“Financial crisis of real sector enterprises: an integral assessment”

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ARTICLE INFO	Inna Shkolnyk, Tomasz Pisula, Liliia Loboda and Natalia Nebaba (2019). Financial crisis of real sector enterprises: an integral assessment. *Investment Management and Financial Innovations*, *16*(4), 366-381. doi:10.21511/imfi.16(4).2019.31
DOI	http://dx.doi.org/10.21511/imfi.16(4).2019.31
RELEASED ON	Thursday, 26 December 2019
RECEIVED ON	Tuesday, 19 November 2019
ACCEPTED ON	Wednesday, 11 December 2019

JOURNAL	"Investment Management and Financial Innovations"
ISSN PRINT	1810-4967
ISSN ONLINE	1812-9358
PUBLISHER	LLC “Consulting Publishing Company “Business Perspectives”
FOUNDER	LLC “Consulting Publishing Company “Business Perspectives”

NUMBER OF REFERENCES	NUMBER OF FIGURES	NUMBER OF TABLES
37	3	4

BUSINESS PERSPECTIVES

LLC "CPC "Business Perspectives"
Hryhorii Skovoroda lane, 10,
Sumy, 40022, Ukraine

www.businessperspectives.org

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FINANCIAL CRISIS OF REAL SECTOR ENTERPRISES: AN INTEGRAL ASSESSMENT

Abstract

Successful crisis resolution of the enterprise depends heavily on its timely detection, which is facilitated by the use of forecasting models. This allows understanding the scale of the problems in a timely manner and developing the appropriate measures, applying various financial mechanisms to prevent it, and in case of occurrence, reducing the amount of losses. In this context, it is important to choose the most optimal informational model that would provide the most objective forecasts, considering the financial activity peculiarities of the analyzed enterprise. Given a wide list of models that predict the financial crisis, there is a need to analyze and select the most accurate model for enterprises in the real economy. Ten Ukrainian machine builders are used to assess the bankruptcy probability using the most popular models; a taxonomic analysis was carried out, which allows systematizing a large amount of data and analyzing their impact on enterprise development. An integral index was determined, which allowed predicting the financial performance dynamics. For each enterprise, ten indicators were used characterizing their financial state for the period 2014–2018. It is substantiated that the selected models differ from each other by the set of initial data and the number of coefficients from four to seven. It is also determined that the efficient use of studied models is quite different; so when choosing a model to predict the bankruptcy probability, it is necessary to consider the peculiarities of the enterprise's production activity, the accuracy in creating the financial statements and many other factors, including the presence of company's shares in circulation at the stock market. It is worthwhile to use a taxonomic analysis to make a comprehensive comparison of the enterprise financial state and to substantiate the final choice of the bankruptcy forecasting model.

Keywords bankruptcy, Altman Z-score, forecasting, taxonomic analysis, financial standing

JEL Classification G32, G33

Received on: 19th of November, 2019
Accepted on: 11th of December, 2019

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INTRODUCTION

Constant changes in country's economy, increased market competition, the influence of various factors that destabilize the enterprises' activity and significantly complicate their development cause various crisis phenomena. The crisis is most often perceived as a negative phenomenon, but if one views it more broadly and knows how to warn the negative changes, the crisis can have a positive impact on enterprise development. This is what contributes to the need to introduce the crisis management at the enterprises. For research, the activity of machine-building enterprises was chosen because they are the basis for the economic development of both Ukraine and Poland. To overcome a crisis, timely identification of its signs and taking adequate measures to prevent them are essential. In this regard, there is a need to find the most informative model that would allow predicting the enterprise bankruptcy most objectively. Given the existence of many models that predict the formation of the financial crisis, there is a need to analyze and select the most accurate one for the real economy en-

http://dx.doi.org/10.21511/imfi.16(4).2019.31

terprises. The purpose of this study is to find out the most objective bankruptcy forecasting model for the real sector enterprises and to compare the obtained results with the calculations received through taxonomic analysis.

1. LITERATURE REVIEW

The issue of predicting the enterprise financial crisis in the real economy sector has been in focus for a long time and does not lose its relevance both in highly developed and less developed countries; for the latter, this problem is even more relevant since the enterprises' activities are significantly affected by external factors due to economic and especially financial instability. This is corroborated by several publications from all over the world contained in the Scopus and Web of Science Core Collection scientometric databases. Besides, a great number of publications are also submitted to Google Scholar and Research Gate. One can fully agree with the conclusion made by Prusak (2018) who analyzed the scientific publications on enterprise bankruptcy forecasts in Poland, Lithuania, Latvia, Estonia, Ukraine, Hungary, Russia, Slovakia, Czech Republic, Romania, Bulgaria, and Belarus. The author motivated this sampling by the fact that bankruptcy research in these countries, unlike the economically developed states, became relevant only at the end of the 20th century. Based on the analysis of Google Scholar and Research Gate scientific publications during the period Q4 2016 – Q3 2017, Prusak (2018) notes that the most up-to-date are the studies conducted in the Czech Republic, Poland, Slovakia, Estonia, Russia, and Hungary. The author referred Ukraine to the countries that use traditional approaches to forecasting, which can only be partially agreed upon.

In highly developed countries, scientific research on this problem became relevant at the beginning of the second half of the 20th century. It is at this time that the most popular bankruptcy forecasting models are emerging, which continue to be relevant today. Haber (2005) cites 22 models that appeared between 1966 and 2000. The Altman *Z*-score (Altman, 1968) is the most popular bankruptcy forecasting model. According to Altman (2018, p. 1), "Fifty years ago, in 1967, I completed my Ph.D. dissertation, which involved the first multivariate model for predicting the financial health of US manufacturing firms and whether or not they were likely to file for bankruptcy. That work was followed shortly afterward (in 1968) by the publication of the model's specifications. Despite its "old age," the Altman *Z*-score is still the standard against which most other bankruptcy or default prediction models are measured and is clearly the most used by financial market practitioners and academic scholars for a variety of purposes." In different countries, this model can give different forecast accuracy because it contains the indicators based on information that is formed in the stock market and characterizes not only the financial condition but also, to some extent, the companies' business activity. In the countries with low levels of stock market development, the use of this model does not provide the most objective information about the company bankruptcy probability.

It is also worth noting that most bankruptcy forecasting models emerged as a result of research of prediction accuracy based on the Altman model. In particular, this is about the Springate model (1978), whose advantage is that the forecast deviation does not exceed 10%. At the same time, the analysis is not limited to companies that use stocks. The nuance is that over time, there is a decrease in the accuracy of indicators; this model takes into account only the economic direction of influence, i.e., it can be used as an additional one.

Beaver's model (1968) is quite popular; it assesses the likelihood of enterprise bankruptcy, a forecast period of one and five years. In Ukraine, the recommendations based on this model have been developed that can help identify and analyze the probability of entity insolvency. When calculating this index, the significant advantage is that profitability, financial leverage, and other vital indicators are taken into account.

