NON-PARAMETRIC ANALYSIS OF RETAILER PERFORMANCE IN SELECTED EU COUNTRIES: ASSESSING THE IMPACT OF COVID-19

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Abstract: The COVID-19 pandemic had a profound impact on microeconomic realities by creating uncertainty, changing economic conditions and ultimately reducing market activity. These effects were felt at a subsectoral level in a large number of European Union (EU) countries. This paper focuses on Spain, Italy, France, Poland and Romania to comparatively assess the differences at a firm level before and after the occurrence of COVID-19. In this study, a non-parametric approach was used for microdata collected from non-specialized retail firms in the agricultural and chemical sectors using multiple correspondence analysis (MCA) and the Wilcoxon signed rank test. The study analyzed micro and small firms and concluded that across firm size and country, return on capital (ROC) distress—ratio of the coefficient of variation of the post-COVID-19 period to the pre-COVID-19 period—was the highest, especially for Spanish and Italian micro firms and Polish small firms. Working capital distress was similar and affected Spanish, Polish and French small businesses. Asset depreciation problems were greatest for Italian, Spanish and Polish small businesses compared to the others. The results of the Wilcoxon signed rank test showed statistically significant differences in employment and working capital between the pre-and post-pandemic samples. Our results suggest that COVID-19 had a noticeable impact at the firm level in the case countries, which can be assessed using non-parametric methods.

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Policymakers should constantly evaluate the performance of firms in each sector to develop rigid policy proposals for the potential economic disruptions in our time of multiple crises.

Keywords: COVID-19; correspondence analysis; Europe; firm performance; Wilcoxon test.

JEL Codes: C14, D24, H12, O52.

1. Introduction

European economies experienced significant setbacks due to the COVID-19 pandemic, as strict lockdowns and social distancing measures led to major disruptions in various economic sectors (Çera, 2022). Various countries showed considerable industrial and sectoral deviations from normal economic functions and also received state support. There are several reasons why the European Union (EU) member states are interesting in academic research from a microeconomic perspective due to the pandemic. For example, EU countries represent one of the most economically integrated regions in the world, which experienced notable supply chain disruptions after the pandemic (Orlando et al., 2022). In addition, there are a significant number of industries in the EU that have been severely affected by the closures and travel restrictions, such as tourism and hospitality, of which Italy and Spain are the best examples (Plzáková and Smeral, 2022). Conversely, countries such as Germany, where manufacturing dominates, have shown greater long-term resilience, but they have not been immune to the effects of the crisis (Sydow et al., 2021). The EU's extensive fiscal stimulus measures were intended to support businesses and workers and potentially mitigate some of the downturn, although the scale and impact varied (Menguy, 2022). Therefore, existing economic conditions may influence vulnerability. Companies and firms in the EU that were already struggling before the pandemic may be more vulnerable, while others may show greater resilience compared to businesses in other regions.

In light of these considerations, a comparative analysis of various firm-level performance indicators (e.g., employment, sales, profitability) in different EU countries would be essential for a thorough comparison based on subsectoral patterns—especially in agriculture and the chemical industry. Most existing academic studies on COVID-19 assessments at the firm level rely on aggregate data (Ahmad et al., 2021; Janzen and Radulescu, 2022), while studies focusing on specific subsectors such as agriculture and the chemical industry among micro and small retailers are less common. This paper focuses on EU member states such as Spain, Italy, France, Romania and Poland. According to the World Bank (The World Bank Group, 2021, 2022a), these five countries account for 58.1% of total agricultural land in the European Union and 54.4% of total grain production. This concentrated distribution of agricultural resources underlines the importance and potential

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contribution of the empirical results of this study.

The aim of this study is to classify micro and small firms in selected European countries according to their distress levels and to investigate the statistical significance of firm-level performance before and after the COVID-19 pandemic. The research questions are therefore as follows:

1. In which selected EU country has firm-level performance been most affected by the COVID-19 pandemic?

2. Are there statistically significant differences in the performance of micro and small firms in agriculture and chemical sectors (measured by employment and working capital) in Spain, Italy, France, Poland and Romania before and after the COVID-19 pandemic?

