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Abstract. In the context of continuing population growth in regional centers, one of which is the city of Rostov-on-Don, industrial enterprises of the city are becoming important as centers of job creation. The reduction in the number and volume of output of industrial enterprises in the city has significant dimensions. This study is scoped at assessing the financial stability of industrial enterprises that continue to operate in the city using the Altman Z-score models, which have proven their effectiveness in the probability of bankruptcy at the global level. The study was conducted on a sample of ten industrial enterprises in the manufacturing industry. Two Altman Z-score models were used as tools: for private enterprises in the industrial sector, and for enterprises from emerging markets. The results of the analysis suggest that the Z-model for private industrial companies is better suited for assessing the financial stability of the manufacturing industry companies. The use of the classic Z-score model and the emerging market Z-score model has some limitations. Assessment of financial stability based on Altman models indicates a good and satisfactory financial condition of the majority of industrial enterprises in the city. As a result of the Altman Z-score models assessment, it was found that the main variables that negatively affect the final results of the Z-score are the long-term functioning of economic entities with negative financial results and negative net working capital.

Keywords: Financial Stability, Bankruptcy, Manufacturing Industry, Altman's Z-Score.

1 Introduction

The preservation and development of industrial enterprises are considered today as the urgent problems of economic well-being for Russian regions [1]. For the development of conditions for the realization of intellectual, labor, and resource potential, the preservation of industrial potential for large regional centers is especially important [2]. Regional and interregional interaction, which is considered by economists as an element of intensifying economic growth and development of innovations, cannot be imagined without regional industrial centers [3]. Rostov-on-Don is a regional center of the South of Russia; historically the city was considered its industrial center. In the past two decades, the decrease in industrial production in the city is noticeable without statistical calculations. Suffice it to say that during this period more than 10 large industrial enterprises of the manufacturing industry were closed down in the city.

Industrial enterprise's bankruptcy is a worldwide problem and is believed to cause economic damage around the world [4]. The main reasons for the industrial manufacturing crisis in the city, of course, were the same factors as throughout Russia: lack of experience in managerial work in the transition to a market economy, inability to adapt to the conditions of a market economy, devaluation, loss of working capital, loss of established markets and technological ties, and, most importantly, low competitiveness and lack of demand for products.

Nevertheless, some industrial enterprises of the city were able to more or less adapt to the new economic conditions and continue to function at present. Adaptation does not mean that there will be no problems in the future since the loss of financial solvency and bankruptcy are the main problems in the context of current events, which can lead to price imbalances, disruptions in the supply of components and finished products. In these conditions, the assessment of financial stability and the ability to withstand shocks look especially relevant. Knowing the likelihood of bankruptcy with reasonable accuracy in advance, companies can better protect themselves and take action to reduce the risk of financial loss or avoid bankruptcy. Besides, the further development of industrial enterprises in the city cannot be imagined without the introduction of innovations and modern technologies that require large investments and investors should have access to qualified information about the financial condition of the companies in which they are interested in investing. For regional economic authorities, such an assessment can help in making decisions on the structural policy of the region, which is recognized as an important component of a balanced economy [5, 6]. Therefore, it will be useful to assess the financial health of industrial enterprises in the city using proven and recognized methods.

Therefore, this study is aimed at assessing the financial sustainability of manufacturing enterprises in the city of Rostov-on-Don using Altman's Z-models. The classical model and its variations are designed to assess the

probability of default (bankruptcy) of a company based on the analysis of several indicators of its financial and economic activities and the calculation of the consolidated indicator of the financial condition [7].

Our study contains several differences from previous studies in this area of assessing the financial problems of business entities. First, we apply Altman's methodology in the study of industrial companies in the mechanical engineering segment, located in a separate zone, which is an example of a Russian industrial city.

Secondly, in the Russian-language segment of the scientific literature, we have found no previous works directly related to our research. In the scientific electronic library "eLibrary" for the keywords "Rostov-on-Don" and "Altman" no single article can be hunted. The only work that addresses the problem of socio-economic development of the city is [8]. At the same time, there is a lot of applied research on assessing the financial stability of companies using the Altman Z-model. In existing studies based on different variants of the Altman Z-model the financial stability of individual companies [9, 10], branches of the economy [7, 11, 12] or countries [13-17] are assessed.