The study also takes into account the model of Gilbert, Menon, and Schwartz (1990); its advantages are the simplicity of calculations, the availability of data for analysis, and equally important that, based on the model obtained, it is possible to

predict the risk identification. However, like most models, this one has many nuances that do not sufficiently consider the entire activity of the enterprise. This model is very similar to Toffler and Tishaw's model (1977).

Also, given the significant popularity of models among Ukrainian and Polish studies, the models of Holder (1979) and Chesser (1974) are considered. The advantage of most of these models is their easy calculation since they use a small number of indicators; all the necessary indicators for the estimation are available in the balance of each enterprise and are open to them; rapid external audit of the enterprise can also be used.

Given the significant developments in international research on the use of different methods and models for bankruptcy forecasting, their use in different countries without taking into account the peculiarities of the current state of the national economy and the development level of the national financial market does not give the objective results, and the forecast accuracy can be extremely low. Thus, Achim et al. (2012, p. 133) state that "…a review of predictive models of bankruptcy risk is imperative. A score function is influenced by characteristics of the country or region for which it was created, by the economic and financial development level of the country concerned, by the industry in which companies are operating, by the accounting system used, by the influence of taxation, by the predominantly type of financing, etc."

It is important to note that the financial crisis formation at the enterprises of the real economy sector is quite different from this process in the financial sector – banks, insurance companies, etc. because of the significant difference in the formation of both assets and capital of enterprises. Assets of real sector enterprises, especially heavy industry, metallurgy, machine building, and energy, have more different levels of liquidity than financial companies, and, therefore, require using other indicators in bankruptcy forecasting. "Corporate failure is generally not a sudden event, it is rare that firms with good profitability and strong balance sheets file for bankruptcy because of a sudden change in the economic environment. Usually, corporate failure is the culmination of several years of adverse performance and, hence, will be largely captured by the firm's accounting statements" (Agarwal & Taffler, 2008, p. 1542). Spicka (2013) analyzes the symptoms of the forthcoming bankruptcy in the Czech construction industry. In contrast to the previous study, the sample of enterprises in the construction industry allows analyzing and identifying the financial preconditions for bankruptcy at the enterprise, taking into account the peculiarities of financial activity. More importantly, a sample of the surveyed enterprises was formed, namely those that had obvious signs of bankruptcy and the companies with relatively good solvency. Given the results obtained, it can be concluded that the financial situation of the studied enterprises in the Czech Republic is quite similar to the financial symptoms of Ukrainian and Polish enterprises, especially since the results of this study show that, like Ukrainian enterprises, they often use the commercial credit by their suppliers, which significantly increases the insolvency risks if the company's financial management is ineffective. In addition, Spicka (2013) concludes that the solvency problems in the construction industry can cause a domino effect over other branches. This may also be characteristic of machine-building enterprises since both in Ukraine and Poland, this sector is essential for the formation of macroeconomic indicators of the countries' development, and a large proportion of the population works there. The results conclude that effective financial management is the most important direction of withdrawing the companies from the crisis.

When studying, it is important to keep in mind the correct use of the information base, including the expediency of using the financial statements for a real valuation of the enterprise assets (Gawron et al., 2019), using Polish enterprises as an example. One can agree that using the financial statements and accounting data for one period to find out the financial position and predict the bankruptcy is not correct because it reflects the statistic at a specific point in time, recorded in the performance reported.

Despite many bankruptcy forecasting models, research is continuing in this direction, moving both towards finding a simplified forecasting model and towards using sophisticated economic and mathematical methods. Therefore, a lot of studies are finding an alternative model that can

http://dx.doi.org/10.21511/imfi.16(4).2019.31

address the existing shortcomings (Horváthová & Mokrišová, 2018; Pisula, Brożyna, & Mentel, 2016; Káčer, Ochotnický, & Alexy, 2019; Pakdaman, 2018; Szetela, Mentel, & Brożyna, 2019). Jabeur and Fahmi (2018) compare three statistical methods predicting the corporate financial distress, in particular, discriminant analysis, logistic regression, and random forest (RF) techniques. These approaches are evaluated based on a sample of 800 companies, composed of 400 healthy companies and 400 failed companies. This study covers the period from 2006 to 2008, using 33 financial ratios.

Brîndescu-Olariu (2016) aims to develop a simplified method for predicting the bankruptcy of companies. More than 1,100 Romanian companies have been surveyed, and the sample of financial indicators is over 53,000 yearly financial statements. It has been determined that it is appropriate to use the solvency ratio to predict the bankruptcy. It is worth noting that this approach is simplified and is limited in formulating the recommendations for crisis management at the enterprises. Besides, it was calculated for different enterprises, and, therefore, did not take into account the peculiarities of the financial flow formation.

Some studies investigate the models of forecasting the financial crises, taking into account non-financial factors, in particular, corporate governance. Hsiao, Lin, and Hsu (2010) developed the logistic regression model to build a financial distress prediction model by using earnings management indicators, corporate governance, and auditor opinion variables.

The above models are generally discriminant. This approach has become popular since its accuracy is approximately 86%.

Research conducted on these issues in Ukraine is gaining momentum since Ukrainian enterprises operate under financial system instability and are significantly influenced by both external and internal factors. This requires the financial management of enterprises to regularly forecast their financial status and crisis events that can lead to enterprise bankruptcy. It is worth noting that two major models of bankruptcy forecasting have become widely known in Ukrainian scientific research, namely Tereshchenko's (2004) model and that of Matviichuk (2010), which are discriminant models and to some extent take into account the peculiarities of financial relations in Ukraine. Matviichuk (2013), in his further studies, will try to use other approaches for bankruptcy forecasting, including neuro-fuzzy models. Kozlovskyi et al. (2019) propose to predict the bankruptcy of enterprises based on the fuzzy set method, including the indicators of international financial reporting.

2. DATA AND METHODS

Ten Ukrainian machine-building enterprises were selected for the research, namely, Energomaskhspetsstal (EMSS), Drogobych Machine-Building Plant (DMBP), Krykovsky Railway Car Building Works (KRCBW), Kharkiv Machine-Building Plant "Svet Shakhtyora" ("KMBPSS"), Berdichev Machine-Building Plant "Progress" (BMBPP), Private Company "AutoKrAZ" (AutoKrAZ), Kramatorsk Heavy Duty Machine Tool Building Plant (KZTS), Azovobschemash (AOM), Turbogaz Uzhhorod, Ltd. (TU LTD), and Poltavskyi Turbomekhanichnyi Zavod (PTMP). They are the leaders in the sector, have diversified activities, and carry out export-import operations, thereby accumulating the maximum number of factors that can affect the financial stability or provoke the crisis financial situations. For each enterprise, ten indicators were taken that characterize their financial status for the 2014–2018 period. The main financial indicators calculated based on the financial statements of these companies are the coefficient of autonomy, tensions (financial dependence), working capital, self-financing, current, fast, and absolute liquidity, as well as the profitability of assets, equity, and the efficient use of assets. This period was chosen due to the need to fulfill the relevance criterion for statistics. Since 2014, both macroeconomic and microeconomic indicators have undergone the changes resulting from political events, including the loss of control over the Crimean Autonomous Republic, as well as parts of Donetsk and Luhansk regions.

