Article

Ratio Selection between Six Sectors in the Visegrad Group Using Parametric and Nonparametric ANOVA

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Abstract: The changes that have been triggered in market economies by COVID-19 have increased the
importance of assessing the financial standing of companies and sectors. It is essential for managers,
lenders, and investors to properly evaluate the financial condition of companies. Therefore, it is
crucial to select indicators that show the differences in the values of market sectors before, and
during, the COVID-19 pandemic (checking the stability of ratios over time). We used parametric and
nonparametric analyses of variance (ANOVA) to single out indicators. The sample consists of listed
companies in six sectors from the Visegrad group: manufacturing, construction, retail, wholesale
trade, transportation and warehousing, and energy. We applied yearly and quarterly analyses in
the periods from Q1 2017–Q1 2021. The analyses take into account 82 indicators. The results of the
parametric ANOVA indicate that only the ratio of the company size shows the differences between the
sectors in most of the periods of quarterly analysis. In comparison, the results of the nonparametric
ANOVA demonstrate that five ratios show differences between the sectors in the quarterly analysis,
and nine show differences in the yearly analysis. On the basis of the results, the construction and
energy sectors are the least effective in managing their assets.

Keywords: COVID-19; normal distribution; Kruskal–Wallis test; indicators; decision-making

1. Introduction

The COVID-19 pandemic has its origins in China at the end of 2019, from where
it spread across the world. In the Visegrad group (Czech Republic, Hungary, Poland,
and Slovakia), COVID-19 appeared at the end of the first quarter of 2020. The confirmed
COVID-19 infections in the Visegrad group (V4) occurred at a similar time: according to
the Worldometer Coronavirus Update, the first case appeared in the Czech Republic on
1 March 2020, then in Hungary and Poland on 4 March 2020, and later in Slovakia on 6
March 2020 [1]. Nervousness among investors reached a peak with the appearance of
the first COVID-19 case in the different countries, as shown by the fall of the main stock
indexes to their lowest points in 2020 (see Figures 1 and 2).

The COVID-19 crisis has revealed to the world that natural disasters can create direct
global deadly economic impacts of a remarkable range [2]. The escalation of the pandemic
has had a negative influence on global economic activity and has revealed the possibility of
financial instability [3]. The coronavirus mutations are still unpredictable, which generates
difficulties for policymakers to work out fitting macroeconomic policy responses [4] to
stabilize the economy by ensuring long-term sustainable growth [5].

Because of the recent changes in market economies caused by COVID-19, continuous
assessment of the financial condition of companies and sectors has become even more
important. It is crucial for managers, lenders, and investors to properly evaluate the
financial standing of companies. For managers, this would enable them to take preemptive
action to protect businesses from bankruptcy. For investors, this would mean that they
could choose sectors and enterprises that, for example, are not susceptible to restrictions
related to the pandemic or, on the contrary, that will produce and sell more, despite

government restrictions. Finally, for lenders, an appropriate analysis can enable them to forecast and prepare for the risk of sectoral and corporate insolvency by preparing an appropriate credit strategy for these sectors and enterprises.
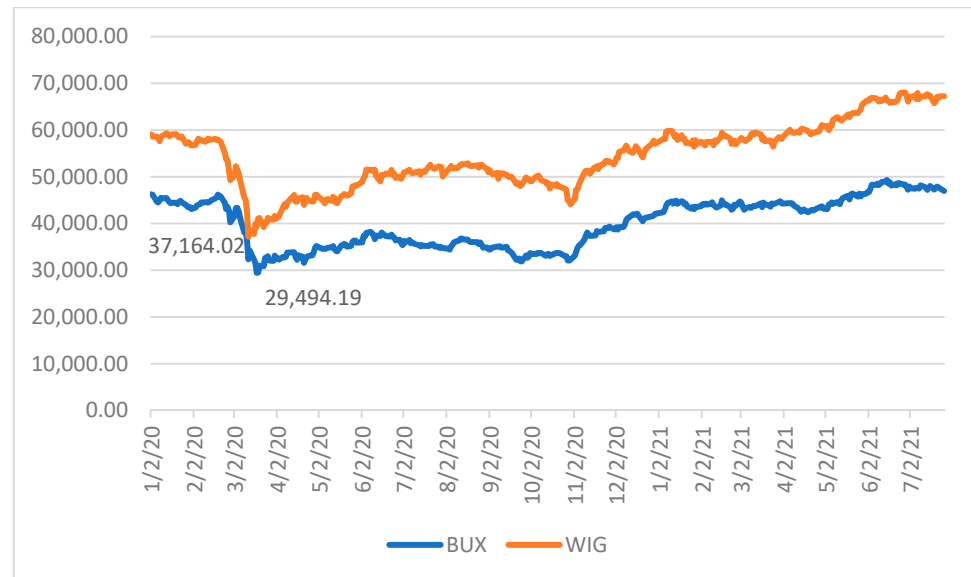
Figure 1. The values of indexes: BUX and WIG in the period from 1 January 2020–2 July 2021. Source: based on data from https://www.gpw.pl; https://www.bse.hu (retrieved 3 July 2021). WIG: the main index on the Warsaw Stock Exchange. BUX: the main index on the Budapest Stock Exchange.
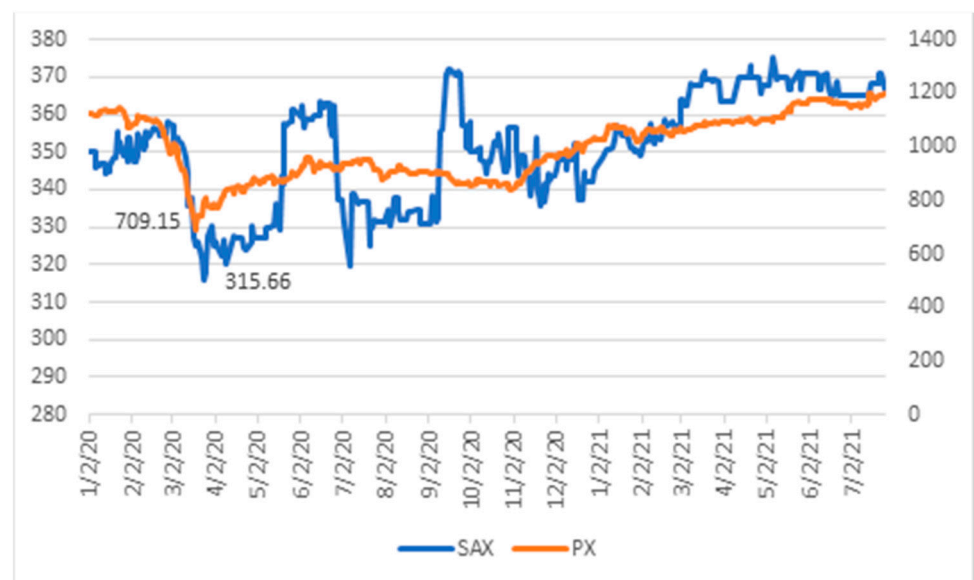
Figure 2. The values of indexes: PX and SAX in the period from 1 January 2020 to 2 July 2021. Source: based on data from https://www.pse.cz; http://www.bsse.sk (accessed on 3 July 2021). PX: the main index on The Prague Stock Exchange. SAX: the main index on the Bratislava Stock Exchange.

The financial status of businesses can be assessed by ratio or synthetic analyses. Ratio analysis uses financial, nonfinancial, and stock market indicators to evaluate companies. In turn, synthetic analysis uses bankruptcy prediction models to classify companies into one of two main groups: those that are in bad condition and those that are in good condition. Bankruptcy prediction models consist of indicators that can be used to identify the financial health of enterprises. In order to apply ratio or synthetic analyses, appropriate indicators

should be selected. Thus, the process for selecting indicators is crucial from the point of view of the assessing enterprise.

The process of selecting indicators is most often described at the stage of building a bankruptcy prediction model. The selection covers indicators that:

- Are popular in the literature [6];
- Were found to be significant in previous studies [7];
- Are simple to calculate [8];
- Are characterized by predictive and discriminant abilities [9];
- Have a normal distribution [10,11];
- Are not highly correlated with each other [12];
- Have the lowest value of the Wilks' lambda test [13];
- Are significant in a stepwise method [14].