This comparative analysis can provide valuable insights into the nuanced impact of COVID-19 on business performance across the EU by examining countries with different economic structures, policy responses and pre-pandemic conditions. Based on non-parametric empirical methods of microdata, the study provides valuable insights for future economic resilience strategies.

Analyzing the impact of COVID-19 on firm performance requires a comprehensive examination of various financial metrics at the firm level. Employment figures may reflect changes in production, layoffs or hiring trends as a result of the pandemic. Fluctuations in working capital may indicate disruptions in the supply chain, shifts in customer payment behavior, or changes in inventory management. Although amortization figures tend to remain stable, they provide a baseline against which more volatile variables can be compared. Sales represent a direct measure of revenue changes caused by closures, travel restrictions, or changing consumer preferences. Additionally, return on capital (ROC) is a key indicator of a firm's profitability, with a decrease indicating a negative impact and an increase indicating a successful adjustment during the pandemic. By analyzing this interlinked microdata at the firm level, researchers can gain a deeper understanding of how COVID-19 impacted a company's operational efficiency, financial health and overall performance.

This study uses multiple correspondence analysis (MCA) and the Wilcoxon signed rank test. The reasons for these methodological choices are based on several factors. First, MCA has gained prominence in the social sciences (Hjellbrekke, 2018), particularly in studies that apply a subsectoral perspective to firm performance in European countries (Di Vita et al., 2023). Second, the use of the Wilcoxon signed rank test to assess differences in firm performance before and after COVID-19 is becoming increasingly popular in academia, as the microdata collected are not normally distributed (as shown by Nguyen (2022) in a study on Vietnamese firms). Finally, large microdata sets require flexible and computationally efficient methods, such as non-parametric tests, which are less dependent on normality assumptions and can efficiently handle a large number of data points. Taking these factors into

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account, we formulated the following hypotheses:

- H1: COVID-19 had a negative effect on employment in micro firms in Spain, Italy, Poland and Romania.
- H2: COVID-19 had a negative effect on working capital in the micro firms in Spain, Italy, Poland and Romania.
- H3: COVID-19 had a negative effect on employment in small firms in Spain, Italy, Poland, France and Romania.
- H4: COVID-19 had a negative effect on working capital in small firms in Spain, Italy, Poland, France and Romania.

By using non-parametric methods such as MCA and the Wilcoxon Signed Rank Test, the study shows significant differences in the impact of COVID-19 on companies, which underlines the importance of country-specific factors. For example, Polish micro and Spanish small businesses suffered significant losses in sales, while Italian small businesses suffered a high burden in amortization amounts. In addition, micro in Romania were affected by relatively high unemployment. These effects were then tested for robustness using the Wilcoxon Signed Rank Test.

The next section provides a brief literature review that focuses on studies examining firm performance in the context of COVID-19 in selected European countries. Subsequently, the third section explains our data sources and methodological preferences in more detail. Section four presents the empirical results, while section five contextualizes the findings and discusses unexpected results. Finally, section six contains the conclusions.

2. Literature review

Given its critical role in human well-being, food security has become a major global concern, leading to increased research interest in agriculture, agrochemicals and the economic efficiency of these sectors. This study examines these issues in the context of the COVID-19 pandemic. The literature review presented here compiles country-specific studies that deal either directly or indirectly with the agricultural and chemical subsectors in the five case study countries. It should be noted that the relevant sources for our specific studies were limited, but we have tried to draw on the gap we found when reviewing previous publications.

Recent literature suggests that the COVID-19 pandemic has had a profound impact on economic sectors through various channels. This can be through employment (Sharma and Rai, 2024), shocks to firms' supply chain activities (Pan and Yue, 2022), realigning business operations (Chen et al., 2021), providing the necessary resources to regulate complex government support measures (Coli et al., 2022) and addressing the challenges of changing consumption functions (Forrest et al., 2023). Such challenges have specific effects on the economic subsectors (Heryán et al., 2024)

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and require new solutions, for example, state-supported microfinance or newly adapted socio-economic programs (Goel, 2024). Consequently, each country and each economic sector or subsector is unique in its own way and needs to be analyzed in terms of the impact of COVID-19 on business performance. For this reason, the country-specific review of the study may be helpful in guiding the present study.