As part of this study, the bankruptcy probability forecast was calculated based on the models of the following authors: Altman (1968), Gilbert et al. (1990), Taffler and Tishaw (1977), Springate (1978), Holder (1979), Chesser (1974), Beaver (1968), Tereshchenko (2004), and Matviichuk (2010).

In addition, a taxonomic analysis will be carried out, which makes it possible to systematize a large amount of data and analyze their impact on enterprise development. The taxonomic analysis will determine the integral indicator based on the above indicators for each enterprise, which will allow understanding the dynamics of financial performance. To summarize a large number of indicators that affect the enterprise's financial position and its development, the data need to be standardized and brought to one dimension; they must be normalized using formula (1):

$$Z_i = \frac{X_i}{X_{average}}, \quad (1)$$

where X_i is the indicator value for the i sign, $X_{average}$ is the indicator value for the i sign.

The normalized calculated data are shown in Appendix A. After indicator standardization, for further calculations, the signs are divided into those that stimulate the enterprise activity and those that discourage it. Such gradation is conducted to highlight the nature of the impact of each sign on the enterprise activity and development. Thus, a reference vector has been found, which is determined by:

$$\begin{cases} X_{vector} = \max Z_i, \text{ if the indicator is an incentive, and} \\ X_{vector} = \min Z_i, \text{ if the indicator is a disincentive.} \end{cases} \quad (2)$$

For example, solvency and autonomy ratios can be assessed with both positive and negative effects on the enterprise, so the standard is the mean for these values.

An important step in calculating the taxonomy is to determine the distance between the vector and the particular period, which are taken for analysis, so the distance between these two points is calculated by the formula:

$$C_{i0} = \sqrt{\sum_{j=1}^{m} \left(Z_{ij} - Z_{0j} \right)^2}, \quad (3)$$

where C_{i0} is the distance between indicator and benchmark, Z_{ij} is the normalized value of the j indicator for the i sign, Z_{0j} is the standardized value of the j indicator in the reference vector.

Given the previous formula, the calculated indicators are presented in Appendix B. The distance obtained is a key indicator and the last step in calculating the taxonomic index:

$$K_i = 1 - \frac{C_{i0}}{\overline{C_0} + 2 \cdot \sqrt{\frac{1}{m} \sum_{i=1}^{m} \left(C_{i0} - \overline{C_0} \right)^2}}, \quad (4)$$

where $\overline{C_0}$ is the average distance between indicator and benchmark.

Using formula (4), one can identify an indicator that reflects the financial changes that occur in the company analyzed. The taxonomy indicator fluctuates between 0 and 1; when the sign grows and approaches to 1, this indicates the adjustment of financial indicators in the analyzed enterprise and vice versa, the decrease indicates very poor financial capacity.

3. RESULTS

Recent years' trends in the development of machine-building enterprises in both Poland and Ukraine are congruent in parts; in particular, the linear growth trends of production value of the manufacture of machinery and equipment show the upward dynamics, i.e., the situation in the sector generally improves. This is indicated by the percentage of profitable machine builders in Ukraine, which is growing quite steadily, and since 2014, it has increased by 28% compared to 2010. Besides, according to the Global Bankruptcy Report 2019, the overall number of companies declared bankruptcy, both in Ukraine and Poland, has significantly decreased over the 2017–2018 period, although in Ukraine, the figure is twice as high as in Poland. Bankruptcy is not a negative phenomenon in itself because bankruptcy procedures clean the economy off the inefficient enterprises and, therefore, redistribute the capital for the benefit of those companies that can use it better. Another thing is the share of such enterprises in the national economy.

Previously, ten indicators were calculated for the selected enterprises. The results showed the need to use models that give integral value and deter-

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Source: Authors' calculations based on the State Statistics Service of Ukraine and Eurostat data.

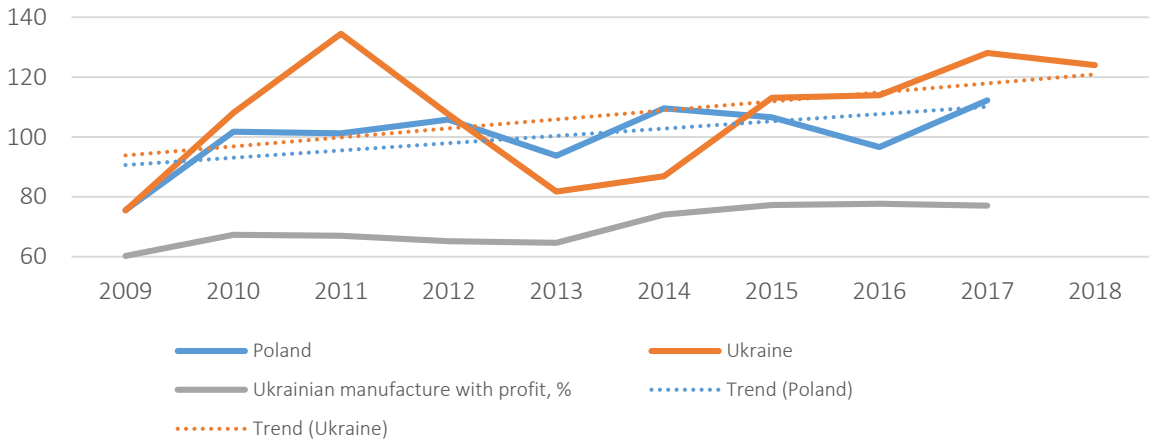

Figure 1. Growth rates of the production value of the manufacture of machinery and equipment

mine the likelihood of the financial crisis formation at the enterprise and, as a consequence, its bankruptcy. As noted above, there are currently many models available to determine the bankruptcy likelihood. Models chosen for the study differ in the number of the selected indicators and their content. Besides, each of the models used sets the different levels of bankruptcy probability.

Let us start the analysis with the Altman *Z*-score, which, among other models, has five coefficients and is characterized by a significant result differentiation, that is, allows determining a very high, average, small, and very low levels. According to the calculation results, three enterprises were included in the area with low bankruptcy probability, the obtained figures are more than 2.9, which is a standard value. These enterprises include Krykovsky Railway Car Building Works, Kharkiv Machine-Building Plant "Svet Shakhtyora," and Poltavskyi Turbomekhanichnyi Zavod. This indicates the stable operation of these enterprises and that they are financially sustainable. These enterprises have high financial capacity. Berdichev Machine-Building Plant "Progress" has received an average level of financial capacity, that is, the company is profitable but its financial stability is significantly dependent on internal and external changes; it should consolidate its position and develop so that in case of a crisis, the company does not conduct loss-making business activities.

