, source: author's elaboration

OUTPUT
SUMMARY

Regression statistics	
Multiple R	0.3377
R^2	0.1141
Adjusted R^2	0.1130
Standard Error	2.7384
Observations	786



	Coefficients	*Standard Error*	*t stat*	*p-value*
Intercept	18.3350	0.1540	119.0526	0
D/TA W	-5.9217	0.5894	-10.0467	2,0102E-22

The D/TA W has proved one of the simplest and most effective means for predicting the rating with a corrected r-squared of 11.3% and an extremely low p-value. The regression coefficient is negative (-5.9), and this result fits with the theory. In conclusion, for each 1% increase in the debt to asset trend, the numerical rating is predicted to decrease by 0.059.

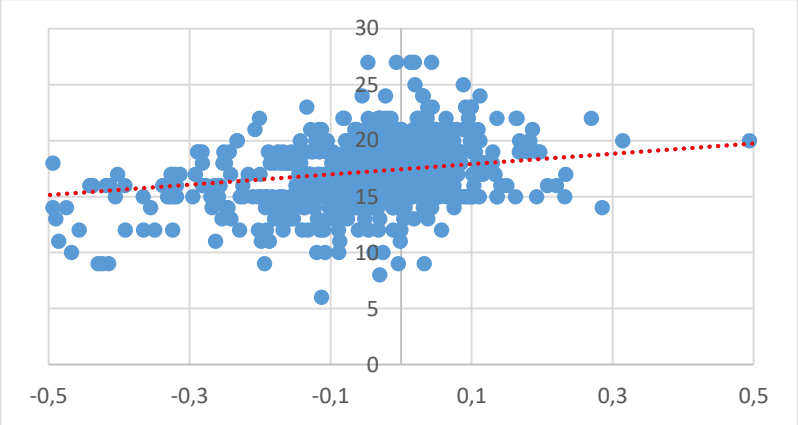
4.4 EVA TO TOTAL ASSETS WEIGHTED AVERAGE 3 YEARS

EVA (Economic Value Added) measures the value generated by the company over investors' expectations. The formula is (net profit after taxes - (WACC * Total Capital))/TA. The WACC (Weighted Average Cost of Capital) is the average return that debt-holders and stock-holders require to bear the company's risk. The total capital is the amount invested in the business (total debt + total equity). The EVA was divided by total assets to obtain a number proportional to the dimension of the company. A firm yielding higher than expected returns has well-functioning operations, thus a higher credit rating. The following tables compare the EVA/TA and the net profit after taxes over assets as profitability measures and predictors of credit rating.

REGRESSIONS OUTPUTS 4.4 and 4.4.1, EVA to total assets, source: author's elaboration

OUTPUT
SUMMARY

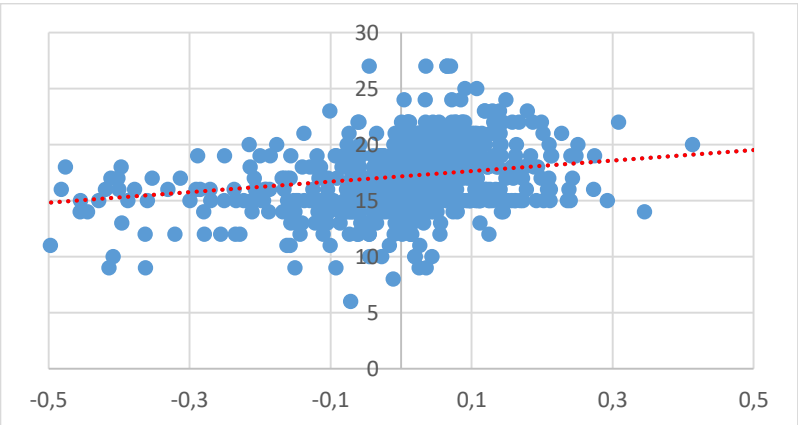
Regression statistics	
Multiple R	0.3147
R^2	0.0990
Adjusted R^2	0.0979
Standard Error	2.7615
Observations	786



	Coefficients	*Standard Error*	*t stat*	*Valp-value*
Intercept	17.4516	0.1041	167.6312	0
EVA/TA W	4.6031	0.4958	9.2834	1.5733E-19

OUTPUT
SUMMARY

Regression statistics	
Multiple R	0.3083
R^2	0.0951
Adjusted R^2	0.0939
Standard Error	2.7676
Observations	786



	Coefficients	*Standard Error*	*t stat*	*p-value*
Intercept	17.1818	0.0988	173.8525	0

ROA W	4.7009	0.5179	9.0760	8,9493E-19

The two parameters are very similar in explaining the dependent variable (NR): the corrected r-squared is almost equal, and the coefficients' values are very close to each other. However, the weighted average of EVA/TA performs slightly better on all parameters: corrected r-squared 9.8% against 9.4%, and standard error of 2.761 against 2.767. This outcome might represent the fact that EVA is a more complex and, thus more reliable measure, taking into account the excess return generated over the expected return on total capital invested in the company, instead of the simple profit in the proportion of the totality of assets. According to these two regressions, when EVA/TA W increases by 1%, the NR increases by 0.046, and when ROA W increases by 1%, the NR increases by 0.047.

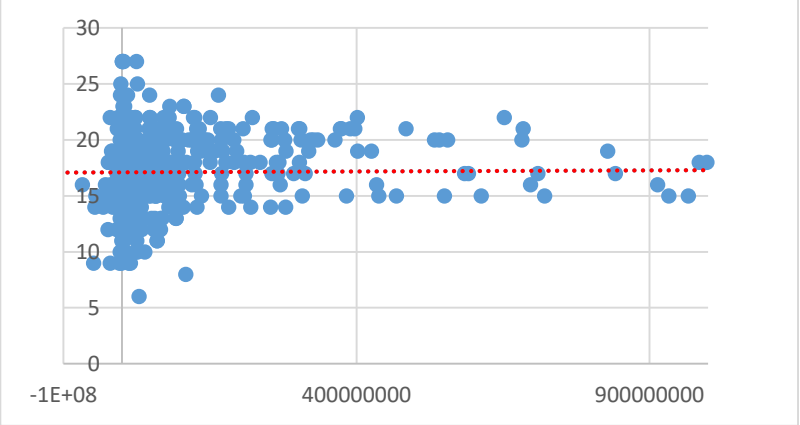
4.5 CASH FLOW FROM OPERATING ACTIVITIES AVERAGE LAST 3 YEARS

Cash flow from operating activities (CFO) is another section of the cash flow statement. It represents the actual cash inflows obtained by the company through main operating activities. It is different from the net profit after taxes since customers often purchase a firm's products and services on credit. Generating immediate cash is crucial for the company and provides the necessary liquidity to cover current liabilities. This variable is both a measure of liquidity and profitability. The following tables show two variants of the metric discussed: a "pure cash flow" one, where the values represent Pounds (£); a "normalized cash flow" one, with all the numbers divided by total assets. The higher the CFO is, the higher the rating: a high rate of cash inflows means higher liquidity for a company. A firm that can dispose of many liquid assets is in a better position to deal with current liabilities and take advantage of investment opportunities without issuing additional debt.