Individual stages of the selection of ratios may be different because they depend on the choice of the method to assess the financial condition of the enterprise, among other things. Sometimes authors only add certain indicators to previous models [15]. At other times, the research is focused on a particular sector and country [16], or groups of countries [17,18].

Nevertheless, indicators that are stable over time and can, for example, distinguish companies in good financial condition from those in bad financial condition are constantly sought because no single optimal bankruptcy prediction model has thus far been identified for which a very high accuracy can be assured over the long run [9,19]. Therefore, the stability of the indicators should be tested over time, taking into account two periods: the precrisis period and the period of crisis. This research takes into account these two periods.

This research is different from previous studies, and it makes three contributions to the financial literature. First, we use a one-way parametric analysis of variance (ANOVA), and a one-way nonparametric ANOVA, the so-called Kruskal–Wallis test, to select indicators that consistently show the differences between the values in individual sectors before and during COVID-19. The analysis takes into account 82 indicators that measure different aspects of the financial condition of companies, namely, liquidity, profitability, turnover, debt, market values, and dynamics indicators. Previous research studies take into account far fewer indicators, i.e., 31 indicators [20], and 37 indicators [21]. Second, we apply yearly analysis (four years), and quarterly analysis (17 quarters), for the period from 2017–2020, for companies listed on the Warsaw Stock Exchange, the Prague Stock Exchange, the Bratislava Stock Exchange, or the Budapest Stock Exchange. The research study takes into consideration the precrisis period (Q1 2017–Q4 2019 for quarterly analysis, and 2017–2019 for yearly analysis), and the period of crisis (Q1 2020–Q1 2021 for quarterly analysis, and 2020 for yearly analysis). Thus, the stability of the indicators will be tested over time. Third, we focus on the energy sector, which is becoming more and more crucial because the European Union has set the goal that 32% of its gross final energy consumption should come from renewable sources by 2030 [22]. There is a lot of work to be done to achieve this target because, for example, in 2020, Poland had just achieved an 18% share of energy from renewable energy resources [23]. This means that there should be more investment in renewable energy sources. Besides the energy sector, manufacturing, construction, retail and wholesale trade, and transportation and warehousing are also analyzed. The last five sectors are key sectors in the economy. The findings of this research will reveal ratios that will be useful to managers, lenders, and investors in assessing the financial condition of companies and sectors.

The paper is composed of five units. The first one is the introduction, and the second one presents the methodology. The third one shows the results of the analyses. The fourth one provides a discussion comparing the findings with other research studies. The last unit concludes the article.

2. Methodology of Research

To select ratios, the following methodology, which consists of several stages, was developed. First, we collected data from the financial reports of companies. The financial

reports were downloaded from the EMIS database (EMIS stands for Emerging Markets Information Service, a Euromoney Institutional Investor Company, www.emis.com (accessed on 28 July 2021)). The research covered six sectors: manufacturing, construction, retail and wholesale trade, transportation and warehousing, and energy (biomass electric power generation, wind electric power generation, fossil fuel electric power generation, hydroelectric power generation, and solar electric power generation). The sample covered 450 companies listed on the Warsaw Stock Exchange, the Prague Stock Exchange, the Bratislava Stock Exchange, or the Budapest Stock Exchange. Nearly nine out of the ten businesses are indexed in Poland (400), and the rest are indexed in Slovakia (25), Hungary (16), and the Czech Republic (9).

The second stage concerned the selection of the time period. The annual and quarterly reports of the study analyses are focused on a four-year period (2017–2020). The analysis of quarterly reports extended the research from four yearly to sixteen quarterly reports, plus the first quarter of 2021 (Q1 2017–Q1 2021). This research covers two periods: the precrisis period (Q1 2017–Q4 2019 for quarterly analysis, and 2017–2019 for yearly analysis), and the period of crisis (Q1 2020–Q1 2021 for quarterly analysis, and 2020 for yearly analysis) for stability testing of the indicators over time. The third stage involved the calculation of variables for the businesses included in the research sample using the downloaded data. We computed 82 indicators. The core of them were also studied in Zięba et al. [24]. The ratios that were taken into consideration characterize diverse features of the financial standings of companies, namely, liquidity, profitability, turnover, debt, market values, and dynamics indicators (see Table 1). In the final stage, a one-way parametric analysis of variance (ANOVA), and a one-way nonparametric ANOVA, the so-called Kruskal–Wallis test, were applied. The ANOVA is a frequently used method for analyzing dissimilarities between the averages of two or more groups. In this particular case, the differences between the values of each ratio in the six sectors were assessed.

The ANOVA analysis assumes that:

1. The probability of the distribution of the values of the ratios in each group is normal;
2. Each probability distribution has the same variance;
3. Samples are independent.

The normal distribution was checked by using the Shapiro–Wilk test. We tested the following hypothesis:

Hypothesis 0 (H0). *The distribution of the values of ratios is normal.*

Hypothesis 1 (H1). *The distribution of the values of ratios is not normal.*

If the significance was lower than the declared significance level ($\alpha = 0.05$), we rejected the hypothesis about the normality of the distribution. If it was higher, then there was no reason to reject it. We used an extension of the test described by Royston (1982), which enabled it to be applied to large samples [25].

The second important assumption in ANOVA analysis is that the variances in the different groups (sectors) are equal (homoscedastic with equal variance). We used the Brown and Forsythe test (1974), and kept the following hypotheses in mind:

Hypothesis 0 (H0). *The variances are equal across groups.*

Hypothesis 1 (H1). *The variances are not equal across groups.*

If the value of the Brown and Forsythe test is statistically significant (lower than 0.05), than the hypothesis of the homoscedastic with equal variance should be rejected [26].

Table 1. List of ratios considered.

No.	Definition	No.	Definition
1	Net profit/total assets	42	Equity/fixed assets
2	Total liabilities/total assets	43	Constant capital/fixed assets
3	Working capital/total assets	44	Working capital
4	Current assets/short-term liabilities	45	Net profit/equity
5	Retained earnings/total assets	46	Long-term liabilities/equity
6	Gross profit/total assets	47	Sales revenues/inventory
7	Book value of equity/total liabilities	48	Sales revenues/receivables
8	Net sales revenue/total assets	49	Sales revenues/short-term liabilities
9	Equity/total assets	50	Sales/fixed assets
10	(Gross profit + financial expenses)/total assets	51	(Current assets-inventory-short-term liabilities)/(total operating revenues-profit before income tax-depreciation)
11	Gross profit/short-term liabilities	52	Net profit/net cash flow from (used in) operating activities
12	(Gross profit + depreciation)/sales revenues	53	Depreciation/net cash flow from (used in) operating activities
13	EBIT/total operating costs	54	Net cash flow from (used in) operating activities/total assets
14	(Gross profit + depreciation)/total liabilities	55	Net cash flow from (used in) operating activities/income
15	Total assets/total liabilities	56	Net cash flow from (used in) operating activities/total liabilities
16	EBIT/total liabilities	57	Net cash flow from (used in) operating activities/long-term liabilities
17	Gross profit/sales revenues	58	Net cash flow from (used in) operating activities/short-term liabilities
18	EBIT/total assets	59	Net cash flow
19	Net profit/sales revenues	60	Net cash flow from (used in) operating activities/current assets
20	(Equity-share capital)/total assets	61	Net cash flow from (used in) operating activities/EBIT
21	(Net profit + depreciation)/total liabilities	62	Net profit per share
22	EBIT/financial expenses	63	Income/outstanding shares
23	Working capital/fixed assets	64	Price per share/net profit per share
24	Logarithm of total assets	65	Yearly dividend/price per share
25	(Total liabilities-cash)/sales revenues	66	Market capitalization/book value
26	EBIT/equity	67	Market capitalization/gross profit
27	Operating expenses/short-term liabilities	68	Market capitalization/EBITDA
28	Operating expenses/total liabilities	69	Market capitalization to EBIT
29	Profit on sales/total assets	70	Market capitalization to total assets
30	Total operating revenue/total assets	71	Market capitalization/capital employed
31	(Current assets-inventories)/long-term liabilities	72	Sales revenues (n)/sales revenues $(n-1)$
32	Constant capital/total assets	73	Total sales revenue (n)/total sales revenues $(n-1)$
33	Profit on sales/sales revenues	74	Total assets (n)/total assets $(n-1)$