According to the Altman *Z*-score, six out of ten analyzed machine-building enterprises are in the area of very high bankruptcy probability. During 2014–2018, these enterprises suffer losses; also, significant uncovered losses in equity are observed. These enterprises are financially unsustainable, among them are Energomaskhspetsstal, Drogobych Machine-Building Plant, AutoKrAZ, Kramatorsk Heavy Duty Machine Tool Building Plant, Azovobschemash, and Turbogaz Uzhhorod, Ltd. AZOVOBSCHEMASH has the most complex financial results, since its integral indicators, calculated by the Altman model, rapidly decrease from –3.9 in 2014 to –12.9 in 2018.

The study next uses Gilbert et al.'s model. Unlike the Altman *Z*-score, this model includes four indicators; it does not take into account the market value of shares. However, the financial leverage ratio appears, so the model focuses not only on the financial performance indicators but also on the capital structure indicators, which are currently the main determinants of financial risk formation. According to the calculation results, there are five companies with low bankruptcy probability, these are Drogobych Machine-Building Plant, Krykovsky Railway Car Building Works, Kharkiv Machine-Building Plant "Svet Shakhtyora," Berdichev Machine-Building Plant "Progress," and Poltavskyi Turbomekhanichnyi Zavod. Accordingly, the other half of enterprises have a high bankruptcy probability. This model does not allow estimating the activity of enterprises reliably since it lacks an indicator characterizing the final financial result – net profit; accounting for operating profit alone does not indicate precisely the risks of borrowing the capital contained in its financial expenses.

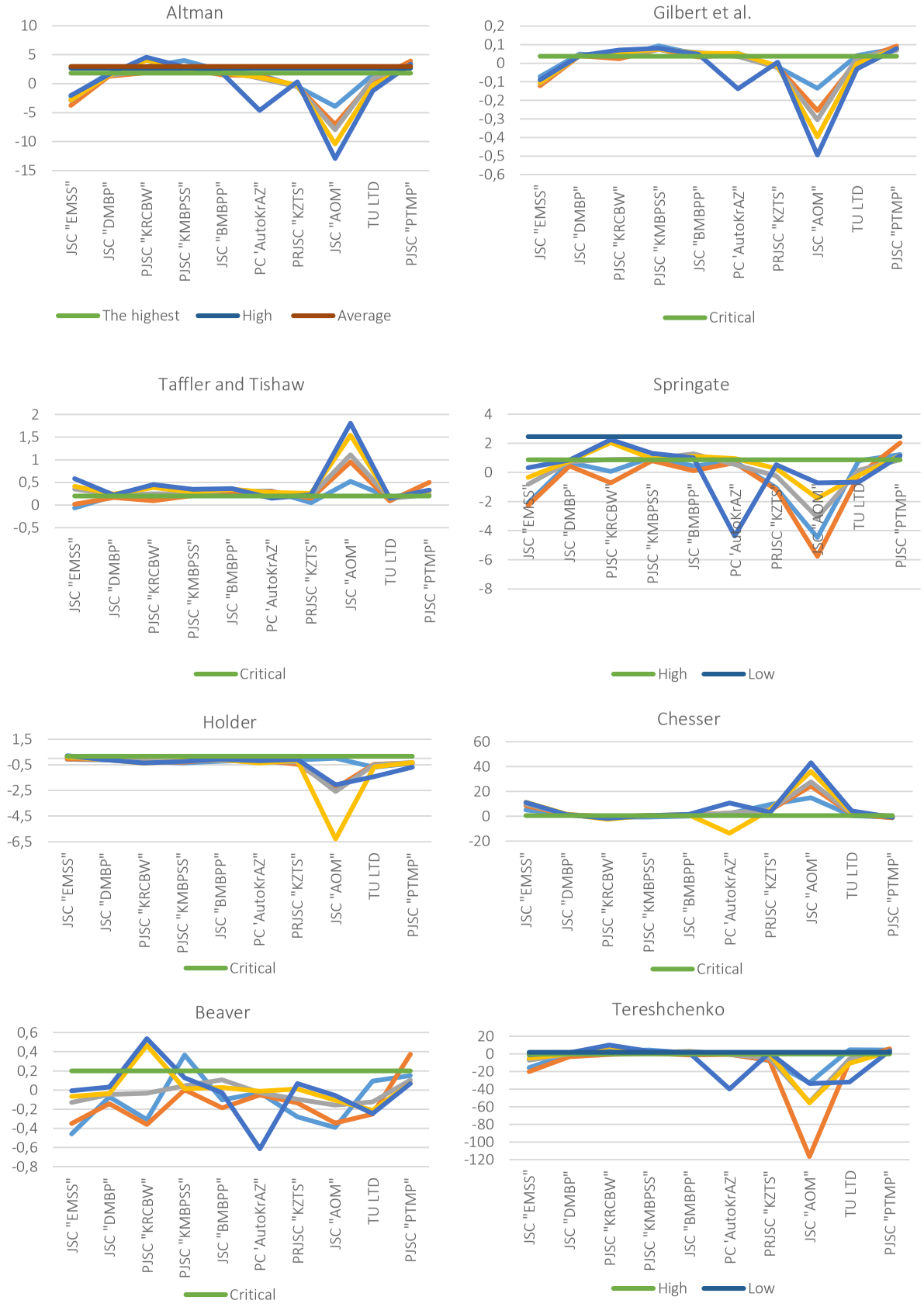

Figure 2 . Dynamics of the Ukrainian machine builders' integral values according to models being studied (2014–2018)

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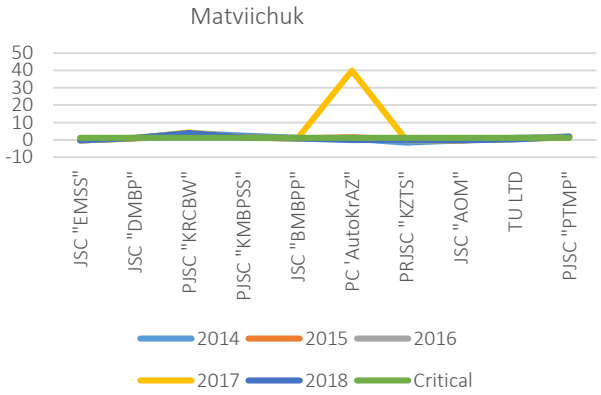

Figure 2 (cont.). Dynamics of the Ukrainian machine builders' integral values according to models being studied (2014–2018)

The Taffler and Tishaw's model, like the previous one, contains four indicators, but does not take into account the created capital structure, and does not contain the indicators that would characterize the ultimate operating financial result. Analyzing the calculations obtained, the study follows the dynamics of indicators, which is inverted to Gilbert et al.'s model. In this case, these are six enterprises with low bankruptcy probability that also included Energomaskhspetsstal and AZOVOBSCHEMASH; the latter, having the worst financial performance, has the best indicators according to this bankruptcy probability model. The growth of such indicators is conditioned by using the ratio of current liabilities to assets; at AZOVOBSCHEMASH, these figures are the highest. Thus, this model cannot be used as a universal one, since the information base used for calculation and the number and quality of factors used in the analysis are not sufficient for a complete and accurate assessment of the bankruptcy probability at machine-building enterprises in Ukraine.