REGRESSIONS OUTPUTS 4.5 and 4.5.1, cash flow from operating, source: author's elaboration

OUTPUT
SUMMARY

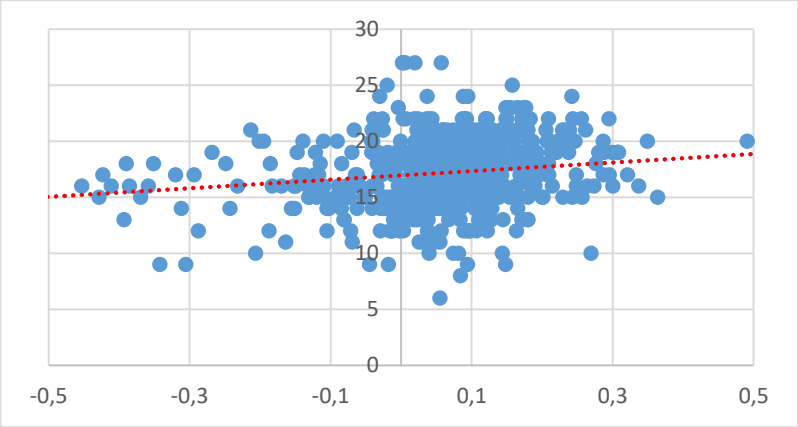
Regression statistics	
Multiple R	0.0998
R^2	0.0010
Adjusted R^2	0.0087
Standard Error	2.8948
Observations	786



	Coefficients	*Standard Error*	*t stat*	*p-value*
Intercept	17.0933	0.1045	163.5534	0
CFO PURE W	1.9265E-10	6.8604E-11	2.8082	0.0051

OUTPUT
SUMMARY

Regression statistics	
Multiple R	0.2211
R^2	0.0489
Adjusted R^2	0.0477
Standard Error	2.8373
Observations	786



	Coefficients	*Standard Error*	*t stat*	*p-value*
Intercept	16.9635	0.1049	161.7146	0
CFO/TA W	3.8304	0.6033	6.3493	3.6608E-10

The correlation is indeed positive and the variable performs better when proportioned to the total assets. Despite being statistically significant, the CFO PURE W does explain a small part of the variation in NR (0.87%) and shows that for each pound increase of the independent variable, the dependent one increases by 1.9265*10^(-10). CFO/TA W combines two metrics to create a more complete measure of credit rating: The corrected r-squared for this regression is 4,77%, and the coefficient shows that a 1% increase in the value of CFO/TA W corresponds to an increase of 0.0383 in the credit rating.

4.6 CURRENT RATIO FY0

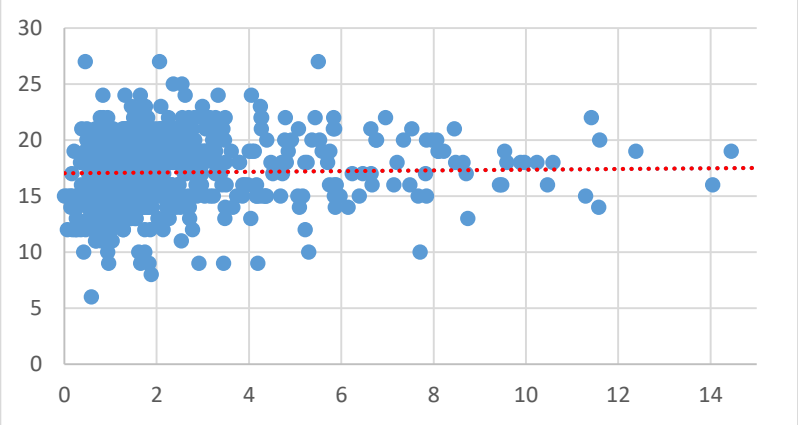
The current ratio is the fraction between current assets and current liabilities, while the cash ratio is the quotient between cash plus marketable securities and current liabilities. These values provide insight into business solvency because they assess the company's ability to pay its short-term obligations. In light of the previous description, it is reasonable to assume that, other things being equal, the higher this index is, the higher the credit rating. This value is not a weighted average of

the last three years because it represents short-term solvency. The calculation of this variable uses only the most recent year's data available.

REGRESSION OUTPUT 4.6, current ratio, source: author's elaboration

OUTPUT
SUMMARY

Regression statistics	
Multiple R	0.0879
R^2	0.0077
Adjusted R^2	0.0065
Standard Error	2.8981
Observations	786



	Coefficients	*Standard Error*	*t stat*	*p-value*
Intercept	17.0394	0,1109	153,6262	0
CURR RATIO FY0	0,0316	0,0128	2,4697	0,0137

This index is a weak explanatory variable since the corrected r- squared is equal to 0.65%. For each 1% increase in the current ratio, the numerical rating is predicted to increase by 0.000316. However, the p-value of the regression's coefficient is below 5%, making this ratio an element worth considering for the building of the final model.

4.7 CATEGORICAL VARIABLES

A categorical variable, also known as a dummy, is a variable that takes values of either zero or one. If the quality described does not represent the element of the sample, the value is zero. If it does, it is one. In this model, there are two categories of dummy variables.

ECONOMIC SECTOR

The sample analyzed is composed of firms belonging to different economic sectors.

TABLE 4.7, sample's economic sectors, source: author's elaboration

Educational services	Healthcare
Basic Materials	Industrial
Consumer's Cyclical	Real Estate
Consumer's non-Cyclical	Technology
Energy	Utilities

Financial	

Only four have proved statistically significant in explaining the variation in the numerical rating, and they are described in the next paragraph with the help of auxiliary regressions.

4.7.1 Real Estate

It comprehends all the sample businesses that operate in this market sector and possess real estate property. A high quantity of valuable tangible assets characterizes these firms' balance sheets. If case of necessity, the company can liquidate assets to pay for liabilities. Firms operating in this sector should have, on average, a higher credit rating.

REGRESSION OUTPUT 4.7.1, real estate sector, source: author's elaboration

OUTPUT
SUMMARY

Regression statistics	
Multiple R	0.1536
R^2	0.0236
Adjusted R^2	0.0224
Standard Error	2.8748
Observations	786

	Coefficients	*Standard Error*	*t stat*	*p-value*
Intercept	17.0069	0.1069	159.0704	0
RE	1.6439	0.3776	4.3530	1,5205E-05

Operating in the real estate sector is an indirect indicator of the overall ability of a company to repay its debt obligations. In line with the previous explanation, the regression's coefficient is positive and shows that, on average, the numerical rating is 1.6439 levels higher in this economic field. The dummy variable explains 2.2% of the rating phenomenon

4.7.2 Energy

Firms supplying gas or oil and running the facilities for their extraction are examples of operators in the energy field. Oil and gas are essential inputs for developed economies. However, the risks involved in the extracting processes, the price volatility, the gradual exhaustion of reserves, and the current shift toward renewable energy might bring traditional energy suppliers to a competitive disadvantage.

REGRESSION OUTPUT 4.7.2, energy sector, *source: author's elaboration*

OUTPUT
SUMMARY

Regression statistics	
Multiple R	0.1160
R^2	0.0135
Adjusted R^2	0.0122
Standard Error	2.8890
Observations	786

	Coefficients	*Errore standard*	*t stat*	*p-value*
Intercept	17.2136	0.1056	163.0293	0
EN	-1.5920	0.4867	-3.2713	0.0011

This time the coefficient is negative: on average, a firm operating in the energy sector has a numerical rating of 1.592 levels lower than the other companies. This statistically significant result might be due to the competitive pressure and venture risk described in the previous paragraph. The corrected r-squared is 1.2%. The overall result of the regression makes this categorical variable a candidate element to add to the model.