Table 1. *Cont.*

No.	Definition	No.	Definition
34	(Current assets-inventory-receivables)/short-term liabilities	75	Current assets (n)/current assets ($n-1$)
35	EBIT/sales revenues	76	EBIT (n)/EBIT ($n-1$)
36	Net profit/inventory	77	Net profit (n)/net profit ($n-1$)
37	(Current assets-inventory)/short-term liabilities	78	Inventory (n)/inventory ($n-1$)
38	EBITDA */total assets	79	Receivables (n)/receivables ($n-1$)
39	EBITDA */sales revenues	80	short-term liabilities (n)/short-term liabilities ($n-1$)
40	Current assets/total liabilities	81	Net cash flow from (used in) operating activities (n)/Net cash flow from (used in) operating activities ($n-1$)
41	Short-term liabilities/total assets	82	Net cash flow(n)/net cash flow ($n-1$)

* Stands for earnings before interest, taxes, depreciation, and amortization.

After the fulfilment of these requirements, the ANOVA analysis can be used. We tested the following hypothesis:

Hypothesis 0 (H0). *There are no mean differences between values of ratios in groups.*

Hypothesis 1 (H1). *There are mean differences between values of ratios in groups.*

If the significance was lower than the declared significance level ($\alpha = 0.05$), we rejected the null hypothesis. If it was higher, there was no reason to reject it. If the null hypothesis was rejected, we performed the least significant difference (LSD) test. The LSD test is comparable to the t-test for independent samples and is based on the numbers of observations (N) in the groups taken in the comparison.

The Kruskal–Wallis test was used as the nonparametric ANOVA, and it does not require a normal distribution of the values of the ratios. Similar to other nonparametric tests, it is carried out on the ranks of the measurement values of the ratios. A rank of 1 is assigned to the smallest value, a rank of 2 is assigned to the second smallest, etc. The sum of the ranks, R_i, is computed for each group, i ($i = 1,2, \ldots ,C$), of size n_i, and then the test statistic, H, is computed [27]. The H is approximately chi-squared-distributed, with the degrees of freedom equal to the groups, C, minus 1.

$$H = \frac{12}{N * (N+1)} \sum_{i=1}^{C} \frac{R_i^2}{n_i} - 3(N+1) \tag{1}$$

where C is the number of groups; n_i is the number of observations in the ith group; $N = \sum n_i$ is the number of observations in all groups combined; and R_i is the sum of the ith group.

The following hypotheses were tested:

Hypothesis 0 (H0). *The different samples in the comparison were drawn from the same distribution, or from distributions with the same median.*

Hypothesis 1 (H1). *The different samples in the comparison were not drawn from the same distribution, or from distributions with the same median.*

The analysis of the Kruskal–Wallis test is very similar to the abovementioned ANOVA. The test is based on ranks instead of means. If the null hypothesis was rejected, various comparisons of the average ranks for all groups were carried out. The comparisons are

computed as the post hoc analysis of the average ranks of all pairs of groups [28]. The z values for each comparison between groups u and v can be calculated as:

$$z_{u,v} = \frac{\left| \overline{R_u} - \overline{R_v} \right|}{\sqrt{\frac{N*(N+1)}{12} * \left(\frac{1}{n_u} + \frac{1}{n_v} \right)}} \tag{2}$$

where $\overline{R}$ indicates the mean ranks for the two groups, and n_u. and n_v represent the number of observations in the two groups (u and v).

Each company is assigned to only one group (sector), which means that samples are independent. The number of companies included in each sector differed, and consisted of 17 companies for transportation and warehousing, 72 companies for wholesale trade, 229 companies for manufacturing, 49 companies for retail trade, 15 companies for the energy sector, and 68 companies for the construction sector.

3. Results

The outcome of the research was processed using Statistica 13.3. (StatSoft Polska Sp. z o.o., Cracow, Poland).

3.1. One-Way Parametric ANOVA Analysis

First, outliers were removed from the sample in order to obtain an estimation of a normal distribution for the indicators. The normal distribution was analyzed by using the Shapiro–Wilk test. The results of the test are presented as histograms, with the probability distribution density function for each group (for six sectors) for each year and quarter (4 years, 17 quarters) for each indicator (82 indicators). A total number of 10,332 histograms were prepared. The summary results are presented in Tables 2 and 3 and Figure 3, which show only that the ratios are characterized by a normal distribution in most of the periods for all of the analyzed sectors.

Table 2. The list of indicators that obtained a normal quarterly distribution for the analyzed sectors.

Ratios/ Period	17 Q1	17 Q2	17 Q3	17 Q4	18 Q1	18 Q2	18 Q3	18 Q4	19 Q1	19 Q2	19 Q3	19 Q4	20 Q1	20 Q2	20 Q3	20 Q4	21 Q1
X2	Yes [1]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No [2]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
X9	Yes	Yes	No	No	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
X24	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes

[1] Yes: means that all six of the sectors in the quarter are characterized by a normal distribution. [2] No: means that at least one of the six sectors in the quarter is not characterized by a normal distribution.

Table 3. The list of indicators that obtained a normal yearly distribution for the analyzed sectors.

Ratios/Period	2017	2018	2019	2020
X2	Yes [1]	Yes	Yes	Yes
X9	Yes	Yes	Yes	Yes
X24	Yes	Yes	Yes	Yes
X60	Yes	Yes	Yes	No [2]

[1] Yes: means that all six of the sectors in the year are characterized by a normal distribution. [2] No: means that at least one of the six sectors in the year is not characterized by a normal distribution.

On the basis of the results of the Shapiro–Wilk test, it can be determined that only three indicators are related to the normal distribution in the quarterly analysis, and four indicators in the yearly analysis. In addition, only in the yearly analysis were three of the four ratios presented in Table 3 characterized by this distribution for the entire period. The first, X2, is the debt ratio, which shows the percentage of a company's assets that are

financed from debt. The second ratio, X9, is the equity ratio, which is the inverse of the first ratio. This ratio presents the relative proportion of equity used to provide a company's assets. Unlike X2, it can have negative values because the equity values in the balance sheet can be negative. Typically, this situation applies to companies that are facing bankruptcy. The third ratio, X24, is the logarithm of total assets, which measures the size of a company. The last one, X60, is the cash-efficiency ratio of current assets. It illustrates the ability to generate cash from operating activities by using current assets.
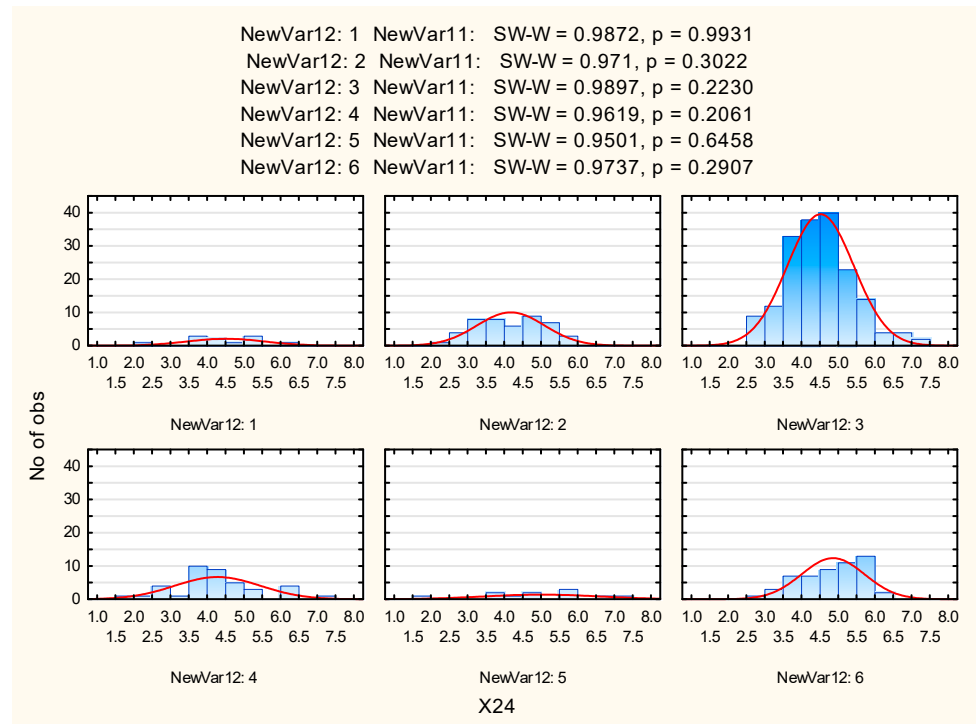
Figure 3. Histogram of indicator X24 for six sectors (1. Transportation and warehousing; 2. Wholesale trade; 3. Manufacturing; 4. Retail trade; 5. Energy; 6. Construction) together with the density function of the probability distribution for 2020. Source: author's work.