Thirdly, taking into account the existing organizational and legal forms of ownership and the absence of circulating securities of companies in the engineering industry of Rostov-on-Don on the stock market, the study was carried out based on an assessment of data from non-public companies. At the same time, with certain adjustments for the non-public nature of companies from the sample, we assessed all three Altman models.

Fourthly, we hope that this study will be useful for investors, as well as for CEOs of companies in the sample, the Ministry of Economic Development of the region, and the City Administration. This hope is justified by the fact that the assessment using Altman's models provides signals of financial distress before it occurs with high efficiency [7]. Investors can get information to analyze industrial companies operating in the city and make decisions about their presence in the region and the city.

2 Materials and Methods

2.1 Methodology

The Z-score model was first proposed by E. Altman in 1968 using a linear combination of five weighted coefficient indicators [12]. The coefficients for the indicators were estimated by discriminant analysis and comparison of two data sets of public companies: survivors and those who filed for bankruptcy with a comparison by industry and approximate size (assets). After more than fifty years, researchers still widely view the Altman Z-model as an indicator of a company's financial classification. Several authors estimate the probability of forecast accuracy for this model at the level of up to 90% [17].

We use two Altman models, a model for private companies in the manufacturing sector whose shares are not listed on the stock exchange (Z_{NP}-score) and a model for companies from emerging markets (Z_{EM}-score). The calculation of integral indicators is carried out according to the formulas (1) and (2) [13, 14]:

$$Z_{NP} = 0.717*X_1 + 0.847*X_2 + 3.107*X_3 + 0.420*X_4 + 0.998*X_5 \quad (1)$$

$$ZEM = 3.25+ 6.56X1 + 3.26X2 + 6.72X3 +1.05X4 \quad (2)$$

where X_1 – Working capital/Total assets;
X_2 – Retained Earnings/Total assets;
X_3 – Earnings before interest and taxes/Total assets;
X_4 – Equity /Total Liabilities (long-term and current);
X_5 – Sales/Total assets.

For Z_{NP} interpretation of the results is carried out according to the scale:
$Z_{NP} > 2.99$ – "Non-bankrupt sector" (the probability of bankruptcy is low);
$1.23 < Z_{NP} < 2.99$ – "Gray area" (area of uncertainty);
$Z_{NP} < 1.23$ – "Bankrupt sector" (high probability of bankruptcy, risk area).
For Z_{EM} interpretation of the results is carried out according to the scale:
$Z_{EM} > 2.6$ – "Non-bankrupt sector" (the probability of bankruptcy is low);
$1.1 < Z_{EM} < 2.6$ – "Gray area" (area of uncertainty);
$Z_{EM} < 1.1$ – "Bankrupt sector" (high probability of bankruptcy, risk area).

2.2 Data

In the study, the financial stability of the sample of 10 manufacturing enterprises in Rostov-on-Don was assessed using all three described models. The selection of manufacturing enterprises located in the city of Rostov-on-Don was made from the list presented on the portal "Encyclopedia of Industry of Russia" (WikiProm) [18]. The data for the analysis were obtained on the information disclosure portals Rusprofile [19] and Interfax [20]. The number of enterprises equal to ten is not a choice of a round number, but a random coincidence of a choice from enterprises located in the city according to two criteria: (1) the main activity is related to the production of industrial products (except for building materials) and (2) the volume of annual revenue is at least 100 million rubles based on the results of two reporting periods out of five studied ones (from 2014 to 2018 inclusive). The sample list is in Table 1. There are also the main parameters of the financial performance of companies for 2018.

Table 1. The sample of industrial enterprises in Rostov-on-Don (data as of 01.01.2019).