Let us start with Romania and Poland, the largest countries of the former communist bloc in terms of area and population. In both countries, agriculture accounts for the highest share of gross domestic product (GDP) of the five countries analyzed. At the EU level, Romania and Poland are among the eight countries with the highest share of agriculture in national GDP (The World Bank Group, 2022b). Despite their shared communist past, Romania and Poland have different backgrounds, both politically and in terms of their natural resources. During the communist era, agricultural land in Romania was entirely state-owned, while in Poland around 75% of arable land was owned by private farms (Sin and Nowac, 2014). Today, Romania has the most farms in Europe with 33.3% of the total area, followed by Poland with 13.7% and Italy with 11.1% (Eurostat, 2020). Although Romania and Poland have various socio-economic similarities, they have different political histories and resource bases.

Stoicea et al. (2023) analyzed profitability indicators for several large Romanian farms using data from their financial statements. Their findings pointed to key factors contributing to the poor financial performance of the sector, including low liquidity, low return on assets and over-reliance on bank loans after the pandemic. Bobitan et al. (2023) used a data envelopment analysis model and the Malmquist index to examine the financial performance of companies in the agricultural sector from 2017 to 2021 and found a limited ability to adapt to change and invest in high-performance technologies. Popescu and Popescu (2022) conducted a survey of farmers and found that the pandemic had an impact on agricultural costs, labor, management and food safety. They highlighted vulnerabilities and emphasized the need for automation, digital solutions and improved communication to increase resilience in Romania.

The Polish case is also similar to the Romanian one. Dudek and Śpiewak (2022) analyzed the economic, legal and social impact of the pandemic on the Polish food system and pointed out disruptions, adjustments and recommendations to strengthen the EU's "From Producer to Consumer" strategy for a more sustainable future. Danilowska and Jedruchniewicz (2023) examined how COVID-19 affected agricultural production in Poland. They found that there was a slight decline in the second year of the pandemic due to labor shortages, with animal production (especially eggs and meat) being more affected than crop production, while milk production remained stable. In this respect, the firm-level performance of Polish agricultural and chemical producers can be considered vulnerable to external shocks.

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Spain, one of the largest exporters of agricultural products, was another country we included in our analysis. A survey conducted in Spain by Fernández-Cerezo et al. (2023) with a sample of 4,004 companies found that the companies most affected by the pandemic were small and relatively new companies in urban areas. In terms of employees, the study found that most companies reduced their workforce through furlough plans rather than layoffs.

Another aspect discussed in more recent studies is the persistence of agricultural profits in Spain. Gómez-Limón et al. (2023) used two different analytical tools—a GMM (General Method of Moments) regression model and a dynamic panel model—to examine the economic performance of over 9,000 agricultural entities in Spain. Their results highlight the complex nature of profits in this sector. Due to the high percentage of agricultural land owned by farmers, Spanish farms tend to have a relatively constant profitability, as the authors' results show.

In the case of Italy, some argue that COVID-19 has not significantly affected agricultural activities (Lovarelli et al., 2022). However, Cortignani et al. (2020) pointed out that the agricultural labor force was subject to significant restrictions, leading to a decrease in production capacity in the central-western Sardinia region. Indeed, Italian agri-food supply chains were under significant stress during the pandemic (Barcaccia et al., 2020).

Previous studies have established empirical relationships between farm-level performance indicators. For example, Coppola et al. (2020) analyzed 6,270 small and medium-sized Italian farms over a three-year period (2015–2017), focusing on farm income per family work unit and the profitability index. In their study, they examined the impact of European financial aid for farmers on the increase in agricultural income. Using an econometric analysis, they found that farm size, invested capital and the quality of agricultural land significantly influence the profitability index in agriculture. With this in mind, it seems logical to include farm sizes and the impact of the COVID-19 outbreak in the analysis of non-specialized agricultural and chemical retailers. This would allow a deeper understanding of how the pandemic has affected these sectors in Italy.