Next, the variances across groups were analyzed using the Brown and Forsythe test. The test was performed only for the four ratios that fulfilled the assumption of normal distribution.

The outcomes of the test, presented in Tables 4 and 5, reveal that the variances across groups are equal and there is, thus, no reason to reject the null hypothesis for X2, X9, and X60. However, for Q1 2018 for X2, and year 2020 for X60, in which the results are negative, the variances across the groups are not equal. In turn, for X24, there is no reason to reject the null hypothesis for only 10 of the 17 quarters and for the year 2020.

Table 4. The results of the Brown and Forsythe test (quarterly).

Ratios/ Period	17 Q1	17 Q2	17 Q3	17 Q4	18 Q1	18 Q2	18 Q3	18 Q4	19 Q1	19 Q2	19 Q3	19 Q4	20 Q1	20 Q2	20 Q3	20 Q4	21 Q1
X2	Yes [1]	Yes	Yes	Yes	Yes	No [2]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
X9	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
X24	Yes	Yes	Yes	Yes	No	Yes	No	No	No	Yes	No	No	No	Yes	Yes	Yes	Yes

[1] Yes: means that the variances across groups are equal. [2] No: means that the variances across groups are not equal.

Table 5. The results of the Brown and Forsythe test (yearly).

Ratios/Period	2017	2018	2019	2020
X2	Yes [1]	Yes	Yes	Yes
X9	Yes	Yes	Yes	Yes
X24	No	No	No	Yes
X60	Yes	Yes	Yes	No [2]

[1] Yes: means that that the variances across groups are equal. [2] No: means that the variances across groups are not equal.

The ANOVA test was then used for these ratios because they met the assumptions for its application in most periods (see Tables 6–9).

Table 6. The results of the ANOVA (quarterly).

Ratios/ Period	17 Q1	17 Q2	17 Q3	17 Q4	18 Q1	18 Q2	18 Q3	18 Q4	19 Q1	19 Q2	19 Q3	19 Q4	20 Q1	20 Q2	20 Q3	20 Q4	21 Q1
X2	Yes [1]	No [2]	Yes	No	No	No	Yes	No	No	No	Yes	No	No	No	No	No	No
X9	Yes	No	No	No	No	No	Yes	No	No	No	Yes	No	No	No	No	No	No
X24	Yes	Yes	Yes	Yes	No	Yes	No	No	No	Yes	Yes	No	No	No	Yes	Yes	Yes

[1] Yes: means that there are mean differences between the values of ratios in the groups. [2] No: means that there are no mean differences between the values of ratios in the groups.

Table 7. The results of the ANOVA (yearly).

Ratios/Period	2017	2018	2019	2020
X2	No [2]	No	No	No
X9	No	No	No	No
X24	No	No	No	Yes [1]
X60	No	Yes	No	No

[1] Yes: means that there are mean differences between the values of ratios in the groups. [2] No: means that there are no mean differences between the values of ratios in the groups.

On the basis of the results of the ANOVA test, shown in Tables 6 and 7, it can be said that the values of means for three ratios in the quarterly analysis, and for four ratios in the yearly analysis, do not differ significantly between groups over the sample period. With the exception of X24, the ratio values of means were significantly different between the groups for 10 of the 17 quarters, and also for year 2020. Moreover, some kind of seasonality of X2 can be observed for the three consecutive quarters of Q3 2017, Q3 2018, and Q3 2019, as the difference in group averages is statistically significant. This seasonality disappeared in the third quarter of 2020, perhaps because of COVID-19. Apart from X24 in the yearly analysis, the significance of differences between the means also occurs for X60 for 2018. Finally, the LSD test was performed to see which sectors differed statistically in means among each other (see Tables 8 and 9).

The outcome of the LSD test shows that the average values of the manufacturing and construction sectors for X2 and X9 are statistically different. In turn, the X24 average values vary between all sectors during the period. This means that particular sectors differ in the size of the enterprises included in them, that is, the measured value of total assets, with the exception of the transportation and warehousing sector, in which the values of means do not differ from the rest.

Table 8. The results of the LSD test (quarterly).

Ratios/Period	Sectors [1]	17 Q1	17 Q2	17 Q3	17 Q4	18 Q1	18 Q2	18 Q3	18 Q4	19 Q1	19 Q2	19 Q3	19 Q4	20 Q1	20 Q2	20 Q3	20 Q4	21 Q1
X2	1																	
	2											**6**						
	3	**6**		**6**				**6**				**4,6**						
	4											**3**						
	5																	
	6	**3**		**3**				**3**				**2,3**						
X9	1																	
	2																	
	3	**6**						**4,6**				**4,6**						
	4							**6**				**3**						
	5																	
	6	**3**						**3,4**				**3**						
X24	1	**5**	**5**	**5**	**5**	5	5		2	5			**5**	5	**5**	5	5	
	2	**3,5,6**	**3,5,6**	**3,5,6**	**3,5,6**	3,5,6	**3,5,6**	3,5,6	1,3,5,6	3,5,6	3,5,6	3,5,6	**3,5,6**	3,5,6	**3,5,6**	3,5,6	3,5,6	**3,5,6**
	3	**2,4,5**	**2,4,5**	**2,4,5**	**2,4,5**	2,5	**2,4,5**	2	2,5	2,5	2,5	2,4	**2,4,5**	2,4,5	**2,4,5**	2,5	2,5,6	**2**
	4	**3,5,6**	**3,5,6**	**3,5,6**	**3,5,6**	5,6	**3,5,6**	5,6	5,6	5,6	5,6	3,6	**3,5,6**	3,5,6	**3,5,6**	5,6	3,5,6	**5,6**
	5	**1,2,3,4,6**	**1,2,3,4,6**	**1,2,3,4,6**	**1,2,3,4,6**	1,2,3,4	**1,2,3,4**	2,4	2,3,4	1,2,3,4	2,3,4	2	**1,2,3,4,6**	1,2,3,4,6	**1,2,3,4,6**	1,2,3,4	1,2,3,4	**2,4**
	6	**2,4,5**	**2,4,5**	**2,4,5**	**2,4,5**	2,4	**2,4**	2,4	2,4	2,4	2,4	2,4	**2,4,5**	2,4,5	**2,4,5**	2,4	2,4	**2,4**

[1] 1–6 correspond to the following sectors: 1. Transportation and warehousing; 2. Wholesale trade; 3. Manufacturing; 4. Retail trade; 5. Energy; 6. Construction. Bold values mean that the obtained results were statistically significant, taking into account all the conditions for applying ANOVA.

Table 9. The results of the LSD test (yearly).

Ratios/Period	Sectors [1]	2017	2018	2019	2020
X24	1	2,4			
	2	1,3,5,6	3,5,6	3,5,6	**3,5,6**
	3	2,4,5	2,5	2,5	**2,6**
	4	1,3,5,6	5,6	5,6	**5,6**
	5	2,3,4	2,3,4	2,3,4	**2,4**
	6	2,4	2,4	2,4	**2,3,4**
X60	1				
	2		**3,5**		
	3		**2,6**		
	4				
	5		**2,6**		
	6		**3,5**		

[1] 1–6 corresponds to the following sectors: 1. Transportation and warehousing; 2. Wholesale trade; 3. Manufacturing; 4. Retail trade; 5. Energy; 6. Construction. Bold values mean that the obtained results were statistically significant, taking into account all the conditions for applying ANOVA.