4.7.3 Consumers' cyclical

Consumers' cyclical products are those goods whose demand is positively related to the economic cycle. A typical example is luxury items, restaurant meals, vehicles, or transportation like air travel. Due to the high exposure to market risk for companies selling this category of products, their credit rating should be lower, on average, than companies operating in other sectors, which are less sensitive to market fluctuations.

REGRESSION OUTPUT 4.7.3, consumers' cyclical sector, source: author's elaboration

OUTPUT
SUMMARY

Regression statistics	
Multiple R	0.1358
R^2	0.0184
Adjusted R^2	0.0172
Standard Error	2.8824
Observations	786

	Coefficients	*Standard Error*	*t stat*	*p-value*
Intercept	17.3255	0.1138	152.3017	0
CC	-1.0200	0.2658	-3.8378	0.0001

Other things being equal, firms operating in these sectors bear a greater risk due to the fluctuations in the economic cycle. The negative coefficient predicts that companies selling consumers' cyclical products are likely to have a numerical rating of 1.02 lower. The corrected r-square of 1.7% is high enough to make it a candidate variable to add to the model.

4.7.4 Consumers' non-cyclical

Consumers' non-cyclical are those goods and services whose demand is not affected by the economic cycle. Food and medicines are clear examples of non-cyclical products. Since market risk has a low impact on companies operating in this sector, they should benefit from higher credit scores on average.

REGRESSION OUTPUT 4.7.4, consumers' non-cyclical sector, source: author's elaboration

OUTPUT
SUMMARY

Regression statistics	
Multiple R	0.0755
R^2	0.0057
Adjusted R^2	0.0044
Standard Error	2.9010
Observations	786

	Coefficients	*Standard Error*	*t stat*	*p-value*
Intercept	17.0815	0.1069	159.7403	0
CNC	0.8985	0.4240	2.1192	0.0344

This variable behaves oppositely concerning consumers' cyclical. Its positive coefficient and low p-value mean that it is reasonable to assume that companies selling consumers' non-cyclical products have, assuming everything else being equal, a numerical rating of 0.8985 higher than businesses operating in different sectors.

4.8 AUDITOR'S FAME (AUD)

The last categorical variable is the auditor of the company's balance sheet. This variable takes a value of 1 when the auditor is one of the seven most recurring auditors in the sample and 0 otherwise. Table 4.8 shows the list of the auditing agencies that are considered famous" for the creation of the dummy variable.

TABLE 4.8, famous auditors, source: author's elaboration

BDLL	CULP
DLLP	EY
KPMG	PWCL
TILL	

The labels of the seven most recurring auditors

4.8.1 AUD

The rationale behind this choice was to investigate a possible link between the fame of the auditing firm and the reliability of the information displayed on the company's balance sheet: when the data is provided to investors by a certified and reliable institution, it reduces uncertainty and risk. It is important to notice that there is also the chance that a financial sounder business can afford a better-known auditor, and so the causality is reversed.

REGRESSION OUTPUT 4.8.1, auditor's impact, source: author's elaboration

OUTPUT
SUMMARY

Regression statistics	
Multiple R	0.0781
R^2	0.0061
Adjusted R^2	0.0048
Standard Error	2.9004
Observations	786

	Coefficients	*Standard Error*	*t stat*	*p-value*
Intercept	16.7423	0.2082	80.3993	0
Common AUD	0.5263	0.2399	2.1935	0.0286

There is, in fact, a positive correlation (0.0781) between the variables Auditor and NR. Causality has not been proven but it is still interesting to look at the result of the regression. A firm with a well-known auditor has, ceteris paribus, a numerical rating of 0.5263 higher. The corrected r-squared of the regression is 0.48%. Despite the explained variation in the numerical rating being quite small,

and the doubts about the causality link remaining, the dummy is statistically significant and worth considering.

4.9 CONCLUSIONS

In the next chapter, these variables are combined to create different versions of the model for credit rating forecasts. The multicollinearity issue is addressed and solved with the aid of correlation tables, Variance Inflation Factor calculation (VIF), and some auxiliary regressions.

CHAPTER 5: THE MODEL

The previous chapter provided many elements for the prediction of the numerical rating. Choosing among the variables will be a sequential process: the first models will have only a few variables, then, other regressors will be added in an attempt to improve the regression's fit and reduce the standard error of prediction.

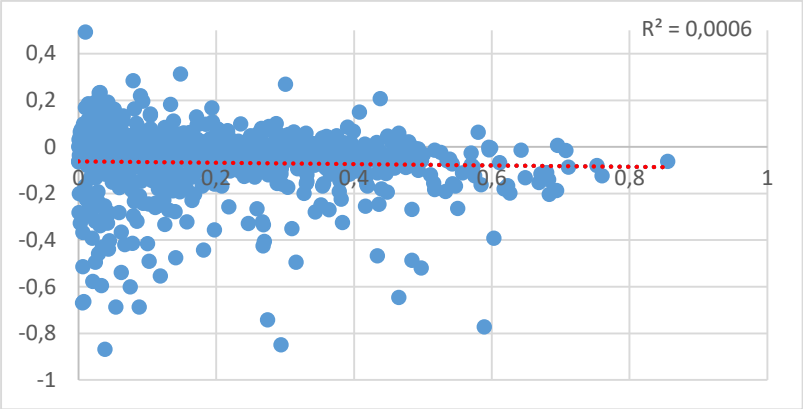
5.1 HOW TO SOLVE MULTICOLLINEARITY ISSUES

Checking for multicollinearity among the variables is a mandatory side activity that allows avoiding a loss of reliability of the multivariable regression result. There exist two kinds of multicollinearity: perfect multicollinearity and imperfect multicollinearity. There is perfect multicollinearity between two variables when the first is a linear combination of the second, while there is imperfect multicollinearity when the regressors are highly correlated with each other. If one of the previous conditions verify, then the data cannot estimate both regression's coefficients effectively because it becomes difficult to distinguish which effect on the dependent variable is due to one independent variable and which is due to the other. One way to check this issue numerically is to calculate the Variance Inflation Factor (VIF) among the variables. The formula for the VIF is $1/(1-R^2)$: the higher the correlation between the elements of the regression is, the higher the R^2 and the VIF. These models set a threshold at a VIF = 2.5: above this level, the variables are considered to be multicollinear and ruled out of the model.

5.2 THE FIRST TWO-FACTORS MODEL: EVA AND DEBT TO ASSETS

It is logical to start with the two variables that managed to explain a greater percentage of the variation in the numerical rating phenomenon: "D/TA W" and "EVA/TA W", with adjusted R^2 of 11.3% and 9.8% respectively. The first step is to check for multicollinearity with a correlation table and the calculation of the VIF.

TABLE 5.2, EVA/TA and D/TA correlation, source: author's elaboration



The graph plots the EVA W against the D/TA W.

VIF = 1/(1-0.0006) = 1.0006

Corr. table	*D/TA W*	*EVA W*
D/TA W	1	
EVA/TA W	-0.0245	1

The correlation between the two variables is negligible (-0.0245) and the consequent low R^2 (0.06%) and VIF (1.0006 < 3) are an indication of the absence of any relevant amount of multicollinearity. It is then possible to have reasonable estimations for the coefficients of the first two-factor model for credit rating prediction.