The other country we examined was France. Perrin and Martin (2021) found that there was minimal disruption in French farms and agricultural entities during the pandemic. They attributed this to family structure and self-sufficiency, while supply chains adapted production and logistics to ensure the continued availability of basic dairy products. This resilience was further enhanced by the extensive support provided to French retailers by the government and large multinational companies (Nicolaï and Grange, 2021). Moreover, Mitaritonna and Ragot (2020) even saw the pandemic as an opportunity for France. These findings are in line with studies showing that COVID-19 can act as a catalyst for the retail sector, as the case study in Belgium shows (Beckers et al., 2021).

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Some previous studies in Italy and France have analyzed the performance of farms. For example, Enjolras et al. (2014) applied econometric models to a sample of 9,555 farms in France and Italy over five years (2003–2007) to measure the dependence of agricultural income on these risk management tools. Their results reveal differences between the two countries. For example, the smaller size of farms in Italy means that their income is more dependent on external factors. Therefore, small farmers resort to a range of risk mitigation tools and manage to stabilize their income over longer periods. On the other hand, larger farms in France tend to be more exposed to risk, which leads to a higher volatility of their income. According to Bochtis et al. (2020), the governments of Italy, France, Spain, etc. have been quick to address the challenges related to labor in the agricultural sector, as these countries are highly dependent on mobile migrant workers.

The literature review reveals that many scholars have studied agricultural entities from the perspective of the COVID-19 pandemic. However, joint and more focused analyses of agricultural and chemical entities are still limited. This work aims to fill this gap by applying non-parametric methods to a large set of microdata. The detailed technical methodology and related information are presented in the following section.
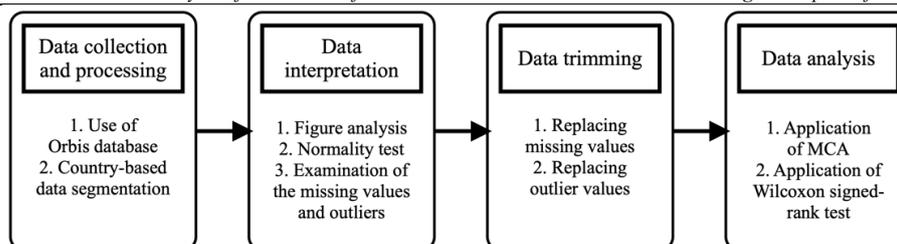
3. Data and Methodology

This study consists of two main components: the MCA of selected firm-level performance indicators (e.g., sales, employment, ROC) and the Wilcoxon signed rank test of microdata for employment and working capital. The MCA visually depicts the performance of micro and small firms from the selected countries in terms of the degree of distress according to COVID-19. The degree of distress is defined as the ratio of the coefficient of variation in the post-COVID-19 data compared to the pre-COVID-19 data (explained in more detail later in this section).

The Wilcoxon signed rank test, on the other hand, examines two key variables, employment and working capital, following the production function of a typical firm to determine whether there are statistically significant differences between the pre- and post-pandemic periods. Several steps were taken to prepare the dataset for statistical analysis, as shown in Figure 1 below.

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Data collection and processing	Data interpretation	Data trimming	Data analysis
1. Use of Orbis database 2. Country-based data segmentation	1. Figure analysis 2. Normality test 3. Examination of the missing values and outliers	1. Replacing missing values 2. Replacing outlier values	1. Application of MCA 2. Application of Wilcoxon signed-rank test

Figure 1 The stages of the data collection and analysis of the current research
Source: self-research

We used the Orbis database (Bureau van Dijk, 2024) to collect microdata for a number of EU countries, focusing on Spain, Italy, France, Poland and Romania for the reasons already mentioned. Orbis is gaining traction among scholars analyzing private firms from various perspectives, including employment, capital, sales, and profitability (see Farole et al., 2017; Poupakis, 2020; Dall'Olio et al., 2022; Chiari, 2022; Lythgoe et al., 2023). The selected time frame was from 2014 to 2022. Originally, the total sample comprised 535 firms operating in non-specialized retail stores and selling mainly non-food products before the data was further segmented in this study. After deleting the firms with missing values, 340 firms remained, including 65 Spanish micro firms, 31 Spanish small firms, 86 Italian micro firms, 58 Italian small firms, 33 French small firms, 22 Polish micro firms, 47 Polish small firms, 18 Romanian micro firms and 48 Romanian small firms.