Subsequently, we proceeded with the nonparametric ANOVA, as it does not require a normal distribution of the values of the indicators.

3.2. One-Way Nonparametric ANOVA Analysis

We started with the Kruskal–Wallis test. The results are presented in Tables 10–13. The tables include only those indicators for which group differences occurred over the entire time period.

Table 10. The results of the Kruskal–Wallis test (quarterly).

Ratios/ Period	17 Q1	17 Q2	17 Q3	17 Q4	18 Q1	18 Q2	18 Q3	18 Q4	19 Q1	19 Q2	19 Q3	19 Q4	20 Q1	20 Q2	20 Q3	20 Q4	21 Q1
X24	Yes [1]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
X25	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
X28	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
X30	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
X49	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

[1] Yes: means that the different samples in the comparison were not drawn from the same distribution, or from distributions with the same median.

Table 11. The results of the Kruskal–Wallis test (yearly).

Ratios/Period	2017	2018	2019	2020
X8	Yes	Yes	Yes	Yes
X24	Yes	Yes	Yes	Yes
X25	Yes	Yes	Yes	Yes
X28	Yes	Yes	Yes	Yes
X30	Yes	Yes	Yes	Yes
X34	Yes	Yes	Yes	Yes
X39	Yes	Yes	Yes	Yes
X49	Yes	Yes	Yes	Yes [1]
X50	Yes	Yes	Yes	Yes

[1] Yes: means that the different samples in the comparison were not drawn from the same distribution, or from distributions with the same median.

On the basis of the results of the Kruskal–Wallis test, as shown in Tables 10 and 11, the values of the median for five ratios in the quarterly analysis, and for nine ratios in the yearly analysis, differ significantly between groups over the sample period. A comparison of the results with the results of the parametric ANOVA shows that there are definitely more indicators for which the median values between the groups differ. Moreover, only one ratio, X24, is repeated, as it was in the parametric ANOVA.

The indicators presented in Tables 10 and 11 can be classified into different groups of indicators: turnover, profitability, debt, size of company, and liquidity ratios. The ratios of X8, X30, X49, and X50 can be considered as turnover ratios. Three of them are so-called asset turnover ratios. The differences lie in the numerator and denominator of individual ratios. The fourth one, X49, is called the accounts payable turnover, which is a very important ratio because it is typically compared to X48, the accounts receivable turnover, to check the collection periods of receivables against the payable periods. They are related to the next group, which are liquidity ratios. The cash ratio (X34) is one of the liquidity ratios. This ratio shows a company's ability to repay its short-term debt with cash. Another one belongs to profitability ratios, the EBITDA-to-sales ratio (X39). This ratio is calculated to evaluate a company's profitability by comparing its gross sales with its earnings.

Finally, a multiple comparison of mean ranks for all groups was performed to see which sectors differed statistically from each other (see Tables 12 and 13).

Table 12. Multiple comparisons of mean ranks for all groups (quarterly).

Ratios/ Period	Sectors [1]	17 Q1	17 Q2	17 Q3	17 Q4	18 Q1	18 Q2	18 Q3	18 Q4	19 Q1	19 Q2	19 Q3	19 Q4	20 Q1	20 Q2	20 Q3	20 Q4	21 Q1
X24	1																	
	2	3,5,6	5,6	5,6	5,6	6	6	6	3,6	6	6	3,6	6	6	6	6	6	5,6
	3	2,4			4				2			2						
	4	3,5,6	5,6	5,6	3,5,6		6	6	6			6	6	6		6	6	6
	5	2,4	2,4	2,4	2,4													2
	6	2,4	2,4	2,4	2,4	2	2,4	2,4	2,4	2	2	2,4	2,4	2,4	2	2,4	2,4	2,4
X25	1																	
	2	5	3,5	3,5,6	5,6	5,6	5	5	5	5,6	5	6			5	5,6	3,5	5,6
	3	4	2,4	2,4							4		4				2	
	4	3,5,6	3,5	3,5,6	5	5,6	5	5	5	5,6	3,5,6	6	3,5,6	6			5	5,6
	5	4	2,4	2,4	2,4	2,4	2,4	2,4	2,4	2,4	2,4		4		2	2	2,4	2,4
	6	2,4		2,4	2	2,4				2,4	4	2,4	4	4		2		2,4
X28	1	6																
	2	5,6	5,6	5,6	6	6	3,6	6	5,6	5,6	5,6	5,6	6	6	6	5,6	5,6	6
	3	6	6	6		6	2			6				6		6		6
	4	5,6	5,6	6	6	5,6	6	6		5,6			6	5,6	6			6
	5	2,4	2,4	2		4			2	2,4	2	2		4		2	2	
	6	1,2,3,4	2,3,4	2,3,4	2,4	2,3,4	2,4	2,4	2	2,3,4	2	2	2,4	2,3,4	2,4	2,3	2	2,3,4
X30	1								5		5					5		
	2	6	5,6	3,5,6	3,5,6	6	3,5	6	5	6	3,5	5,6	3,5,6	5,6	5	5		6
	3	6	6	2,4,6	2	6	2				2		2					6
	4	6	5,6	3,5,6	5	6					5			6	5			
	5		2,4	2,4	2,4		2		1,2		1,2,4	2	2	2	2,4	2	1	
	6	2,3,4	2,3,4	2,3,4	2	2,3,4		2		2		2	2	2,4				2,3
X49	1	6		6		6	6	6					6		6		6	
	2	6	6	6	6	6	6	6		6	6	6	6	6	6	6	6	6
	3	6	6	6		6	6			6			4,6		6	6		6
	4	6	6	6		6	6	6		6	6	6	3,6	6	6	6		6
	5																	
	6	1,2,3,4	2,3,4	1,2,3,4	2	1,2,3,4	1,2,3,4	1,2,4		2,3,4	2,4	2,4	1,2,3,4	2,4	1,2,3,4	2,3,4	1,2	2,3,4

[1] 1–6 correspond to the following sectors: 1. Transportation and warehousing; 2. Wholesale trade; 3. Manufacturing; 4. Retail trade; 5. Energy; 6. Construction.

After analyzing the results of multiple comparisons of mean ranks for all groups for the quarterly analysis (Table 12), the values of X24, X28, and X49 for the wholesale and retail trade and construction sectors are statistically different in most of the periods. For X25, on the other hand, there are differences in values between the wholesale and retail trade and energy sectors. In turn, for X30, the difference occurs between the wholesale trade, energy, and construction sectors. These four abovementioned ratios can be considered as stable over time. Despite the outbreak of COVID-19, no significant differences can be observed in the results obtained before (Q1 2017–Q4 2019) and during (Q1 2020–Q1 2021) the pandemic. With the exception of X30, for the quarters from Q2 2020 to Q1 2021, there are some changes between the differences in sectors. The differences occur between the wholesale trade and energy sectors in Q3 2020, the transportation and warehousing and energy sectors in Q4 2020, and the wholesale trade, manufacturing, and construction sectors in Q1 2021. The values of this ratio are related to the increase or decrease in the numerator, which is the operating income of enterprises. If the operation is suspended because of the increased number of coronavirus infections, it will significantly affect the value of the ratio.

Table 13. Multiple comparisons of mean ranks for all groups (yearly).