The Springate's model also contains four indicators. Unlike the previous ones, it takes into account the profit before tax, which is a financial result of the activity and considers the financial expenses incurred by the enterprise as a result of servicing its capital, although the criterion of forming the capital structure is missing in the model. Analyzing the dynamics of the integral indicators obtained by this model, one can see that there are no enterprises with low bankruptcy probability. The following companies are in the medium range: Krykovsky Railway Car Building Works, Kharkiv Machine-Building Plant "Svet Shakhtyora," Berdichev Machine-Building Plant "Progress," AutoKrAZ, and Poltavskyi Turbomekhanichnyi Zavod. This model was designed to evaluate the creditworthiness of businesses, so it is clear that there are three out of four indicators that assess the financial performance. Also, it is crucial for the assessment of creditworthiness to analyze the actual capital structure, to understand the current level of financial risk, and the ability to assess the prospective solvency. According to this model, the problem enterprises are the following: Energomaskhspetsstal, Drogobych Machine-Building Plant, AutoKrAZ, Kramatorsk Heavy Duty Machine Tool Building Plant, Azovobschemash, and Turbogaz Uzhhorod, Ltd.

The following calculations are based on Holder's model, which consists of five ratios. Unlike all the models under study, it contains an indicator characterizing personnel costs, as well as highly liquid assets (accounts receivable and cash) in the enterprise's asset structure; it also contains an indicator describing the financial expenses of an enterprise, namely their share of income. The whole set of ratios is more aimed at assessing the efficient creation of the enterprise's capital structure and the corresponding financial risks, taking into account the interest of the company in its staff development. Analysis of the obtained indicators using this model allows highlighting the enterprises with low probability of bankruptcy. These are Krykovsky Railway Car Building Works, Kharkiv Machine-Building Plant "Svet Shakhtyora," AutoKrAZ, Azovobschemash, Turbogaz Uzhhorod, Ltd., and Poltavskyi Turbomekhanichnyi Zavod. According to the data obtained, Azovobschemash stands out

because the results of the previously analyzed indicators are one of the lowest. These are because the payables used in the calculation are one of the largest at this enterprise.

Like the Springate's model, Chesser's model is designed to analyze the borrower's valuation, but unlike Springate, it takes into account the capital structure formed by estimating the proportion of long-term and short-term liabilities in the capital structure; it also considers the enterprise's asset structure by determining the share of fixed assets, which partially reflects the peculiarities of the enterprise production activity and can vary significantly depending on the line of business. In addition, among the models analyzed above, this one contains six indicators, but allows identifying only two levels of threat, high and low, which makes the conclusions rough. Analyzing the dynamics of the calculated indicators, one can observe that only two enterprises have low bankruptcy probability, namely Krykovsky Railway Car Building Works and Poltavskyi Turbomekhanichnyi Zavod. This model is most often used and recommended as an additional one for Ukrainian enterprises.

The Beaver's model is another popular model in Ukraine. It, unlike the previous ones, does not give an integral value, but determines a specific factor that characterizes the ratio of internal sources of enterprise financing to its long-term and short-term liabilities. It should be used to pre-analyze a financial crisis. According to the estimate results, a favorable situation is observed at Krykovsky Railway Car Building Works. About five years before the bankruptcy, three enterprises are distinguished: Drogobych Machine-Building Plant, Kharkiv Machine-Building Plant "Svet Shakhtyora," and Poltavskyi Turbomekhanichnyi Zavod. These results were obtained since current liquidity reaches 2 at these enterprises. Other enterprises are in the time interval of one year by before bankruptcy because, in most of these enterprises, the balance sheet structure is unsatisfactory, the working capital ratio is less than 0.1 and enterprises have a steadily increasing debt. The downside to this model is that the financial position is graded one year and five years before the bankruptcy because, in the current circumstances, the five-year period is a long time to forecast, so the results obtained are unrealistic.

In Ukrainian research, Tereshchenko's model is prevalent. It contains six coefficients, includes the indicators that characterize both financial results of operations, and considers the presence of obligations in the enterprise. Besides, in this model, unlike others, the formation of cash flow and its relationship with the formed liabilities is taken into account, which allows estimating the degree of coverage of the latter by the movement of the enterprise's cash flows. In addition, this model is close to the Altman *Z*-score in terms of results differentiation and forms four levels of bankruptcy assessment – no threat, imperfect financial equilibrium, and the necessity for taking anti-crisis measures to restore lost equilibrium, bankruptcy risk, and the enterprise semi-bankrupt. Similar to the previous bankruptcy probability model, Azovobschemash has the lowest level of the obtained indicators. For example, in 2015, this indicator was –116.72 because the company received significantly more losses than in 2014, even reducing production by five times compared to the previous year. A similar situation occurs in 2018 at Energomaskhspetsstal, Turbogaz Uzhhorod, Ltd., and AutoKrAZ. According to the model criterion, these companies are considered semi-bankrupt. According to Tereshchenko's model, three enterprises are not in danger of bankruptcy – Krykovsky Railway Car Building Works, Kharkiv Machine-Building Plant "Svet Shakhtyora," and Poltavskyi Turbomekhanichnyi Zavod. Others are considered enterprises with impaired financial equilibrium.

The last model for analysis is the one of Matviichuk, which contains the largest number of indicators (compared to other models), seven, and takes into account both the enterprise's capital structure through four indicators and the efficiency of its functioning, as well as the state of the balance mobility. The last indicator only appears in this model and reflects the enterprise's capacity to accelerate its assets turnover. As to Taffler and Tishaw's model, one can observe that AutoKrAZ has a significant fluctuation during 2014–2018, since in 2017, this indicator increased from 0.8 to 39.947 and fell to –0.189 in 2018. Such fluctuations are observed both in the calculated coefficients and in the enterprise's balance sheets. The year 2017 observes a significant increase in uncovered loss; accordingly, there was a significant decrease in the equi-

http://dx.doi.org/10.21511/imfi.16(4).2019.31

Table 1. Summary of business assessment results*

Source: Authors' calculations.