REGRESSION OUTPUT 5.2, the two-factors model, source: author's elaboration

OUTPUT
SUMMARY

Regression statistics	
Multiple R	0.4561
R^2	0.2080
Adjusted R^2	0.2060
Standard Error	2.5908
Observations	786

	Coefficients	*Standard Error*	*t stat*	*p-value*
Intercept	1.6132	01485	125.3094	0
D/TA W	-5.7898	0.5578	-10.3799	9.7641E-24
EVA W	4.4846	0.4653	9.6376	7.5425E-21

Both regressors are statistically significant and their combination explains almost 21% of the variation in the numerical rating.

5.3 THE THREE-FACTORS MODEL: CASH FLOW FROM FINANCING

It is time to add another variable to improve the performance of the model. The two candidates are "CFF PURE W" and "CFF/TA W". CFF PURE W corrected R^2 is 1.24% if regressed against numerical rating while CFF/TA W explains 5% of NR variation. In the following table, there is a correlation analysis and VIF value for these variables.

TABLE 5.3, preliminary correlations for the three-factors model, source: author's elaboration

Corr. table	***D/A W***	***D PURE W***	***EVA/TA W***	***CFF PURE W***	***CFF/TA W***	***EVA PURE W***
D/TA W	1					
D PURE W	-0.0267	1				
EVA/TA W	-0.0245	0.0369	1			
CFF PURE W	-0.0388	-0.1160	-0.0648	1		
CFF/TA W	-0.0682	-0.0336	-0.6568	0.1029	1	
EVA PURE W	0.0240	-0.4494	-0.0032	0.0192	-0.0190	1

The variables "EVA PURE W" and "D PURE W" are added to the table to better check for correlation between the numerators of these regressors. These two additional elements are the same variables as before except for the fact that they are not divided by total assets. The only alarming correlation coefficient is the one between EVA/TA W and CFF/TA W. Since the weighted average of the cash flow from financing activities divided by total assets accounts for a greater portion of credit rating variation, the next step is to calculate the VIF for the corresponding variable and the other two elements of the first model.

REGRESSION OUTPUT 5.3, CFF/TA multicollinearity, source: author's elaboration

OUTPUT
SUMMARY

Regression statistics	
Multiple R	0.6622
R^2	0.4386
Adjusted R^2	0.4371
Standard Error	0.1346
Observations	786

The dependent variable is CFF/TA

VIF = 1/(1-0.4386) = 1.7812

	Coefficients	*Standard Error*	*t stat*	*p-value*
Intercept	-0.0090	0.0077	-1.1663	0.2439
D/A W	-0.0913	0.0290	-3.1502	0.0017
EVA/TA W	-0.5945	0.0242	-24.5992	1.9145E-99

Despite the relatively high correlation, the VIF is still well below 3. The next regression table shows the results for the weighted average of cash flow from financing activities not divided by total assets.

REGRESSION OUTPUT 5.3.1, CFF PURE multicollinearity, source: author's elaboration

OUTPUT
SUMMARY

Regression statistics	
Multiple R	0.0763
R^2	0.0058
Adjusted R^2	0.0033
Standard Error	981050606.9
Observations	786

The dependent variable is CFF PURE W

VIF = 1/(1-0.0058) = 1.0058

	Coefficients	*Standard Error*	*t stat*	*p-value*
Intercept	-89440947.55	56247360.67	-1.5901	0.1122
D/TA W	-239480942.7	211222096.8	-1.1338	0.2572
EVA/TA W	-325164614.4	176206236.6	-1.8454	0.0654

The CFF PURE W has an extremely low VIF concerning the first model variables. There is no risk for multicollinearity. It is possible to choose one of these two variables to add to the two-factors model.

REGRESSION OUTPUT 5.3.2, the three-factors model with CFF/TA, source: author's elaboration

OUTPUT
SUMMARY

Regression statistics	
Multiple R	0.4605
R^2	0.2120
Adjusted R^2	0.2090
Standard Error	2.5859
Observations	786

The three-factors model with CFF/TA W

The dependent variable is NR

	Coefficients	*Standard Error*	*t stat*	*p-value*
Intercept	18.60089864	0.1484	125.3549	0
D/A W	-5.9147	0.5603	-10.5571	1.8975E-24
EVA/TA W	3.6711	0.6184	5.9366	4.3741E-09
CFF/TA W	-1.3684	0.6868	-1.9924	0.0467

The corrected R^2 slightly improved from the previous model and all the coefficients maintained a p-value below 0.05. The standard error of prediction decreased enhancing the overall regression's performance. However, imperfect multicollinearity seems to play a marginal but disturbing role that hampers the ability of the regression to explain a greater portion of the numerical rating.

REGRESSION OUTPUT 5.3.3, the three-factors model with CFF PURE, source: author's elaboration

OUTPUT
SUMMARY

Regression statistics	
Multiple R	0.4692
R^2	0.2201
Adjusted R^2	0.2171
Standard Error	2.5725
Observations	786

The three-factors model with CFF PURE W

The dependent variable is NR

	Coefficients	*Standard Error*	*t stat*	*p-value*
Intercept	18.58400146	0.1477	125.7970	0
D/A W	-5.868041178	0.5543	-10.5860	1,4497E-24
EVA/TA W	4.37844711	0.4631	9.4556	3,6474E-20
CFF PURE W	-3.26568E-10	9.3710E-11	-3.4849	0,0005

The weighted average of the cash flow from financing activities is a better variable to consider because it increases the regression R^2 by a higher amount than CFF/TA W. This might be due to the extremely low correlation with the other regressors. This three-factors model improved corrected R^2 from 20.6% to 21.7% and the standard error of prediction decreased from 2.59 credit rating levels to 2.57. Despite the little progress made by the new model, there is still a conspicuous set of independent variables to incorporate to improve its performance.

5.4 THE FOUR-FACTORS MODEL: COMPANY'S AGE

In the previous chapter, the company's age was used as a predictor variable for the numerical rating. It showed a corrected R^2 of almost 1.5%. The more complex the model becomes, the higher the chance to incur multicollinearity issues because of a higher number of variables and a greater likelihood of interactions among them. The following table shows the correlation of the Company's age with the variables of the three-factors model.

TABLE 5.4, company's age correlations, source: author's elaboration

Corr. table	***D/A W***	***EVA/TA W***	***CFF PURE W***	***Company's age***
Company's age	-0.0327	0.1464	-0.0656	1

There is no significant correlation among the regressors when paired individually with Company's age. To investigate further the presence of issues, the next table shows the results of the Company's age regressed against the other three variables.

REGRESSION OUTPUT 5.4, company's age multicollinearity, source: author's elaboration

OUTPUT
SUMMARY

Regression statistics	
Multiple R	0.1600
R^2	0.0256
Adjusted R^2	0.0219
Standard Error	33.4532
Observations	786

The dependent variable is Company's age

VIF = 1/(1-0.0256) = 1.0263

	Coefficients	*Standard Error*	*t stat*	*p-value*
Intercept	35.8495	1.9211	18.6610	1.4623E-64
D/A W	-6.4221	7.2085	-0.8909	0.3732
EVA/TA W	24.1492	6.0216	4.0104	6.6413E-05
CFF PURE W	-1.9847E-09	1.2186E-09	-1.6286	0.1038

The small VIF of 1.0263 makes the result of this preliminary analysis positive. It is possible to add the latest variable to the model without decreasing the reliability of its coefficients.