Ratios/Period	Sectors [1]	2017	2018	2019	2020
X8	1			5	
	2	5,6	5,6	5,6	5,6
	3	6	5		
	4	6	5,6	5	
	5	2	2,3,4	1,2,4	2
	6	2,3,4	2,4	2	2
X24	1				
	2	6	6	6	6
	3				
	4	6		6	6
	5				
	6	2,4	2	2,4	2,4
X25	1				
	2	5,6	5	3,5	3,5,6
	3	4	4,5	2,4	2
	4	3,5,6	3,5,6	3,5	5
	5	2,4	2,3,4	2,4	2,4
	6	2,4	4		2
X28	1				
	2	5,6	5,6	5,6	5,6
	3	5,6	5	5,6	5
	4	5,6	5,6	5,6	
	5	2,3,4	2,3,4	2,3,4	2,3
	6	2,3,4	2,4	2,3,4	2
X30	1				
	2	5,6	5,6	5,6	5,6
	3	6	5		
	4	6	5,6	5	
	5	2	2,3,4	2,4	2
	6	2,3,4	2,4	2	2
X34	1				
	2	6	6	5,6	6
	3	6	6	6	6
	4			6	6
	5			2	
	6	2,3	2,3	2,3,4	2,3,4
X39	1				
	2	5	5	3	3
	3			2,4	2
	4	5	5	3	
	5	2,4	2,4		
	6				

Table 13. *Cont.*

Ratios/Period	Sectors [1]	2017	2018	2019	2020
X49	1				
	2	6	6	5,6	6
	3	6		6	
	4	6	5,6	5,6	6
	5		4	2,4	
	6	2,3,4	2,4	2,3,4	2,4
X50	1			5	5
	2	5,6	5	3,5	5
	3		5	2,5	5
	4	5	5	5	5
	5	2,4	2,3,4,6	1,2,3,4,5,6	1,2,3,4
	6	2	5	5	

[1] 1–6 correspond to the following sectors: 1. Transportation and warehousing; 2. Wholesale trade; 3. Manufacturing; 4. Retail trade; 5. Energy; 6. Construction.

Moving on to the yearly analysis of multiple comparisons of mean ranks for all groups (Table 13), the differences between the sectors for five ratios are primarily the same as those mentioned in the quarterly analysis. The values of the cash ratio (X34) differ between the wholesale and retail trade, manufacturing, and construction sectors in the period. Moreover, the differences in the values of the EBITDA-to-sales ratio (X39) between the sectors was not stable in the period. In the first and second periods, the differences concerned the same sectors while, in the third period, the differences related to the wholesale and retail trade and manufacturing sectors. In the last period, the differences related only to the wholesale trade and manufacturing sectors. COVID-19 is only relevant to the last period.

3.3. Analysis of Results

On the basis of the ANOVA results, it can be concluded that 12 of the 82 indicators met the criteria for value differences between sectors (Figures 4–9). Five of them were selected and analyzed in detail, namely, two turnover indicators (Figures 5 and 8), one indicator of the size of the enterprise (Figure 4), a liquidity indicator (Figure 6), and a profitability indicator (Figure 7). Additionally, the X48 turnover ratio was included (Figure 9), which is usually analyzed with X49.

The first ratio is the size of the enterprise (X24). This ratio was the only one out of the 82 analyzed indicators that met the conditions for both of the ANOVA analyses. On the basis of the results shown in Figure 4, a dramatic decline cannot be seen in the size of enterprises measured by total assets in the period. In turn, a slight increase in the size of companies for the construction and retail trades, and a slight decrease for the energy sector, can be observed. According to the previous analyses, there are differences between the construction sector, the wholesale trade sector, and the retail trade sector. In Figure 4, we can see that companies in the construction sector have grown during the last three years, and at the end of the period, they were the biggest of all of the analyzed sectors.

The asset turnover ratio (X30) was the second analyzed ratio. This ratio is similar to X8 and X50. The difference between them is in the numerator. Figure 5 reveals a downward trend for four sectors, namely, wholesale and retail trade, manufacturing, and construction, in the period of 2018–2020. The highest decline was recorded in the retail trade sector in 2020: up to 0.76. Any number less than 1 means that the involvement of euro 1 of assets only brings 76 cents of income. For wholesale trade only, the number is higher than 1 for the entire period, and the lower values are related to the energy sector. Moreover, there was an upward trend for two sectors, namely, transportation and warehousing and the energy sector, in the period from 2017–2019. Unfortunately, in 2020, this trend stopped and, as in other sectors, the value of the ratio decreased. As stated in the nonparametric ANOVA

analysis, there were differences between the wholesale trade, the construction, and the energy sectors. These differences are significant and they favor the wholesale trade sector. Taking into account the previous ratio, X24, which showed that the largest enterprises are in the construction and energy sectors, these sectors turned out to be the least effective in managing their assets in this case. It could be said that bigger does not mean better.
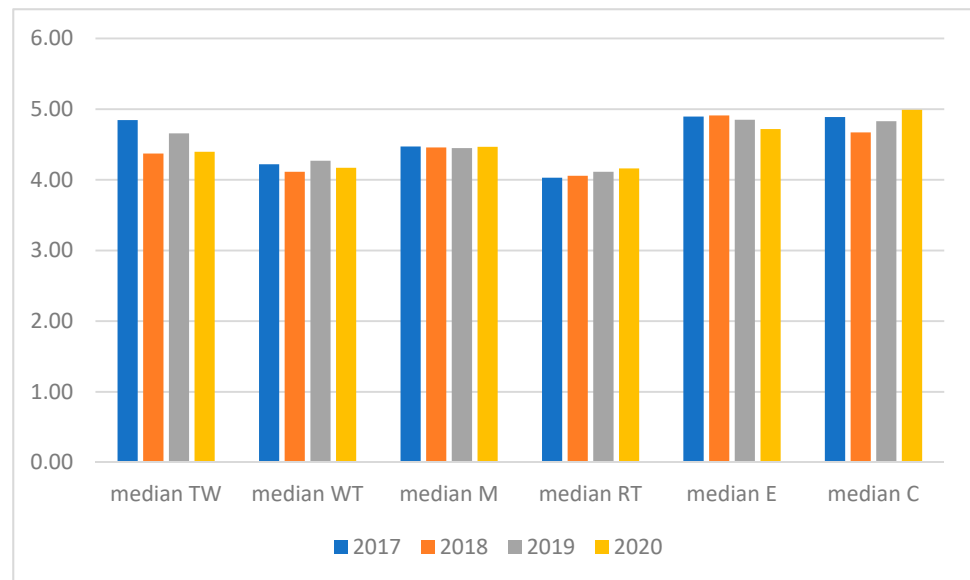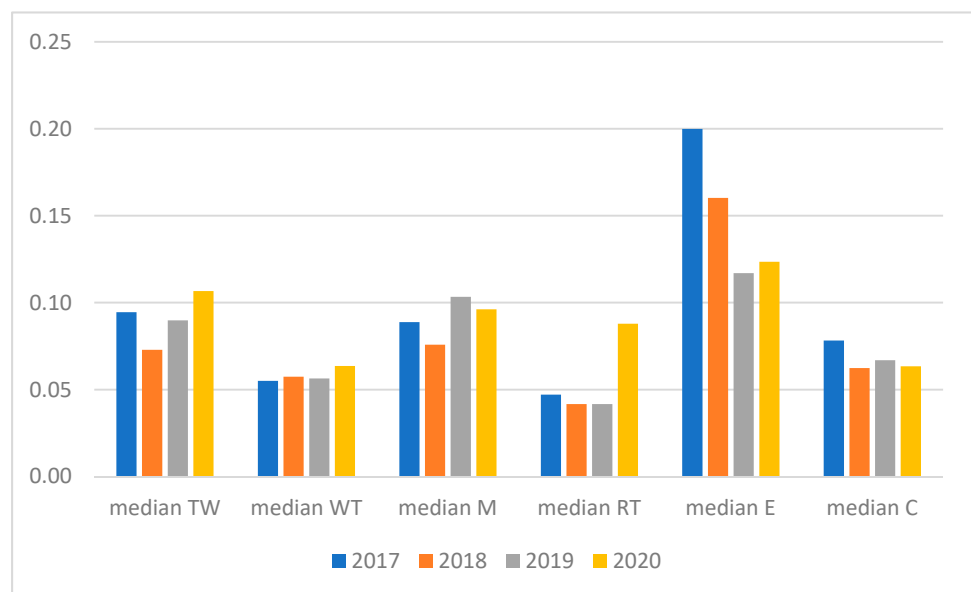