We focused specifically on firms involved in agricultural and chemical production, as these businesses face particular challenges due to possible closures, the shift in consumer behavior to online channels and disrupted supply chains compared to grocery stores or key service providers. The sample size of 340 companies provides sufficient statistical power to detect significant impacts given the heterogeneity within the non-specialized retail sector.

Figure 2 illustrates the conceptual framework in which the periodic differentiation (i.e., performance before and after the pandemic) in the non-specialized retail sector was made based on the selected EU countries and firm types (i.e., micro and small).
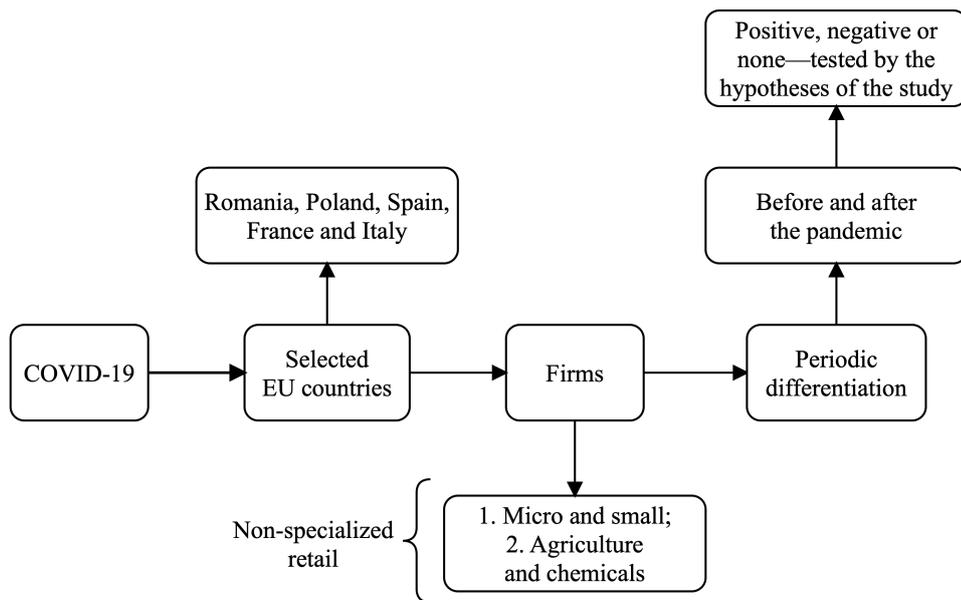
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Figure 2 Conceptual framework of the present study
Source: self-research

For both the MCA and the Wilcoxon signed rank test, it is important to handle outlier values prior to analysis to avoid biased estimates, skewed data structures and incorrect conclusions. Hair et al. (2018) emphasize the importance of handling outliers to ensure the robustness of statistical analyses, especially for multivariate techniques such as MCA. Jolliffe and Cadima (2016) emphasize the need to identify and handle outliers to improve the reliability of dimensionality reduction methods, while Conover (1999) highlights the risk of false conclusions due to outliers in non-parametric tests such as the Wilcoxon signed rank test. Table 1 therefore shows the broad distribution of outlier values based on five variables of interest, including periodic segregation (i.e., pre-COVID-19 and post-COVID-19).

Table 1 Distribution of the number of outlier values

	Employment		Working capital		Amortization		Sales		Return on capital	
	M	*S*	*M*	*S*	*M*	*S*	*M*	*S*	*M*	*S*
Spain										
Pre-Covid-19	0	1	4	2	4	6	10	1	7	1
Post-Covid-19	0	2	7	3	8	3	12	1	6	1

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Poland										
Pre-Covid-19	0	0	0	1	1	5	3	4	3	4
Post-Covid-19	0	0	1	2	2	3	2	5	1	3
Italy										
Pre-Covid-19	0	0	3	9	3	4	0	4	6	3
Post-Covid-19	0	1	1	5	5	3	0	4	8	5
Romania										
Pre-Covid-19	0	0	—	—	1	2	1	5	0	5
Post-Covid-19	0	3	—	—	1	5	2	1	0	3
France										
Pre-Covid-19	—	1	—	4	—	4	—	2	—	0
Post-Covid-19	—	1	—	0	—	6	—	2	—	2