REGRESSION OUTPUT 5.4.1, the four-factors model, source: author's elaboration

OUTPUT SUMMARY

Regression statistics	
Multiple R	0.4736
R^2	0.2243
Adjusted R^2	0.2203
Standard Error	2.5672
Observations	786

The four-factors model with Company's age

The dependent variable is NR

	Coefficients	*Standard Error*	*t stat*	*p-value*
Intercept	18.3821	0.1772	103.7137	0
D/A W	-5.8319	0.5535	-10.5370	2,2994E-24
EVA/TA W	4.2425	0.4668	9.0877	8,1808E-19
CFF PURE W	-3.1539E-10	9.3677E-11	-3.3668	0.0008
Company's age	0.0056	0.0027	2.0521	0.0405

Slow but steady improvements: All the coefficients maintained their statistical relevance, the corrected R^2 increased to 0.2203 from 0.2171, and the standard error of prediction decreased from 2.5725 to 2.5672.

5.5 FAILED ATTEMPT ONE: CASH FLOW FROM OPERATING ACTIVITIES

CFO PURE W and CFO/TA W explain 0.87% and 4.77% of the variation in the dependent variable. They are two metrics for the liquidity and profitability of a firm. Since there is already an independent variable that accounts for the ability of a business to generate profit (EVA/TA W), auxiliary regressions and analyses must be conducted to check for multicollinearity.

TABLE 5.5, CFO/TA and CFO PURE correlations, source: author's elaboration

Corr. table	***D/A W***	***EVA/TA W***	***CFF PURE W***	***Company's age***	***CFO/TA W***	***CFO PURE W***
CFO/TA W	0.0671	0.7949	-0.0653	0.0597	1	
CFO PURE W	0.0731	0.0650	-0.9337	0.0612	0.0707	1

As expected, CFO/TA W has a strong correlation (0.7949) with EVA/TA W because they measure similar aspects of the business and both are divided by total assets. CFO PURE W has instead a much smaller correlation (0.0650). To verify the validity of the last result, the strength of the interaction between the weighted average of EVA (EVA PURE W) and CFO PURE W is measured in another correlation table.

TABLE 5.5.1, CFO PURE and EVA PURE correlations, source: author's elaboration

Corr. table	***CFO PURE W***	***EVA PURE W***
CFO PURE W	1	
EVA PURE W	0.0187	1

Despite both being measures related to profit, their correlation is only 0.0187. The second step is to calculate the VIF of this to variables concerning the latest model.

REGRESSION OUTPUT 5.5, CFO/TA multicollinearity, source: author's elaboration

OUTPUT SUMMARY

Regression statistics	
Multiple R	0.8015
R^2	0.6425
Adjusted R^2	0.6407
Standard Error	0.1006
Observations	786

The dependent variable is CFO/TA W

VIF = 1/(1-0.6425) = 2.7972

	Coefficients	*Standard Error*	*t stat*	*p-value*
Intercept	0.0836	0.0069	12.0350	1.0068E-30
D/A W	0.0855	0.0217	3.9424	8.7904E-05
EVA/TA W	0.6792	0.0183	37.1179	1.3426E-174

CFF PURE W	-2.3318E-12	3.6717E-12	-0.6351	0.5256
Company's age in years	-0.0003	0.0001	-2.5930	0.0097

The variance inflation factor is higher than the threshold of 2.5. CFF/TA W is multicollinear and it is not possible to use it to develop a well-functioning forecasting model.

REGRESSION OUTPUT 5.5.1, CFO PURE multicollinearity, source: author's elaboration

OUTPUT SUMMARY

Regression statistics	
Multiple R	0.9344
R^2	0.8731
Adjusted R^2	0.8725
Standard Error	537861981.3
Observations	786

The dependent variable is CFO PURE W

VIF = 1/(1-0.8725) = 7.8431

	Coefficients	*Standard Error*	*t stat*	*p-value*
Intercept	4480001.679	37133165.99	0.1206	0.9040
D/A W	336605337.6	115956549.8	2.9029	0.0038
EVA/TA W	41532325.81	97805642.81	0.4246	0.6712
CFF PURE W	-1.4281	0.0196	-72.7664	0
Company's age in years	22226.7839	574949.0873	0.0387	0.9692

The VIF is even higher for this variant of the CFO metric (7.8431). This variable cannot enhance the performance of the four-factor model because the previously added predictors already explain the portion of the variation in NR caused by CFO PURE W.

It is not possible to make progress and the only alternative is to choose other elements to analyze.

5.6 FAILED ATTEMPT TWO: CURR RATIO FY0

The last non-categorical candidate variable is the most recent current ratio (CURR RATIO FY0). It explains a very small percentage of the rating variation (0.65%). As usual, a correlation table is the first step to examine multicollinearity.

TABLE 5.6, current ratio correlations, source: author's elaboration

Corr. Table	***D/TA W***	***EVA/TA W***	***CFF PURE W***	***Company's age***	***CURR RATIO FY0***
CURR RATIO FY0	-0.1636	0.0070	0.0316	0.0123	1

All the correlation coefficients are acceptably low. The VIF will determine the feasibility of this variable as a regressor for numerical rating.

REGRESSION OUTPUT 5.6, current ratio multicollinearity, source: author's elaboration

OUTPUT
SUMMARY

Regression statistics	
Multiple R	0.1658
R^2	0.0275
Adjusted R^2	0.0225
Standard Error	7.9868
Observations	786

The dependent variable is CURR RATIO FY0

VIF = 1/(1-0.0275) = 1.0283

	Coefficients	*Standard Error*	*t stat*	*p-value*
Intercept	4.7064	0.5514	8.5353	7.2358E-17
D/TA W	-7.9045	1.7219	-4.5907	5.1469E-06
EVA/TA W	0.1408	1.4523	0.0969	0.9228
CFF PURE W	2.1449E-10	2.9143E-10	0.7360	0.4620
Company's age	0.0020	0.0085	0.2300	0.8184

The VIF calculation provided an encouraging result (1.0283) multicollinearity is avoided, and the variable will be added to the four-factor model.

REGRESSION OUTPUT 5.6.1, five-factors model with the current ratio, source: author's elaboration

OUTPUT SUMMARY

Regression statistics	
Multiple R	0.4749
R^2	0.2255
Adjusted R^2	0.2205
Standard Error	2.5669
Observations	786

Five-factors model attempt

The dependent variable is NR

	Coefficients	*Standard Error*	*t stat*	*p-value*
Intercept	18.3229	0.1853	98.8836	0
D/TA W	-5.7324	0.5608	-10.2216	4.2048E-23
EVA/TA W	4.2407	0.4668	9.0850	8.3880E-19
CFF PURE W	-3.1809E-10	9.3697E-11	-3.3949	0.0007
Company's age	0.0056	0.0027	2.0433	0.0414

CURR RATIO FY0	0.0126	0.0115	1.0937	0.2744

The CURR RATIO FY0 coefficient does not maintain an acceptable degree of statistical relevance when added to the model. The regressor explains a very little portion of the rating phenomenon by itself, and the coefficient is very close to zero. If a larger sample was available, there would be a chance to add CURR RATIO FY0 to the multivariable regression without altering its p-value. In the current situation, it is not possible to add the last variable examined to the four-factor model.

5.7 ADDING THE CATEGORICAL VARIABLES

The categorical variables related to the economic sector of operations are four: Real Estate, Energy, Consumers' cyclical, and Consumers' noncyclical. These variables will be analyzed one by one and then, if not multicollinear, added to the model.