Figure 4. The results of values for size of company (X24), in the period from 2017—2020, for six sectors (TW: transportation and warehousing; WT: wholesale trade; M: manufacturing; RT: retail trade; E: energy; C: construction). Source: author's work.
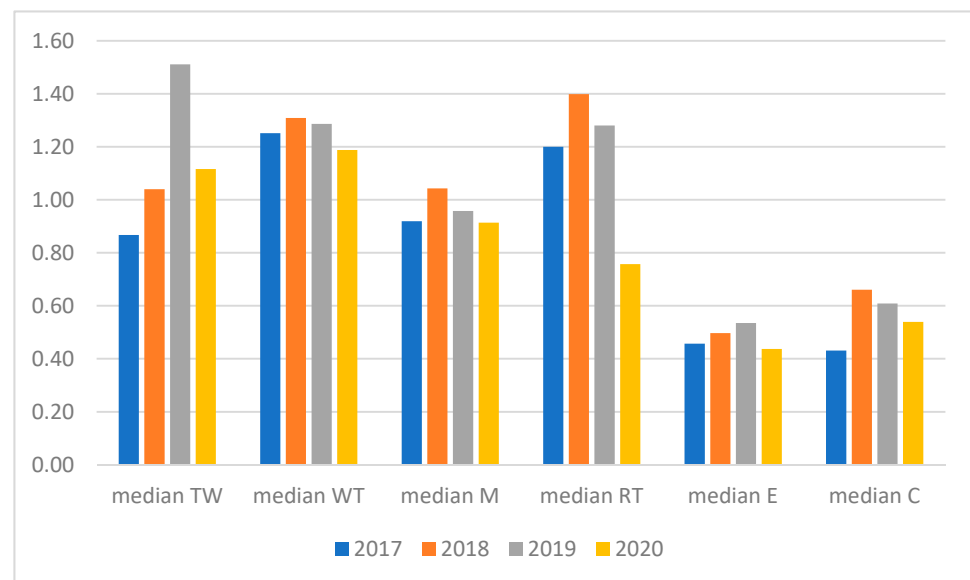
Figure 5. The results of values of asset turnover (X30) in the period from 2017–2020 for six sectors (TW: transportation and warehousing; WT: wholesale trade; M: manufacturing; RT: retail trade; E: energy; C: construction). Source: author's work.
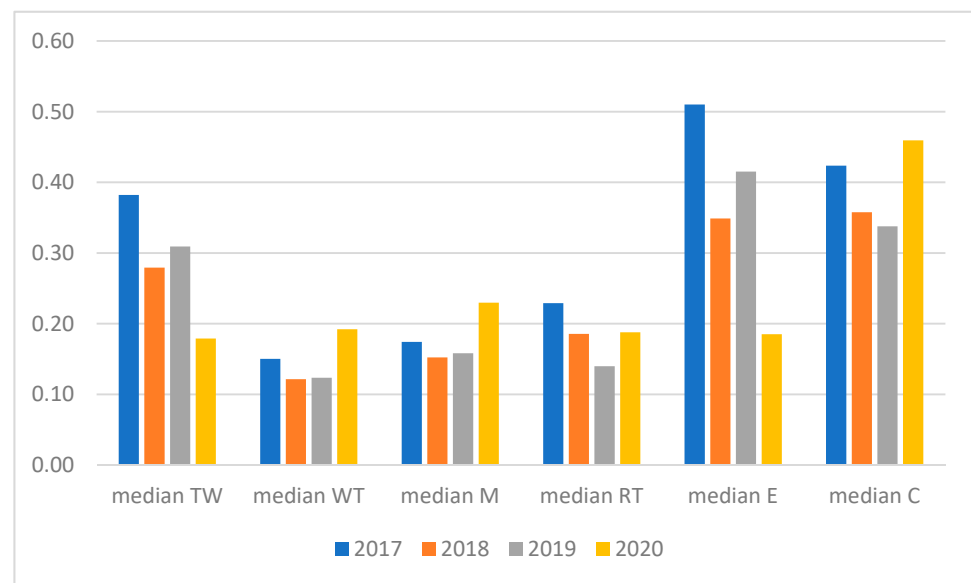
Figure 6. The results of the values of the cash ratio (X34) in the period from 2017–2020 for six sectors (TW: transportation and warehousing; WT: wholesale trade; M: manufacturing; RT: retail trade; E: energy; C: construction). Source: author's work.
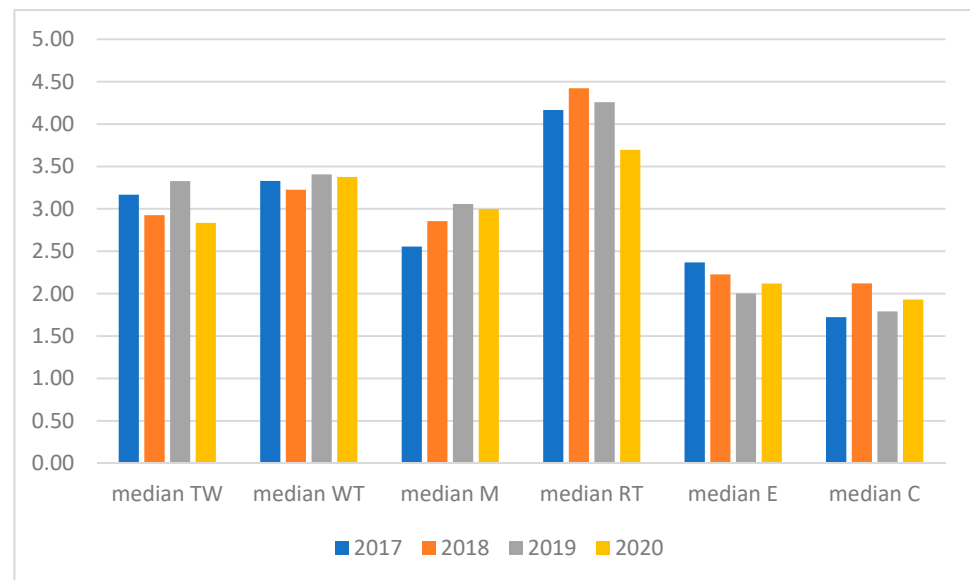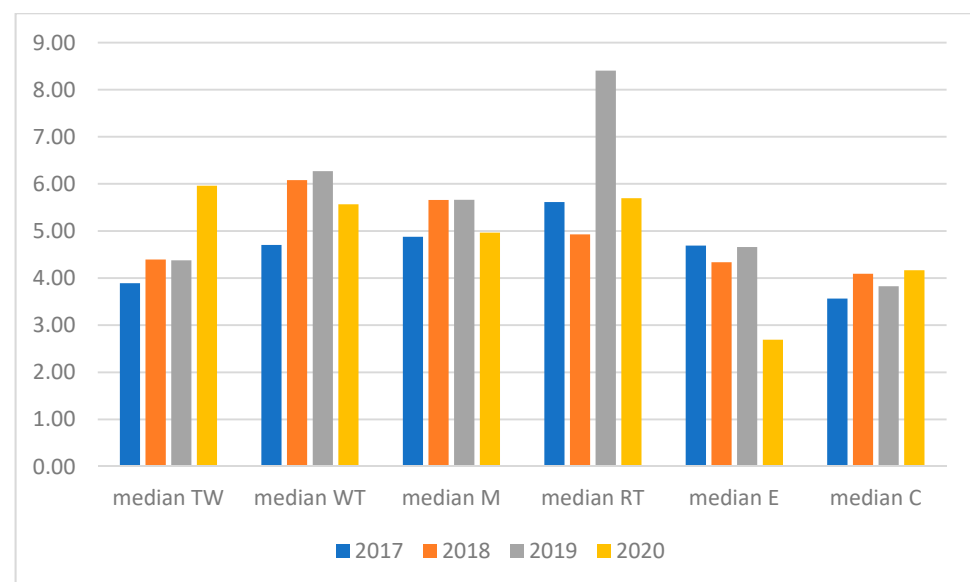

Figure 7. The results of values of the EBITDA-to-sales ratio (X39) in the period from 2017–2020 for six sectors (TW: transportation and warehousing; WT: wholesale trade; M: manufacturing; RT: retail trade; E: energy; C: construction). Source: author's work.