Full Name	Code	Main activity	Assets	Revenue	Net Profit
PJSC "Rostvertol"	RVP	Helicopters production	95 583 228	93 988 806	15 911 956
LLC "Rostselmash"	RSM	Agro-industrial equipment production	40 207 278	39 704 836	4 751 434
JSC "Prodmash"	PDM	Food-industrial equipment production	1 011 120	272 125	1 023
JSC "Rostovgasoapparat"	RGA	Gas heating equipment production	382 020	364 225	525
LLC "Rostov foundry"	RFP	Foundry production	354 751	1 019 780	273
LLC "Rostov Compressors Plant"	RCP	Compressors (pumps) production	273 732	446 374	8 063
JSC "Sevkavelektroremot"	NCE	Electrical transformer production	249 721	489 978	35 636
LLC "Yujtechmontaj"	YTM	Metal structures production	1 955 96	364 225	525
LLC "Rosvelektroremot"	RER	Electrical machines equipment production	70 748	100 291	441
JSC "Elektrotechnika"	ELT	Technological equipment production	70 656	86 255	4 393

3 Results and Discussion

3.1 Descriptive statistics of the models

For both models, calculations were carried out based on the results of 2014-2018 financial years. The results of descriptive statistics of variables, the annual results of which are presented according to model (1), can be found in Table 2. In general, we can state a good homogeneity of the financial performance of the sample, since the mean values of the variables and the standard deviation (SD) are rather densely grouped. Significant deviations from the mean values are observed only for variable X4, especially for 2017 and 2018. For model (2) we do not present data: results of calculations completely coincide with model (1).

Table 2. Descriptive statistics of variables in model (1).

Variables	Year	Min	Max	Mean	SD
X1	2014	-0.6377	0.7663	0.2905	0.4329
	2015	-0.7523	0.7848	0.2918	0.4517
	2016	-0.7510	0.7660	0.2991	0.4409
	2017	-0.5676	0.7042	0.2947	0.4038
	2018	-0.6600	0.7142	0.1002	0.4927
X2	2014	-0.0563	0.7663	0.2578	0.3337
	2015	-0.0463	0.7800	0.2669	0.3280

	2016	-0.0291	0.7903	0.3171	0.3236
	2017	-0.0237	0.8127	0.4026	0.3109
	2018	-0.0563	0.8155	0.2745	0.3591
	2014	-0.0969	0.3101	0.1198	0.1410
	2015	-0.0630	0.1812	0.0660	0.0812
X3	2016	-0.0204	0.3901	0.1295	0.1377
	2017	-0.0182	0.4599	0.1630	0.1557
	2018	-0.0247	0.2078	0.0628	0.0758
	2014	-0.0532	4.4973	0.8035	1.4672
	2015	-0.0405	4.6107	0.8273	1.4596
X4	2016	0.0000	4.2791	0.9186	1.3615
	2017	0.0000	11.6635	2.2199	3.5775
	2018	-0.0532	11.8934	2.2073	3.6995
	2014	0.2961	3.2518	1.5352	1.0190
	2015	0.2056	2.7389	1.3594	0.8263
X5	2016	0.3932	3.1204	1.5993	0.8204
	2017	0.5946	2.9225	1.4474	0.7110
	2018	0.2691	2.8746	1.3782	0.6948

Table 3 provides descriptive statistics for the X1-X5 and Z-score variables for each model. Calculations show that the minimum value for almost each of their variables demonstrates negative values; the exception is variables X5 in models (1).

Table 3. Descriptive statistics of variables and Z-score for the sample for the entire period.

Score	Min	Max	Mean	SD
X1	-0.7523	0.7848	0.2874	0.4125
X2	-0.0563	0.8155	0.3243	0.3173
X3	-0.0969	0.4599	0.1113	0.1232
X4	-0.0532	11.8934	2.2986	3.1600
X5	0.2056	3.2518	1.4702	0.7910
Z_{NP}	**0.11**	**8.80**	**3.26**	**2.12**
X1	-0.7523	0.7848	0.2874	0.4125
X2	-0.0563	0.8155	0.3243	0.3173
X3	-0.0969	0.4599	0.1113	0.1232
X4	-0.0532	11.8934	2.2986	3.1600
Z_{EM}	**-1.71**	**23.24**	**9.35**	**6.38**

The mean values of most of the variables are at comfortable levels. Calculations based on the indicators of return on assets and equity in the sample (Table 8) demonstrate results that are higher than the average for the Russian industry in the aggregate. According to Rosstat, the profitability of industrial enterprises assets (excluding SMEs) in the period 2014-2018 amounted to respectively: 2.5; 3.7; 5.9; 3.8 and 4.7% [21]. Fluctuations in variables for the period under study are within fairly moderate limits. The widest scatter is observed here for the X4 variable: the standard deviation is 3.16.