5.7.1 Real Estate (RE)

It is the first dummy variable for the economic sector. The corrected R^2 of its simple regression with NR as the dependent variable is 2.24%. The following correlation table is a useful tool to predict RE multicollinearity.

TABLE 5.7.1, real estate correlations, source: author's elaboration

Corr. table	***D/TA W***	***EVA/TA W***	***CFF PURE W***	***Company's age***	***RE***
RE	0.1584	0.0636	0.0365	-0.0227	1

There is no sign of relevant correlation with individual variables. The RE is then regressed against all the variables of the four-factors model.

REGRESSION OUTPUT 5.7.1, real estate multicollinearity, source: author's elaboration

OUTPUT
SUMMARY

Regression statistics	
Multiple R	0.1803
R^2	0.0325
Adjusted R^2	0.0275
Standard Error	0.2679
Observations	786

The dependent variable is RE

VIF = 1/(1-0.0325) = 1.0336

	Coefficients	*Standard Error*	*t stat*	*p-value*
Intercetpt	0.0419	0.0185	2.2648	0.0238
D/TA W	0.2641	0.0578	4.5716	5.6263E-06
EVA/TA W	0.1014	0.0487	2.0819	0.0377
CFF PURE W	1.2678E-11	9.7767E-12	1.2968	0.1951
Company's age	-0.0002	0.0003	-0.7086	0.4788

The VIF of 1.0336 shows that there is no substantial multicollinearity and RE can be added to the model.

REGRESSION OUTPUT 5.7.1.1, four-factors model with RE, source: author's elaboration

OUTPUT
SUMMARY

Regression statistics	
Multiple R	0.5127
R^2	0.2629
Adjusted R^2	0.2582
Standard Error	2.5042
Observations	786

The four-factors model plus RE

The dependent variable is NR

	Coefficients	*Standard Error*	*t stat*	*p-value*
Intercept	18.2926	0.1735	105.4624	0
D/TA W	-6.3962	0.5470	-11.6924	3.2515E-29
EVA/TA W	4.0257	0.4566	8.8161	7.6398E-18
CFF PURE W	-3.4249E-10	9.1473E-11	-3.7441	0.0002
Company's age	0.0061	0.0027	2.2651	0.0238
RE	2.1372	0.3344	6.3905	2.8418E-10

Adding the first dummy variable increased the adjusted R^2 from 22.03% to 25.82% with respect to the four-factors model. The standard error of prediction decreased from 2.57 to 2.50 and the incumbent coefficients' variance has slightly diminished.

5.7.2 Energy (EN)

Second categorical variable. Its simple regression with NR as the dependent variable shows an adjusted R^2 of 1.22%. A correlation table is created for a routine multicollinearity check.

TABLE 5.7.2, energy correlations, source: author's elaboration

Corr.table	***D/TA W***	***EVA/TA W***	***CFF PURE W***	***Company's age***	***RE***	***EN***
EN	-0.0555	-0.1518	-0.1259	-0.0531	-0.0656	1

The dummy variable EN has no significant correlation with any of the other regressors. The VIF will provide the final insight on multicollinearity.

REGRESSION OUTPUT 5.7.2, energy multicollinearity, source: author's elaboration

OUTPUT
SUMMARY

Regression statistics	
Multiple R	0.2217
R^2	0.0492
Adjusted R^2	0.0431
Standard Error	0.2073
Observations	786

The dependent variable is EN

VIF = 1/(1-0.0492) = 1.0517

	Coefficients	*Standard Error*	*t stat*	*p-value*
Intercept	0.0593	0.0144	4.1322	3.98261E-05
D/TA W	-0.0759	0.0453	-1.6764	0.0941
EVA/TA W	-0.1634	0.0378	-4.3235	1.7351E-05
CFF PURE W	-3.0067E-11	7.5730E-12	-3.9702	7.8437E-05
Company's age	-0.0003	0.0002	-1.2071	0.2278
RE	-0.0330	0.0279	-1.1928	0.2333

The VIF is at a tolerable level (1.0517) and implies no risk in adding the EN categorical variable to the last model.

REGRESSION OUTPUT 5.7.2.1, adding EN to the model, source: author's elaboration

OUTPUT
SUMMARY

Regression statistics	
Multiple R	0.5214
R^2	0.2719
Adjusted R^2	0.2662
Standard Error	2.4905
Observations	786

The EN categorical value is added to the model

The dependent variable is NR

	Coefficients	*Standard Error*	*t stat*	*p-value*
Intercept	18.3716	0.1744	105.3518	0
D/TA W	-6.4973	0.5450	-11.9208	3.2682E-30
EVA/TA W	3.8080	0.4595	8.2867	5.0746E-16
CFF PURE W	-3.8251E-10	9.1889E-11	-4.1628	3.4949E-05

Company's age	0.0057	0.0027	2.1418	0.0325
RE	2.0932	0.3329	6.2877	5.3650E-10
EN	-1.3312	0.4301	-3.0949	0.0020

The second dummy variable improves the efficiency of the model and its ability to predict companies' credit ratings. The adjusted R^2 grows from 25.82% to 26.62% and the standard error of prediction decreases to 2.49 from 2.50. Moreover, the variance of the regression's coefficient remained almost invariant.

5.7.3 Consumers' Cyclical (CC)

Third dummy variable. It explains 1.72% of the variation in the numerical rating.

TABLE 5.7.3, consumers' cyclical correlations, source: author's elaboration

Corr.table	***D/TA W***	***EVA/TA W***	***CFF PURE W***	***Company's age***	***RE***	***EN***	***CC***
CC	0.2261	-0.0288	0.0677	0.0390	-0.1398	-0.1053	1

When paired with the other variables, CC does not show high correlation coefficients. The VIF will determine the multicollinearity with all the other variables at once.

REGRESSION OUTPUT 5.7.3, consumers' cyclical multicollinearity, source: author's elaboration

OUTPUT
SUMMARY

Regression statistics	
Multiple R	0.3180
R^2	0.1011
Adjusted R^2	0.0942
Standard Error	0.3684
Observations	786

The dependent variable is CC

VIF = 1/(1-0.1011) = 1.1125

	Coefficients	*Standard Error*	*t stat*	*p-value*
Intercept	0.0749	0.0258	2.9042	0.0038
D/TA W	0.5928	0.0806	7.3525	4.9315E-13
EVA/TA W	-0.0533	0.0680	-0.7841	0.4332
CFF PURE W	2,8995E-11	1.3592E-11	2.1332	0.0332
Company's age	0.0005	0.0004	1.3600	0.1744
RE	-0.2653	0.0492	-5.3865	9.5238E-08
EN	-0.1749	0.0636	-2.7492	0.0061

A VIF of 1.1125 gives no concerns as regards the increasing variance of the regression coefficients. In the following output summary, CC is added to the model.