Company	Altman	Gilbert et al.	Taffler and Tishaw	Springate	Holder	Chesser	Beaver	Tereshchenko	Matviichuk
EMSS	TH	H	L	H	H	H	H	H	H
DMBP	TH	L	H	H	H	H	H	A	H
KRCBW	TH	L	L	A	L	L	L	L	L
KMBPSS	L	L	L	A	L	H	H	L	L
BMBPP	A	L	L	A	H	H	H	A	H
AutoKrAZ	TH	H	H	H	L	H	H	H	H
KZTS	TH	H	H	H	H	H	H	A	H
AOM	TH	H	L	H	L	H	H	H	H
TU LTD	TH	H	H	H	L	H	H	H	H
PTMP	TH	L	L	A	L	L	H	L	L

Note: *The highest (TH), High (H), Average (A), Low (L), The lowest (TL).

ty indicator almost 78.5 times, which is why such fluctuations were obtained. An adequate assessment was received in the analysis of Krykovsky Railway Car Building Works, Kharkiv Machine-Building Plant "Svet Shakhtyora," and Poltavskyi Turbomekhanichnyi Zavod since they have good performance indicators and are financially sound. Thus, according to Matviichuk's model, these enterprises are not subject to bankruptcy.

Table 1 gives the results for all models and analyzed enterprises.

Having generalized each of the models worked out, one can note that there is no one model or company that would receive the same bankruptcy probability. This situation is due to a considerable divergence in the list of indicators that were taken as the basis for calculating the coefficients involved in the models. It can be observed that some of the models do not reflect the objective situation arising from the status of financial reporting and the presence of losses resulting from financial activities, which themselves testify to the formation of crisis phenomena at enterprises. Models of Taffler and Tishaw, Holder, and Matviichuk were the least effective. Gilbert et al.'s model also failed to deliver the expected results; although similar to the Altman *Z*-score, the results were different. The models of Altman, Springate, and Tereshchenko proved to be quite effective in the enterprise analysis since the obtained results are adequate, financial stability, and the enterprise creditworthiness are taken into account. One can also use Chesser's model as an accompanying one, which will indicate a failure to repay the liabilities, which in turn affects the financial standing and sustainability of the enterprise.

The main problem in the calculation is a limited number of factors; the omission of one factor increases the probability of inaccuracy for the entire model. Since the financial standing of an enterprise can be influenced by various factors, it is, therefore, important to analyze and evaluate all areas of its financial activity.

For a more thorough study of the situation at the studied enterprises, a taxonomic analysis was applied, and an integral indicator was calculated characterizing the enterprise's financial capacity. The taxonomy coefficient varies from 0 to 1, where approaching 0 indicates the formation of crisis financial standing and vice versa when approaching 1, the enterprise financial position is stable.

The dynamics of the 2014–2018 taxonomy indicator at ten Ukrainian machine-building enterprises show that Poltavskyi Turbomekhanichnyi Zavod and Krykovsky Railway Car Building Works have the highest taxonomic index in 2015, which can range from 0.8 to 1. At the first enterprise, a decrease in financial stability can be seen due to the decrease in return on assets and capital; in the following years, the indicators normalized and amounted to 0.803 in 2018. Krykovsky Railway Car Building Works has satisfactory financial ratios; they meet regulatory values, but experience a significant decline in liquidity indicators. For example, in 2017, the current liquidity indicator was 5.056, and in 2018, it fell to 3.674. Consequently, the rapid liquidity ratio fell from 3.374 to 1.516,

Source: Authors' calculations.

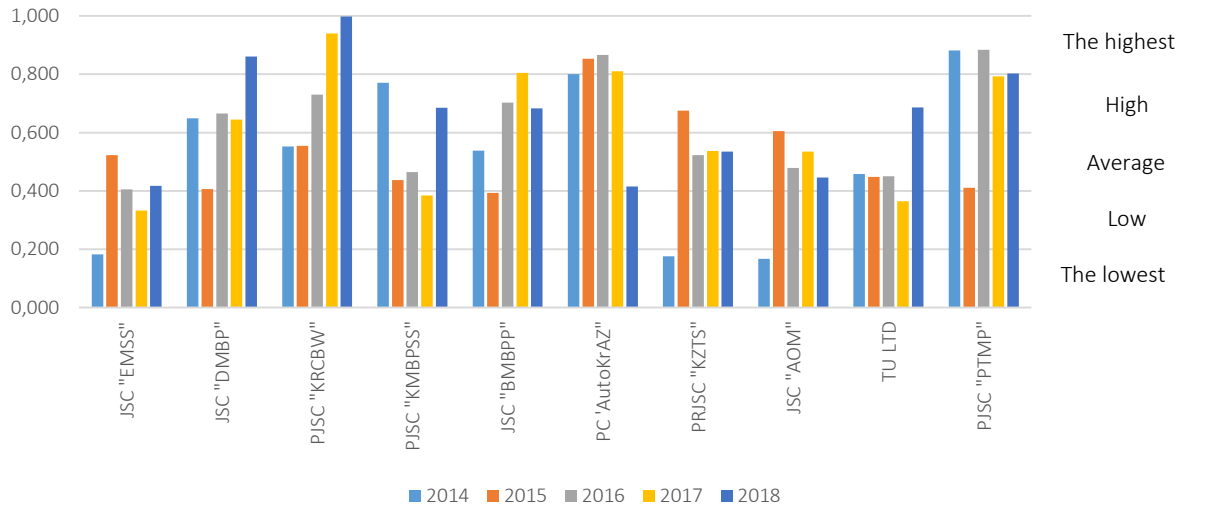

Figure 3. Dynamics of the taxonomy index change of machine-building enterprises for 2014–2018

which further influenced the overall indicator assessment. Nevertheless, the profitability indicators increased, and this encouraged the company to develop.

Kharkiv Machine-Building Plant "Svet Shakhtyora," Berdichev Machine-Building Plant "Progress," and Drogobych Machine-Building Plant have high levels from 0.79 to 0.6. Drogobych Machine-Building Plant is rated high, not the highest since during the period analyzed, there was a slight decrease in production, with the most significant decline observed in 2015.

Energomaskhspetsstal, AutoKrAZ, Kramatorsk Heavy Duty Machine Tool Building Plant, Azovobschemash, and Turbogaz Uzhhorod, Ltd. have an average level within 0.59-0.4. The lowest level can also be attributed to Energomaskhspetsstal, since in 2014, its taxonomy was 0.182; in 2017, it amounted to 0.333, which is the lowest coefficient among all ten Ukrainian machine builders analyzed.

If one compares the dynamics of taxonomic indicators as a whole, in 2014, almost every enterprise has the lowest level, which is probably due to the macroeconomic and political factors. The presence of uncovered loss, which significantly reduces the amount of equity, is a negative phenomenon in the balance sheet of many enterprises. Therefore, for any enterprise to operate successfully, it is necessary to follow the dynamics of financial indicators because the crisis likelihood arises a long time before the crisis itself.