According to the results of the Z-account obtained for the entire period of estimate, one can also judge the sufficient stability of the financial condition of the sample. The results of statistics of model (1) are not alarming, the results for model (2) are slightly different: when evaluating by the model for emerging markets, both negative values of the composite indicator are observed, as well as the largest spread (24.95 units) with a standard deviation of 6.38 units. The average Z-score for both models is in the safe area. Therefore, based on the results of the analysis of descriptive statistics of variables and resulting indicators of the Z-score, it can be argued that the financial situation of industrial enterprises of the city of Rostov-on-Don for the entire period locates in a safe area.

Next, we will analyze the statistical results of evaluating models for each year of the study period separately. The obtained data of descriptive statistics are in Table 4.

Table 4. Descriptive statistics of Altman's Z-score by years.

Score	Year	Min	Max	Mean	SD
Z_{NP}	2014	0.75	5.53	3.03	1.89
	2015	0.58	7.62	3.09	2.37

	2016	1.19	8.80	3.48	2.33
	2017	0.59	8.59	3.50	2.39
	2018	0.11	7.52	2.79	2.09
	2014	-0.32	15.68	8.56	5.31
	2015	-1.71	20.73	9.20	6.94
Z_{EM}	2016	-1.24	23.24	9.61	6.86
	2017	-0.40	22.98	10.08	6.96
	2018	-0.81	22.26	7.51	7.58

At the annual assessment, there are both similarities and differences with the summary data for the entire period (Table 3). The negative minimum value of the Z-score was found only in the results by model (2). Here, the largest spread of the resulting indicator is observed. Z-score volatility for emerging markets ranges from 5.31 to 7.58, which is approximately three times higher than that for model (1). The presence of a 3.25 constant in the formula for calculating Z_{EM}, which should "elevate" the results obtained at the expense of the remaining elements of the formula, is superfluous for our sample. Should we conclude that this model is not suitable for assessing the financial soundness of our sample? The answer can be obtained only after detailing the results for each of the companies included in the sample and evaluating other financial indicators.

3.2 The results of the Z-score for each enterprise

The results of calculating the variables and Z-score are detailed for each model separately and are presented in Tables 5, 6, respectively. According to the results of the assessment using model (1), six of the ten (60%) industrial enterprises in Rostov-on-Don are in a safe financial area. It is important to note that the financial condition of all enterprises in the sample has improved over the period.

Table 5. Estimate results for every enterprise – model (1): for non-public companies.

Enterprise	2014		2015		2016		2017		2018	
s	Z_{NP}	Class.	Z_{NP}	Class.	Z_{NP}	Class.	Z_{NP}	Class.	Z_{NP}	Class.
RVP	0.85	D	1.08	D	1.90	G	2.10	G	2.64	G
RSM	1.72	G	2.72	G	3.76	S	5.12	S	4.21	S
PDM	0.75	D	0.75	D	1.19	D	0.59	D	0.11	D
RGA	3.47	S	3.38	S	3.42	S	3.08	S	3.56	S
RFP	4.38	S	3.28	S	4.97	S	5.10	S	3.70	S
RCP	n/d	-	0.99	D	1.25	G	1.88	G	1.72	G
NCE	4.66	S	4.85	S	4.34	S	3.97	S	3.65	S
YTM	1.24	G	0.58	D	1.33	G	0.85	D	1.50	G
RER	4.71	S	5.63	S	3.85	S	3.69	S	3.13	S
ELT	5.53	S	7.62	S	8.80	S	8.59	S	7.52	S

$Z_{NP} > 2.99$ – "Non-bankrupt sector" (the probability of bankruptcy is low) – (S);
$1.23 < Z_{NP} < 2.99$ – "Gray area" (area of uncertainty) – (G);
$Z_{NP} < 1.23$ – "Bankrupt sector" (high probability of bankruptcy, risk area) – (D).

Table 6. Estimate results for every enterprise – model (2): for emerging market companies.