REGRESSION OUTPUT 5.7.3.1, adding CC to the model, source: author's elaboration

OUTPUT
SUMMARY

Regression statistics	
Multiple R	0.5219
R^2	0.2724
Adjusted R^2	0.2658
Standard Error	2.4913
Observations	786

Attempting to add CC to the model

The dependent variable is NR

	Coefficients	*Standard Error*	*t stat*	*p-value*
Intercept	18.3849	0.1754	104.8306	0
D/TA W	-6.3922	0.5638	-11.3376	1.1080E-27
EVA/TA W	3.7986	0.4599	8.2604	6.2266E-16
CFF PURE W	-3.7737E-10	9.2185E-11	-4.0936	4.6906E-05
Company's age	0.0058	0.0027	2.1742	0.0300
RE	2.0462	0.3392	6.0332	2.4848E-09
EN	-1.3622	0.4323	-3.1508	0.0017
CC	-0.1774	0.2423	-0.7321	0.4643

The CC variable does improve the regression and it is not statistically significant. The high number of regressors in the model is hindering the ability of the new variables to predict the change in the numerical rating in a reliable way. CC is not a useful element for credit score prediction if considered alongside the incumbent set of variables.

5.7.4 Consumers' NonCyclical (CNC) and auditor's fame (AUD)

The last two dummy variables account for only 0.4%(CNC) and 0.5%(AUD) of the variation in the dependent variable NR. To avoid excessive complications of the model, they are excluded from the regression.

5.8 THE FINAL MODEL

The final model includes four variables plus two dummies for the economic sector.

REGRESSION OUTPUT 5.8, the final model, source: author's elaboration

OUTPUT
SUMMARY

Regression statistics	
Multiple R	0.5214
R^2	0.2719
Adjusted R^2	0.2662
Standard Error	2.4905
Observations	786

The final model for predictions of numerical rating

	Coefficients	*Standard Error*	*t stat*	*p-value*
IntercePT	18.3718	0.1744	105.3518	0
D/TA W	-6.4973	0.5450	-11.9208	3.2682E-30
EVA/TA W	3.8081	0.4595	8.2867	5.0746E-16
CFF PURE W	-3.8251E-10	9.1889E-11	-4.1628	3.4949E-05
Company's age	0.0057	0.0027	2.1418	0.0325
RE	2.0932	0.3329	6.2877	5.3650E-10
EN	-1.3312	0.4301	-3.0949	0.0020

It explains 26.62% of the variation in the rating with a standard error of prediction of 2.49 levels. From a base rating of 18.3718, an increase of 1% in the D/TA W decreases the rating by 0.0650, an increase of 1% in EVA/TA W increases the rating by 0.0381, a 1£ increase in the CFF decreases the rating by 3.8251E-10, for each additional year of operations the rating increases by 0.0057. Moreover, a company enjoys a bonus of 2.0932 on the rating if it belongs to the real estate sector and a malus of 1.3312 if it belongs to the energy sector. All the coefficients are statistically significant. The next step involves putting the model to test and seeing how it performs for companies with different credit ratings.

CHAPTER 6: TESTING THE MODEL

The model is tested on 9 randomly chosen companies belonging to three different rating zones: "AAA" to "A-", "BBB+" to "B-", and "CCC+" to "C-". The results are then commented on and compared. To facilitate the calculation of the numerical rating through the regression equation, the variable EVA/TA W is substituted with ROA W: the two variables are highly correlated with each other (R = 0.9812), and ROA W does not show any multicollinearity with the other regressors (VIF = 1.0498). The new model is the following.

REGRESSION OUTPUT 6.0, the adjusted model, source: author's elaboration

OUTPUT
SUMMARY

Regression statistics	
Multiple R	0.5186
R^2	0.2690
Adjusted R^2	0.2633
Standard Error	2.4954
Observations	786

The final model with ROA W instead of EVA/TA W

The dependent variable is NR

	Coefficients	*Standard Error*	*t stat*	*p-value*
Intercept	18.1392	0.1708	106.1809	0
D/TA W	-6.4669	0.5463	-11.8372	7.6195E-30
ROA W	3.8677	0.4785	8.0827	2.4134E-15
CFF PURE W	-3.9341E-10	9.1984E-11	-4.2769	2.1304E-05
Company's age	0.0058	0.0027	2.1615	0.0310
RE	2.1203	0.3334	6.3599	3.4394E-10
EN	-1.3904	0.4301	-3.2324	0.0013

The overall performance is slightly worsened but collecting information on the weighted average of the return on assets rather than on the weighted average of EVA/TA is a better approach to use with the available data. The model's formula is:

Numerical Rating = 18.1392 – 6.4669(D/TA W) + 3.8677(ROA W) – 3.9341E-10(CFF PURE W) + 0.0058(Company's age) + 2.1203(RE) – 1.3904(EN)

TABLE 6.0, review of the numerical rating, source: author's elaboration

AAA	AAA-	AA+	AA	AA-	A+	A	A-		
27	26	25	24	23	22	21	20		
BBB+	BBB	BBB-	BB+	BB	BB-	B+	B	B-	
19	18	17	16	15	14	13	12	11	
CCC+	CCC	CCC-	CC+	CC	CC-	C+	C	C-	D
10	9	8	7	6	5	4	3	2	1

6.1 A-RATING ZONE TEST

SHELL PLC

SHELL is a global group of energy and petrochemical companies. S&P assigned it a credit rating of "A+", corresponding to a numerical rating of 22.

D/TA W = 0.2415, ROA W = 0.0152, CFF PURE W = -16495200000, Company's age = 115,

RE = 0, EN = 1

Numerical Rating = 18.1392 – 6.4669(0.2415) + 3.8677(0.0152) – 3.9341E-10(-16495200000) + 0.0058(115) + 2.1203(0) – 1.3904(1) = 22.4022

Predicted rating = A+

The high amount of repurchased debt and equity in the last three years, and the relatively low leverage are the company's strengths and the main reasons for the rating outcome.

UNILEVER PLC

A British multinational firm that sells alimentary, hygiene, and personal care products. The S&P credit rating is "A+", corresponding to a numerical rating of 22.

D/TA W = 0.3987, ROA W = 0.0830, CFF PURE W = -5139300000, Company's age = 93,

RE = 0, EN = 0

Numerical Rating = 18.1392 – 6.4669(0.3987) + 3.8677(0.0830) – 3.9341E-10(-5139300000) + 0.0058(93) + 2.1203(0) – 1.3904(0) = 18.4431

Predicted rating = BBB

The high percentage of debt in the capital structure is the reason for the lower predicted rating.

GLAXOSMITHKLINE PLC

A pharmaceutical company set in London. The S&P rating is "A", corresponding to a numerical rating of 21.

D/TA W = 0.3239, ROA W = 0.0605, CFF PURE W = -7096100000, Company's age = 22,

RE = 0, EN = 0

Numerical Rating = 18.1392 – 6.4669(0.3239) + 3.8677(0.0605) – 3.9341E-10(-7096100000) + 0.0058(22) + 2.1203(0) – 1.3904(0) = 19.1978

Predicted rating = BBB

The company's history starts about 300 years ago with a pharmacy in London but the official date of incorporation is in the year 2000. It might have influenced the outcome of the model.

DERWENT LONDON PLC

A company that invests in real estate property. The credit rating is "A-", corresponding to a numerical rating of 20.

D/TA W = 0.2125, ROA W = 0.0265, CFF PURE W = 67040000, Company's age = 38, RE = 1, EN = 0

Numerical Rating = 18.1392 – 6.4669(0.2125) + 3.8677(0.0265) – 3.9341E-10(67040000) + 0.0058(38) + 2.1203(1) – 1.3904(0) = 19.1818

Predicted rating = BBB+

The predicted rating is close to the actual one. The positive cash flow from financing activities, due to the issuance of a high amount of long-term debt, works against the credit soundness of the company.