Source: self-research

Notes: M indicates "micro enterprises" and S indicates "small enterprises"

The employment variable contained few outliers, but in the post-COVID-19 period there were some outliers in Spain and Romania, mainly affecting small firms. There were 11 outlier values for Spanish micro firms, while there were a total of 14 outlier values for small firms in Italy. For amortization values, the distribution of outlier values between micro and small firms was more or less even, with no significant difference between pre- and post-COVID-19 values. However, the sales variable showed a strikingly high number of outliers. For example, there were a total of 24 outliers among Spanish micro and small firms and 14 outliers among Polish micro and small firms, which could distort the statistical results. This was also the case for the ROC outliers, which led us to adjust these variables for inflation as they were expressed in monetary terms. Therefore, we used the OECD Domestic Producer Price Indices database with the base year 2015 for each individual country. In addition, all remaining outlier values as well as employment were replaced by the mean of the data series, a method according to Kaiser (2014), which proves to be a useful and easily accessible method for dealing with outliers.

The Shapiro-Wilk test in Table 2 supports our decision to use non-parametric methods. The results show that most of the data at the firm level have a non-normal distribution. Applying parametric methods would lead to biased results if no normalization is applied.

Table 2 Shapiro-Wilk test of normality

	Employment		Working capital		Amortization		Sales		Return on capital	
	1	*2*	*1*	*2*	*1*	*2*	*1*	*2*	*1*	*2*
Spain										
Micro	0.94***	0.95***	0.97	0.96	0.92***	0.93***	0.92***	0.95**	0.97	0.97
Small	0.94*	0.94	0.95	0.91**	0.69***	0.68***	0.70***	0.70***	0.68***	0.68***
Poland										
Micro	0.97	0.95	0.89**	0.91*	0.72***	0.79***	0.96	0.95	0.91*	0.93
Small	0.88***	0.87***	0.90***	0.89**	0.94**	0.91**	0.84**	0.91***	0.98	0.97
Italy										
Micro	0.95***	0.96**	0.96**	0.97*	0.91**	0.91**	0.92**	0.96**	0.92**	0.96**
Small	0.90***	0.95**	0.97	0.97	0.91**	0.88**	0.93**	0.90***	0.99	0.98
Romania										
Micro	0.97	0.84***	—	—	0.92	0.96	0.94*	0.91	0.93	0.97
Small	0.93**	0.95*	—	—	0.94**	0.94**	0.95*	0.91***	0.98*	0.98
France										
Small	0.91**	0.87***	0.98	0.90*	0.97	0.96	0.86**	0.88***	0.97	0.94*

Source: self-research

Notes: 1 indicates "pre-COVID-19" and 2 indicates "post-COVID-19" period

Since our dataset did not meet the main assumptions of the paired t-test summarized by Kim (2015), we followed the recommendations of King and Eckersley (2019) to choose the appropriate statistical test. In other words, since our data set had exhaustive non-normal distributions and was paired, we opted for the two-sample Wilcoxon signed rank test (hereafter simply Wilcoxon signed rank test). Based on Field's (2013) arguments about the Wilcoxon signed rank test, we can argue that this method was the most appropriate for our consideration as it focuses on ranks rather than raw values of the dataset. Moreover, it is also suitable for small sample sizes.

It should be noted that in the Wilcoxon Singed Rank Test, "Negative ranks" means that the values for a variable i after the COVID-19 test are lower than the values before the COVID-19 test; "Positive ranks" means that the values for a variable i after the COVID-19 test are higher than the values before the COVID-19 test; and "Tie" means that the values for variable i after the COVID-19 test are identical to the values before the COVID-19 test. Z-scores are given for the test statistics, and all significance values are based on asymptotic 2-tailed values. The other technical

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details can be found in the Results section in the corresponding tables for the indicated Wilcoxon Signed Rank Tests. Additional technical and methodological details are described below.