The third ratio analyzed was the cash ratio (X34). This ratio is the liquidity ratio, and it illustrates a company's ability to repay its short-term debt with cash. The highest values of this ratio are in the construction sector which, despite the declining trend of 2017–2019, increased significantly in 2020. The values of this ratio increased in three more sectors: wholesale trade, retail trade, and manufacturing. This was caused by the uncertainties that emerged with the outbreak of the pandemic, as well as the restrictions that occurred. Significant fluctuations in the values of this ratio occurred in two sectors, namely, transportation and warehousing, and energy. The reduced values could be due to the need to increase fixed assets in order to increase, for example, the handling of more parcels for the first sector, and power from renewable energy sources for the second sector.

The nonparametric ANOVA showed that the values of X34 differed between the wholesale and retail trade sectors, the manufacturing sector, and the construction sector in this time period. On the basis of Figure 6, it can be said that the values for the construction sector are much higher than those mentioned in the analysis.

Figure 8. The results of the values of the payable turnover ratio (X49) in the period from 2017–2020 for six sectors (TW: transportation and warehousing; WT: wholesale trade; M: manufacturing; RT: retail trade; E: energy; C: construction). Source: author's work.

Figure 9. The results of the values of the accounts receivable turnover ratios (X48) in the period from 2017–2020 for six sectors (TW: transportation and warehousing; WT: wholesale trade; M: manufacturing; RT: retail trade; E: energy; C: construction). Source: author's work.

The fourth ratio analyzed was the EBITDA-to-sales ratio (X39). This is one of the profitability ratios. The X39 ratio is calculated to estimate a company's profitability by comparing its gross sales with its earnings. The highest values of this ratio were in the energy sector, in which the values had a significant downward trend in 2017–2019, while in 2020, there was a slight increase. On the other hand, the values for the transportation and

ware-housing sector were characterized by a reverse trend; first, there was a decrease, and then an upward trend starting in 2017. This sector is one of the few to experience a large increase in orders because of the pandemic. As reported by the nonparametric ANOVA analysis, the values of the ratio are not stable within the sectors during the time period, which means that it cannot be stated between which sectors this is different, especially when comparing 2017–2018 and 2019–2020, when the differences between sectors have changed. There is a difference in the values between sectors, but they are not as visible as in the previous figures.

The final ratio analyzed was the accounts payable turnover ratio (X49). This ratio is typically compared to X48, the accounts receivable turnover. Therefore, we added the values in Figure 7. The higher the value of the ratios, the more frequently companies pay off their liabilities (X49) or collect receivables (X48). On the basis of an analysis of Figures 8 and 9, the sectors are characterized by higher values for the X48 ratio than for the X49 ratio. This is a favorable phenomenon because enterprises first collect their receivables and then pay their liabilities. In this situation, it is not necessary to obtain additional funds to pay off liabilities. The obligations were paid the fastest in the retail trade sector, and the slowest in the construction sector. On the other hand, in the construction sector, receivables were collected the slowest, and were collected the fastest in the wholesale trade sector. There is a downward trend in the retail trade sector starting in 2018, which means that enterprises extended the repayment period of their liabilities. Moreover, there is an upward trend for transportation and warehousing, which significantly increased in 2020. Comparing the results to the ANOVA analysis, the values for the wholesale and retail trade sectors and the construction sector were statistically different during most of the period, which means that the construction sector differs from the rest by lower values of the index.

4. Discussion

Our results from the parametric ANOVA reveal that the size of the company ratio (X24) shows a difference between the sectors for only 10 of the 17 quarters in the quarterly analysis. On the other hand, the results of the nonparametric ANOVA expose five ratios in the quarterly analysis, and nine ratios in the yearly analysis. They belong to different groups of indicators, namely, four turnover ratios (X8, X30, X49, X50), two debt ratios (X25, X28), one ratio for the size of the enterprise (X24), one ratio for liquidity (X34), and one profitability ratio (X39). It is worth noting that the ratios mentioned in the results are not equally statistically significant for each sector. For example, the construction and energy sectors turned out to be the least effective in managing their assets. The construction sector is also characterized by the highest cash ratio and the longest period of repayment of its obligations. In turn, the energy sector is represented by high values for the cash ratio and long periods of repayment of its obligations, but this is statistically irrelevant. This indicates that the stability of the selected indicators over time can only be observed for some sectors.

Lin and McClean [21] selected ratios based on financial theory, human judgement, and ANOVA. They focused on two groups of UK-listed companies: non-failed and failed. They stated that, among other ratios, the cash ratio and the accounts payable turnover were significant. Those two ratios (X34, X49) in this study are also significant using the nonparametric ANOVA. On the other hand, Geng et al. [20] used a one-way ANOVA to select the crucial ratios to build models for predicting financial distress in Chinese-listed companies. They singled out the top ten financial ratios with the highest predictive abilities, but none of those are similar to this research. This may be due to the fact that they only analyzed 31 indicators and in a completely different market. Tomczak [29] applied a new hybrid approach (ratio analysis, the Altman model, cluster analysis, and the Student's t-test, testing only two groups of companies in the same sector) to assess the financial state of power generators, companies from the energy sector from eight countries (including V4 countries). The results showed that there were differences in the values of ratios but, according to the results of the Student's t-test, these differences, in most

cases, were insignificant. the Student's t-test is similar to the parametric ANOVA but is only for two groups. This study also did not show the relevant differences in the yearly parametric ANOVA analyses. Moreover, Zięba et al. [24] assessed the importance of the ratios by analyzing the forest based on Polish manufacturing companies. Their results took into account similar ratios that were found to be useful: the asset turnover ratio (X8 in this research), the cash ratio (X34 in this research), and the payable turnover ratio in days (similar to X49). The assets turnover ratio was also considered to be useful by Alman as the result of the selection of ratios [6]. In addition, the size of the company ratio (X24), which was marked in the parametric and nonparametric ANOVAs, is also relevant in the model of Altman et al. [15], and in the model of Mączyńska and Zawadzki [13].

We recognize some limitations of our study. First, we analyzed only listed companies, mainly from Poland, because the Warsaw Stock Exchange is the largest in the region. Second, we took into consideration six sectors, each of which consisted of a different number of companies. This may have influenced the results. Finally, the analysis of the six sectors clearly influenced the results of the parametric ANOVA, especially the obtainment of the normal distribution of the ratio values. In the case of fewer sectors, more ratio values could obtain this distribution.

5. Conclusions

Our study aimed to select indicators that consistently (stable over time) showed the differences between the values in individual sectors before and during COVID-19. The research was conducted taking into account quarterly and annual analyses. The analyses included 450 companies listed on the Warsaw Stock Exchange, the Prague Stock Exchange, the Bratislava Stock Exchange, or the Budapest Stock Exchange, and covered six sectors: manufacturing, construction, retail trade, wholesale trade, transportation and warehousing, and energy. We calculated 82 indicators that characterized various aspects of financial performance: liquidity, profitability, turnover, debt, market values, and dynamics indicators. We applied one-way parametric and one-way nonparametric ANOVA to the selected indicators. The results of the parametric ANOVA show that only one ratio reveals differences between the sectors in most of the periods of quarterly analysis, mainly because most of the indicators did not meet the assumptions for the application of the ANOVA. On the other hand, the results of the nonparametric ANOVA demonstrate that five ratios showed differences between the sectors in the quarterly analysis, and nine showed differences in the yearly analysis. It should be pointed out that the ratios mentioned in the outcome are not equally statistically significant for each sector. It means that the ratios are stable over time only for certain sectors.

We hope that the results will help managers, lenders, and investors to: make the right decisions; take preemptive action to protect businesses from bankruptcy; choose sectors and enterprises that, for example, are not susceptible to restrictions related to the pandemic or, on the contrary, will produce and sell more, despite government restrictions; or to forecast and prepare for the risk of sectoral and corporate insolvency by preparing an appropriate credit strategy for these sectors and enterprises.

The research presented in the article is focused on a certain aspect concerning the selection of indicators. However, future research could also take into account textual information about the enterprises. This would answer the question of how this affects the selection of indicators and, above all, the assessment of the financial condition of the Visegrad group of enterprises.

Conflicts of Interest: The author declares no conflict of interest.

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