6.2 B-RATING ZONE TEST

AVAST PLC

It is a cybersecurity and software producer company. The S&P equivalent credit rating is "BB+", corresponding to a numerical rating of 16.

D/TA W = 0.3122, ROA W = 0.1003, CFF PURE W = -209985900, Company's age = 16,

RE = 0, EN = 0

Numerical Rating = 18.1392 – 6.4669(0.3122) + 3.8677(0.1003) – 3.9341E-10(-209985900) + 0.0058(16) + 2.1203(0) – 1.3904(0) = 16.6836

Predicted rating = BB+

It is a relatively young company with an average debt ratio and solid profitability. The model predicts its rating accurately.

HARBOUR ENERGY

A British independent oil and gas company. The S&P equivalent credit rating is “BB”, corresponding to a numerical rating of 15.

D/TA W = 0.2676, ROA W = -0.0195, CFF PURE W = -479200000, Company’s age = 8,

RE = 0, EN = 1

Numerical Rating = 18.1392 – 6.4669(0.2676) + 3.8677(-0.0195) – 3.9341E-10(-479200000) + 0.0058(8) + 2.1203(0) – 1.3904(1) = 15.1778

Predicted rating = BB

The company’s relatively low percentage of debt on its total assets and the effort paid in repurchasing debt make up for the low profitability of the last three years.

BT PLC

It is a telecommunication service provider. The S&P credit rating is “BBB”, corresponding to a numerical rating of 18.

D/TA W = 0.4480, ROA W = 0.0273, CFF PURE W = -1823600000, Company’s age = 21,

RE = 0, EN = 0

Numerical Rating = 18.1392 – 6.4669(0.4480) + 3.8677(0.0273) – 3.9341E-10(-1823600000) + 0.0058(21) + 2.1203(0) – 1.3904(0) = 16.1868

Predicted rating = BB+

The company has previously been a monopolist strongly intertwined with the state. It might play a role in the credit evaluation that is not accounted for in the regression.

6.3 C-RATING ZONE TEST

ASTON MARTIN LAGONDA PLC

A company specializing in sportscars manufacturing. S&P assigned it a credit rating of “CCC”, corresponding to a numerical rating of 9.

D/TA W = 0.4481, ROA W = -0.0911, CFF PURE W = 337180000, Company’s age = 109,

RE = 0, EN = 0

Numerical Rating = 18.1392 – 6.4669(0.4481) + 3.8677(-0.0911) – 3.9341E-10(337180000) + 0.0058(109) + 2.1203(0) – 1.3904(0) = 15.3886

Predicted rating = BB

The leverage and low profitability are slightly counteracted by the company's age. The average negative profit of the previous years might be a stronger signal for credit rating agencies rather than for the model.

DOMINO'S PIZZA PLC

An international fast-food and pizza delivery chain. Analysts assigned it a rating of "C+", corresponding to a numerical rating of 4. All the financial statement's USD values are converted to GBP at 1 dollar for 0.8 Pounds rate.

D/TA W = 3.0401, ROA W = 0.3053, CFF PURE W = -375920640, Company's age = 62,

RE = 0, EN = 0

Numerical Rating = 18.1392 – 6.4669(3.0401) + 3.8677(0.3053) – 3.9341E-10(-375920640) + 0.0058(62) + 2.1203(0) – 1.3904(0) = 0.1675

Predicted rating = D

The company is currently in a particular situation where its equity is negative but it still manages to generate constant profits. The model is highly susceptible to the presence of debt, and it is why it predicts a default for the firm.

6.4 FINAL RESULTS

Considering all nine firms, the model fails to predict their exact rating by an average of 2.16 levels, which is very similar to the standard error of prediction of the regression (2.50). The outcomes are also analyzed according to the firm rating sector.

TABLE 6.4, rating zones' tests, source: author's elaboration

	NUMBER	**AVG ERROR**
A-RATING ZONE	4	1.64
B-RATING ZONE	3	0.89
C-RATING ZONE	2	5.11

The data shows a better performance of the regression when forecasting the rating for companies in the B-rating zone. The final chapter presents a possible explanation for this phenomenon and some insights into the main limitations of the model.

CHAPTER 7: MODEL'S LIMITATIONS AND FINAL COMMENTS

The previous tests revealed some limitations that make the model imprecise. However, the predictions of the regression are not intended to be a definitive statement of a company's financial soundness, but rather a quantitative instrument of analysis to use in combination with qualitative tools to understand the elements of credit rating.

7.1 LIMITATIONS: R^2

The percentage of the variation in the numerical rating explained by the regression is far from 100%: it is 26.9%. This percentage is calculated as the ratio of the variance of the predicted outcome from the mean and the variance of the observed values with the same mean. The model fails to explain the remaining 73.1% of the variation in the rating phenomenon, and it is more likely to be noticed when the credit scores approach the edges of the ranking. To better visualize the model performance, three regression tables show the same outcome for companies in differing rating zones.

REGRESSION OUTPUT 7.1, A-rating zone regression, source: author's elaboration

OUTPUT SUMMARY

Regression statistics	
Multiple R	0.4063
R^2	0.1651
Adjusted R^2	0.1330
Standard Error	1.4336
Observations	163

A-RATING ZONE regression statistics

The fit of the regression for the A-rated companies is lower than the total sample fit. It explains the weaker results compared to B-rated firms.

REGRESSION OUTPUT 7.1.1, B-rating zone regression, source: author's elaboration

OUTPUT SUMMARY

Regression statistics	
Multiple R	0.4961
R^2	0.2461
Adjusted R^2	0.2386
Standard Error	1.6968
Observations	609

B-RATING ZONE regression statistics

B-rated companies have a higher R^2 and number of observations. It contributes to making the predictions for that credit zone more accurate.

REGRESSION OUTPUT 7.1.2, C-rating zone regression, source: author's elaboration

OUTPUT SUMMARY

Regression statistics	
Multiple R	0.3657
R^2	0.1337
Adjusted R^2	-0.2513
Standard Error	1.2298
Observations	14

C-RATING ZONE regression statistiscs

The low number of observations of C-rated firms, and the consequent high p-value of the regression's coefficients, make the model quite imprecise in predicting the credit rating.

7.2 LIMITATIONS: DEBT TO ASSETS

The predicted outcome is highly influenced by the amount of a company's debt. The levels of profitability required to compensate for high leverage might be overestimated by the model. The optimal capital structure of a firm is also influenced by the pertinence in a specific industry or economic sector, a condition often not described by the available dummy variables.

7.3 LIMITATIONS: CASH FLOW FROM FINANCING

The "CFF PURE W" variable is not proportional to the dimension of the business. It computes the variation in the numerical rating for each Great Britain Pound added or subtracted from the net cash flow from financing. A bigger company repaying a lesser percentage of its debt compared to a smaller one might benefit from an unfair advantage as regards credit rating.

7.4 LIMITATIONS: COMPANY'S AGE

"Company's age" measures the time elapsed from the date of the firm's incorporation and January 1, 2022. Many companies created new legal entities through mergers and acquisitions, so they result younger than they are. These situations may trick the model into giving the business a lower rating.

7.5 FINAL COMMENTS

The credit rating forecasting model is a useful tool that allows getting a general idea about a company's credit rating. It consents to identify the reasons for its result and works with easy-to-find data from the firm's financial statements. It has many limitations but its outcomes offer valuable insight into the strength and weaknesses of a business in light of its credit rating evaluation.