According to the estimate results, all analyzed enterprises are divided into three categories. The first category (the minimum) includes two enterprises, which are allocated based on estimates by coefficients, the conclusions made using different bankruptcy models and taxonomic analysis. These enterprises are Krykovsky Railway Car Building Works and Poltavskyi Turbomekhanichnyi Zavod. These companies can expand the production to increase the economic growth, possible search for new consumers and, most importantly, they may not allow reducing their financial sustainability. For the company to operate successfully, it is necessary to continually analyze its indicators and take into account the factors negatively affecting its activity. Thus, Krykovsky Railway Car Building Works and Poltavskyi Turbomekhanichnyi Zavod must constantly monitor and analyze their activities to avoid the crises. The use of plans for further activities and forecasts, the search for new ways of selling goods and, most importantly, support for financial sustainability – all these together stimulate the development of the economic activity.

There are three enterprises with the average bankruptcy probabilities: Kharkiv Machine-Building Plant "Svet Shakhtyora," Berdichev Machine-Building Plant "Progress," and Drogobych Machine-Building Plant. These enterprises need to stabilize their operations to avoid a crisis. An

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enterprise needs crisis management to help manage and prevent the risks.

The third category of enterprises with the highest crisis level comprises five enterprises. They are Energomaskhspetsstal, AutoKrAZ, Kramatorsk Heavy Duty Machine Tool Building Plant, Azovobschemash, and Turbogaz Uzhhorod, Ltd. During the whole analyzed period, these enterprises experience the downfall, which represents a decrease in their profitability, liquidity, and financial sustainability. Above all things, these enterprises need to stabilize their financial situation, and for this purpose, they regain their strength. It is necessary to optimize the capital structure, review the effectiveness of the enterprise strategy created. It is also mandatory to introduce the management to control the risks. Every enterprise should pay attention to creating internal financial reserves.

CONCLUSION

The scientific literature currently proposes many approaches to forecasting the financial crisis and identifying the signs of bankruptcy. The most popular are those by Altman, Gilbert et al., Taffler and Tishaw, Springate, Holder, Chesser, and Beaver. The prevalent Ukrainian techniques are those by Tereshchenko and Matviichuk. These models differ in the set of initial data for constructing the model and the number of coefficients from four to seven.

The calculations for ten Ukrainian enterprises of the machine-building sector showed that the efficient use of these models is quite different. Therefore, when choosing a model to predict the bankruptcy, it is necessary to consider the peculiarities of the enterprise's production activity, the accuracy of the financial statements formation, and many other factors, including the presence of shares in circulation on the stock market. It is advisable to use a taxonomic analysis to finally substantiate the choice of the bankruptcy forecasting model to make a comprehensive comparison of the financial position of enterprises.

According to the results of the calculations, three categories of enterprises were defined according to the level of financial crisis probability at the enterprise, taking into account using all the models, as well as calculating the integral indicator based on the taxonomic analysis. From ten studied enterprises, the first category with minimum crisis probability includes only two enterprises: "PJSC "Krykovsky railway car building works" and PJSC "Poltavskyi Turbomekhanichnyi Zavod". The second category with moderate level of crisis probability includes three enterprises: PJSC "Kharkiv Machine Building Plant "Svet Shakhtyora", JSC "Berdichev Machine-Building Plant "Progress", JSC "Drogobych machine-building plant". The third category with high level of crisis probability includes the half of the studied enterprises – JSC "Energomaskhspetsstal", Private Company "AutoKrAZ", PJSC "Kramatorsk Heavy Duty Machine Tool Building Plant", JSC "Azovobschemash", "Turbogaz Uzhhorod, Ltd.". The key tasks, which will ensure avoiding the crisis phenomena, were defined for each category of enterprises.

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APPENDIX A

Table A1. Normalized matrix of indicators of enterprises' financial capacity for 2014–2018

Years	Financial capacity indicators									
	1	2	3	4	5	6	7	8	9	10
Energomaskhspetsstal										
2014	0.209	2.892	0.765	0.185	1.444	1.771	0.155	1.190	2.756	0.780
2015	0.826	0.730	0.988	0.782	0.960	1.678	1.345	1.475	1.108	0.716
2016	–1.177	0.513	1.186	1.124	0.765	0.365	0.282	0.709	0.715	1.139
2017	1.374	0.439	1.102	1.388	0.907	0.540	2.058	0.709	0.269	0.925
2018	1.415	0.426	0.959	1.520	0.925	0.645	1.161	0.438	0.152	1.440
Reference vector	0.529	1.000	1.186	0.185	1.444	1.771	0.155	1.475	0.152	1.440
Drogobych Machine-Building Plant										
2014	1.144	0.864	1.285	1.150	1.138	1.561	0.763	1.104	0.992	0.983
2015	1.014	0.975	0.996	0.973	0.992	1.169	1.017	2.019	1.922	0.508
2016	0.916	1.079	0.857	0.950	0.934	1.046	0.829	0.930	0.992	1.072
2017	0.851	1.161	0.769	0.933	0.901	0.974	1.142	0.863	1.004	1.363
2018	1.075	0.920	1.093	0.994	1.036	0.251	1.250	0.084	0.091	1.075
Reference vector	1.000	1.000	1.285	1.150	1.138	0.251	1.250	2.019	1.922	0.508
Krykovsky Railway Car Building Works										
2014	1.059	0.939	0.989	0.696	1.069	1.022	0.503	24.498	31.615	0.903
2015	0.992	1.003	0.800	0.611	1.468	1.439	1.601	8.504	41.176	0.444
2016	–0.863	1.152	0.874	1.050	0.564	0.631	0.620	–24.86	12.564	0.706
2017	1.046	0.951	1.155	1.193	1.100	1.311	1.595	–24.86	–35.71	1.352
2018	1.041	0.955	1.183	1.449	0.800	0.596	0.681	–34.08	–44.63	1.594
Reference vector	0.655	1.000	1.183	1.449	0.564	0.596	0.503	24.498	41.176	1.594
Kharkiv Machine Building Plant "Svet Shakhtyora"										
2014	1.315	0.733	1.418	1.111	1.465	2.332	3.351	122.989	–39.70	0.899
2015	1.096	0.879	1.088	0.923	1.016	0.927	0.127	–50.092	17.841	0.553
2016	0.960	1.004	0.958	1.065	0.890	0.683	0.187	–41.723	17.277	0.880
2017	0.887	1.086	0.866	1.028	0.823	0.810	0.055	–67.103	30.839	1.107
2018	0.741	1.299	0.671	0.872	0.805	0.248	1.280	40.929	–21.25	1.561
Reference vector	1.000	1.000	0.671	0.872	0.805	0.248	3.351	122.989	30.839	1.561
Berdichev Machine-Building Plant "Progress"										
2014	1.495	0.596	1.469	0.972	0.918	0.936	0.070	1.973	1.496	1.126
2015	0.692	1.287	3.208	0.492	0.797	0.871	0.886	–1.203	3.847	0.974
2016	–1.336	0.667	–0.432	1.491	1.313	1.569	2.288	–0.177	–1.266	0.963
2017	0.831	1.072	0.183	1.152	1.015	0.912	1.312	–0.177	–0.196	0.867
2018	0.646	1.378	0.572	0.893	0.955	0.713	0.444	0.727	1.120	1.070
Reference vector	0.466	1.000	–0.432	0.492	0.797	0.713	0.444	–1.203	–1.266	1.126
Private Company "AutoKrAZ"										
2014	–0.391	0.008	0.338	–0.362	1.231	1.325	1.509	0.136	0.707	1.241
2015	–0.162	0.018	–0.045	–1.668	1.207	1.266	1.126	0.252	1.910	1.193
2016	–0.052	0.057	1.049	–0.032	0.910	0.816	0.004	0.140	2.683	0.742
2017	–0.001	4.918	0.144	–0.002	1.323	1.327	1.836	0.063	5.055	0.574
2018	5.606	–0.001	3.513	7.064	0.329	0.266	0.526	4.410	–5.355	1.250
Reference vector	1.000	1.000	–0.045	–1.668	0.329	0.266	0.004	0.063	5.055	1.250
Kramatorsk Heavy Duty Machine Tool Building Plant										
2014	0.033	4.412	0.612	0.036	1.502	1.687	0.922	2.592	4.782	1.244
2015	0.967	0.152	1.288	0.926	0.785	0.639	0.982	1.145	0.177	0.619
2016	–1.743	0.084	1.417	1.685	0.686	0.278	0.107	0.099	0.053	0.818
2017	1.703	0.086	1.167	1.707	0.686	0.716	1.564	0.099	0.004	1.138
2018	0.554	0.265	0.516	0.647	1.340	1.680	1.424	–0.224	–0.014	1.181
Reference vector	0.303	1.000	1.417	1.707	1.502	1.687	0.107	2.592	–0.014	1.244