Enterprises	2014		2015		2016		2017		2018	
	Z_{EM}	Class.	Z_{EM}	Class.	Z_{EM}	Class.	Z_{EM}	Class.	Z_{EM}	Class.
RVP	7.21	S	7.56	S	9.13	S	9.26	S	9.56	S
RSM	7.13	S	9.12	S	11.54	S	16.68	S	15.18	S
PDM	3.65	S	3.06	S	3.61	S	2.49	G	2.41	G
RGA	15.68	S	15.81	S	15.33	S	13.61	S	13.95	S
RFP	5.19	S	5.52	S	9.15	S	10.70	S	6.45	S
RCP	n/d	-	3.89	S	3.07	S	3.49	S	3.21	S
NCE	11.82	S	11.88	S	10.84	S	10.81	S	10.15	S
YTM	-0.32	D	-1.71	D	-1.24	D	-0.40	D	-0.81	D
RER	12.72	S	16.19	S	11.47	S	11.17	S	9.99	S
ELT	13.92	S	20.73	S	23.24	S	22.98	S	22.26	S

$Z_{EM} > 2.6$ – "Non-bankrupt sector" (the probability of bankruptcy is low) – (S);
$1.1 < Z_{EM} < 2.6$ – "Gray area" (area of uncertainty) – (G);

Z_{EM} < 1.1 – "Bankrupt sector" (high probability of bankruptcy, risk area) – (D).

According to the Emerging market model, eight out of ten elements (80%) of our sample received the maximum score. One enterprise (YTM) gets the lowest score: it is in the "risk area". The main reason for which the company receives negative Z-Scores is the negative amount of net current assets, insignificant volumes of operating, and retained earnings. Separately, we should dwell on the results of another outsider of model (1), "PDM", which in model (2) receives Z-scores (S) and (G). Therefore, we can conclude that this object gets an overestimated Z-score due to the (3.25) constant in formula (2).

3.3 The estimate of profitability and financial stability indicators

We do not evaluate the level of defaults (due to the lack of reliable information), which would allow us to objectively assess the suitability of the employed models for applied use, therefore, the effectiveness of the financial results of the sample was assessed using traditional indicators of return on assets (ROA) and on equity (ROE). In addition to them, we evaluate the Margin of Financial Stability (MFS) estimated as the ratio of the number of own funds and long-term loans to total assets.

The choice of this indicator is due to the fact that a rather high requirement of -75% and higher is imposed on its standard value. All three indicators were evaluated for all elements of the sample for the entire period of the analysis. Descriptive statistics of the ratios are provided in Table 7. Large variation is observed only in the indicators of ROE. This is due to the fact that one element of the sample (PDM) has a loss in the first two periods, and another (YTM) has a negative value of equity. These two objects showed the worst marks for all three Altman models. For the rest of the sample, there are quite good levels of profitability. Thus, when comparing estimates by Altman's models and indicators of profitability, we can state that all three models identified those two enterprises which have the worst indicators of profitability as unfavorable.

Table 7. Descriptive statistics of profitability and financial stability.

Variables	Year	Min	Max	Mean	SD
Return of assets (ROA)	2014	-0.0461	0.2635	0.1083	0.1043
	2015	-0.0123	0.1434	0.0634	0.0622
	2016	0.0079	0.3122	0.1130	0.1045
	2017	0.0012	0.3648	0.1342	0.1202
	2018	0.0008	0.1665	0.0520	0.0596
Return of equity (ROE)	2014	-2.3896	0.7138	-0.2725	1.0914
	2015	-5.0922	0.9507	-0.3060	1.7099
	2016	0.0147	6.8457	1.0441	2.0594
	2017	0.0034	0.8258	0.3440	0.2301
	2018	-1.9211	0.4722	-0.0146	0.6934
Margin of financial stability (MFS)	2014	-0.0562	0.8181	0.5440	0.2876
	2015	-0.0422	0.9069	0.5253	0.3377
	2016	0.0075	0.9163	0.5364	0.3320
	2017	0.0116	0.9210	0.5280	0.3286
	2018	-0.0562	0.9224	0.3984	0.3841

Finally, we compare the results of the models with the Margin of Financial Stability (MFS), which is not included in the variables of Altman's models. Full details of the ROA, ROE, and MFS are given in Table 8.

Table 8. Ratios of return on assets, equity and financial stability.