http://dx.doi.org/10.21511/imfi.16(4).2019.31

Table A1. Normalized matrix of indicators of enterprises' financial capacity for 2014–2018

Years	Financial capacity indicators									
	1	2	3	4	5	6	7	8	9	10
AZOVOBSCHEMASH										
2014	0.491	0.755	0.564	0.440	1.804	1.815	4.971	1.193	1.564	2.251
2015	0.961	0.386	1.072	0.816	1.002	0.825	0.008	1.640	1.481	0.662
2016	0.108	3.424	0.244	0.083	0.784	0.632	0.012	0.940	1.150	0.764
2017	1.545	0.240	1.544	1.421	0.713	0.633	0.007	0.740	0.622	0.639
2018	1.894	0.196	1.576	2.240	0.698	1.095	0.002	0.486	0.183	0.683
Reference vector	1.000	1.000	0.244	0.083	0.698	1.815	0.002	1.640	0.183	2.251
Turbogaz Uzhhorod, Ltd.										
2014	2.343	0.662	–0.384	2.456	1.727	1.778	1.527	–0.231	0.102	0.542
2015	1.846	0.841	0.266	1.755	1.204	1.185	1.309	0.663	–0.514	1.291
2016	–1.415	1.096	0.662	1.360	0.967	0.951	1.003	1.455	–0.420	1.146
2017	0.392	3.958	1.493	0.396	0.656	0.645	0.634	1.455	–1.693	1.375
2018	–0.996	–1.558	2.963	–0.967	0.446	0.441	0.527	2.062	7.526	0.646
Reference vector	0.434	1.000	–0.384	–0.967	0.446	0.441	0.527	–0.231	7.526	0.542
Poltavskyi Turbomekhanichnyi Zavod										
2014	1.100	0.889	1.149	0.971	0.930	0.255	1.653	0.672	0.625	1.179
2015	0.766	1.275	0.516	0.729	0.866	0.713	1.732	3.595	3.701	1.406
2016	1.184	0.826	1.150	0.808	1.093	1.215	1.305	0.362	0.332	0.614
2017	0.926	1.055	1.032	1.262	1.004	1.337	0.168	0.279	0.252	0.785
2018	1.024	0.955	1.154	1.229	1.107	1.479	0.141	0.092	0.090	1.017
Reference vector	1.000	1.000	1.154	0.729	1.107	1.479	1.732	0.092	0.090	1.406

APPENDIX B

Table B1. The distance between indicators and reference vector of machine-building enterprises of Ukraine for 2014–2018

Enterprise	2014	2015	2016	2017	2018
Energomaskhspetsstal	3.340	1.912	2.734	2.962	2.564
Drogobych Machine-Building Plant	1.980	1.017	1.859	1.966	2.739
Krykovsky Railway Car Building Works	9.649	16.150	57.086	91.386	103.91
Kharkiv Machine Building Plant "Svet Shakhtyora"	70.584	173.603	165.302	190.123	97.221
Berdichev Machine-Building Plant "Progress"	4.795	6.307	3.136	2.014	3.285
Private Company "AutoKrAZ"	5.280	3.908	3.522	5.009	15.449
Kramatorsk Heavy Duty Machine Tool Building Plant	6.231	2.586	3.752	3.580	3.498
AZOVOBSCHEMASH	5.345	2.624	3.422	3.059	3.490
Turbogaz Uzhhorod, Ltd.	8.661	8.809	8.777	10.137	5.005
Poltavskyy Turbomekhanichnyy Zavod	1.513	5.147	1.040	1.797	1.713

APPENDIX C

Table C1. An integral indicator of taxonomy of Ukrainian machine-building enterprises for 2014–2018

Enterprise	2014	2015	2016	2017	2018
Energomaskhspetsstal	0.255	0.574	0.390	0.340	0.428
Drogobych Machine-Building Plant	0.545	0.766	0.573	0.549	0.371
Krykovsky Railway Car Building Works	0.953	0.921	0.722	0.555	0.494
Kharkiv Machine Building Plant "Svet Shakhtyora"	0.771	0.437	0.464	0.384	0.685
Berdichev Machine-Building Plant "Progress"	0.538	0.393	0.698	0.806	0.684
Private Company "AutoKrAZ"	0.800	0.852	0.867	0.810	0.415
Kramatorsk Heavy Duty Machine Tool Building Plant	0.170	0.656	0.500	0.523	0.534
AZOVOBSCHEMASH	0.154	0.585	0.458	0.516	0.448
Turbogaz Uzhhorod, Ltd.	0.457	0.448	0.450	0.365	0.686
Poltavskyi Turbomekhanichnyi Zavod	0.826	0.409	0.881	0.794	0.803