Firm	MFS						ROA						ROE					
	14	15	16	17	18	$\bar{X}$	14	15	16	17	18	$\bar{X}$	14	15	16	17	18	$\bar{X}$
RVP	0.66	0.66	0.72	0.70	0.62	0.67	0.03	0.06	0.14	0.14	0.17	0.11	0.21	0.37	0.54	0.43	0.35	0.38
RSM	0.57	0.65	0.68	0.81	0.82	0.71	0.04	0.13	0.20	0.37	0.12	0.17	0.11	0.26	0.33	0.47	0.15	0.26
PDM	0.32	0.18	0.24	0.16	0.16	0.21	-0.05	-0.01	0.02	0.00	0.00	-0.01	-2.39	-5.09	0.87	0.07	0.06	-1.30
RGA	0.82	0.82	0.81	0.77	0.78	0.80	0.02	0.00	0.01	0.00	0.00	0.01	0.03	0.00	0.02	0.00	0.00	0.01
RFP	n/d	0.38	0.42	0.56	0.67	0.51	n/d	0.26	0.11	0.22	0.18	0.20	n/d	0.71	0.27	0.40	0.28	0.42

RCP	0.61	0.12	0.01	0.06	0.06	0.17	0.00	0.00	0.01	0.05	0.03	0.02	0.00	0.95	0.86	0.83	0.47	0.62
NCE	0.61	0.65	0.63	0.57	0.53	0.60	0.22	0.14	0.09	0.17	0.14	0.15	0.37	0.23	0.15	0.31	0.28	0.27
YTM	-0.06	-0.04	0.01	0.01	0.01	-0.01	0.11	0.01	0.05	0.01	0.00	0.04	-1.92	-0.25	6.85	0.47	0.20	1.07
RER	0.80	0.89	0.79	0.61	0.57	0.73	0.19	0.05	0.07	0.20	0.11	0.12	0.23	0.06	0.09	0.33	0.18	0.18
ELT	0.79	0.91	0.92	0.92	0.92	0.89	0.15	0.14	0.31	0.23	0.06	0.18	0.20	0.15	0.34	0.25	0.07	0.20

The sample is divided into five groups according to the MFS. The first group consists of three elements (RGA, RER, and ELT), in which the coefficient values above the recommended level (75%) are observed throughout the period. Two elements of the sample (RVP and RSM) show values at the level of 65-70%. For the next two objects (RFP and NCE), the coefficient is in the range of 40 to 60%. For PDM, the MFS fluctuates within 20%, and for YTM, about 0%. Thus, the assessment both according to Altman's models and in terms of profitability and financial stability ratio shows two outsiders. At the same time, the results that are closest to alternative calculations are shown by the second Z-score model (Z_{NP}), i.e. a model designed to examine the probability of bankruptcy of industrial enterprises whose shares are not traded on the market. Actually, our entire sample consists of such enterprises, which allows us to declare a high degree of efficiency of using model (2) when analyzing enterprises of the manufacturing industry in Russian conditions.

Our findings are consistent with other studies based on Russian data [11, 16], which showed that model (2) overcomes the limitations of the first model and can be used to assess financial sustainability both at the level of individual economic entities and at the level of over industry data.

4 Conclusion

Our analysis of the financial stability of the sample of manufacturing enterprises located in the city of Rostov-on-Don using three versions of the Altman Z-model indicates that the model for private (non-public) industrial enterprises is able to most objectively assess the financial sustainability of industrial enterprises. The classical model requires the public nature of the subject of estimate; therefore, instead of the market price of enterprises, one has to use the net asset value of the balance sheet. The model for emerging markets gives too high values of the resulting indicator due to the presence of the (3.25) constant in the formula. This allows us to state the need for further research of this model to examine this constant and, possibly, to select more correct coefficients for the model variables.

The results of the analysis allow us to assert that most of the manufacturing enterprises of the city of Rostov-on-Don have good or satisfactory financial stability. Data for those enterprises that show a high level of bankruptcy risk indicate the importance of variables X2 and X3 which are formed with the participation of indicators of net working capital and retained earnings, respectively. The effect of the presence of a positive result of retained earnings on the data of our sample is especially highlighted: the long-term operation of a business with a negative financial result is a reliable indicator of its inefficiency and impending bankruptcy. Long-term operation with negative financial results also becomes the reason for negative equity. And equity is an indicator that is involved in calculating variable X4 in the model for non-public companies.

Summing up, we note that, in accordance with the calculations, it looks ideal when all the variables in the models are positive, in order to have a higher resulting Z-score.

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