We applied MCA according to the approach described by Sączewska-Piotrowska (2021), which is primarily based on Clausen (1998). This approach involves creating a frequency-based correspondence table, calculating the row and column mass, determining the row and column profiles and using the chi-square metric for estimation. The chi-square method calculates the total variance or "inertia" as the weighted sum of the squared chi-square distances between the individual row profiles and the average row profile.

To estimate inertia and determine the optimal distance measures, we followed Abdi (2007) and chose the chi-square method because our data set was free of outliers, and this approach provided more interpretable graphical results. The graphical representation of the MCA results on a multidimensional map, the so-called biplot, usually shows two or sometimes three dimensions and depicts all relevant variables. To maintain consistency with MCA best practices, we removed row and column averages as a standardization method and used symmetric normalization according to Lombardo et al. (2021), Greenacre (2007) and Le Roux and Rouanet (2010). Symmetric normalization ensures that the analysis does not unduly favor categories with higher frequencies, thereby avoiding bias in the results and providing a clearer insight into the underlying patterns in the data. By applying both the standardization and normalization methods, marginal distributions were effectively removed, facilitating a more precise comparison of correlations between categories and providing a more comprehensive understanding of the results.

The correspondence table is based on the ratio of the coefficients of variation (CV) of the periods before and after COVID-19 and follows the following simple formula:

$$Distress\ level = \frac{CV_{post\_COVID-}}{CV_{pre\_COVID}} = \frac{\frac{\sigma_{post-COVID}}{\mu_{post-COVID}}}{\frac{\sigma_{pre-COVID}}{\mu_{pre-COVID}}} \tag{1}$$

where: σ is the standard deviation and μ is the mean value of the data vector. The distress level indicates the extent to which COVID-19 has disrupted the employment and working capital of micro and small businesses, as shown by the proximity to the attribute on the MCA biplot. This disruption reflects the impact on production efficiency and overall business performance during public crises such as COVID-19. This concept makes it possible to focus on firm-level performance and distinguish between the periods before and after COVID-19.

On the MCA biplot, the closer the variable (e.g., either micro or small firms of a given country) is to the attribute, the more diverse it is, which means that COVID-19 has disrupted the respective indicator. The period before COVID-19 (pre_COVID) covers the years 2015–2019, the period after COVID-19 (post_COVID) the years 2020–2022.

Our definition of micro and small firms is in line with the European Commission's classification (European Commission, 2020). More precisely, micro firms have less than 10 employees, while small firms have between 10 and 50 employees. In the Wilcoxon signed rank test, we focused exclusively on employment and working capital, as these ratios are the cornerstones of a firm's production function (Varian, 1992). Given their direct influence on a firm's ability to convert resources into outputs, these are key variables for assessing a firm's production efficiency and overall performance, especially in the context of public crises such as COVID-19. Additionally, we calculated the effect size to obtain a standardized measure for comparing the observed differences (Gerald, 2018; Pallant, 2020) using the following formula:

$$r = \frac{Z}{\sqrt{N}} \qquad (2)$$

where: Z was determined directly from the paired Wilcoxon signed rank tests and N represents the total number of observations.

4. Results

First, this section presents the results of the MCA analysis (e.g., biplot and the summary table). Second, this section reports the results of the Wilcoxon signed rank test based on micro and small firms in the five selected EU Member States. Finally, the effect sizes are given to allow a more integrated and comparable statistical interpretation of the test results.

4.1. Multiple Correspondence Analysis

In the MCA analysis, each attribute (e.g., sales, employment) serves as a reference point for measuring the extent of distress. The closer a classification (e.g., Spanish micro firms, Italian small firms) is to a particular attribute, the higher the degree of distress associated with that attribute for the country-specific firms.

Figure 3 is the biplot for the MCA. In terms of sales, Polish micro firms and Romanian small firms showed the highest levels of distress compared to the rest of the sample. Romanian micro firms showed high levels of distress in terms of employment, a pattern that was also observed for French small firms. Most companies in the sample had high ROC distress, with particularly high scores for Spanish micro and small firms and Italian micro firms. Polish small companies also

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had higher ROC distress values.

The situation with working capital is similar to that in the ROC. Spanish and Polish small firms, like French small firms, had a high level of working capital distress. Finally, Italian, Spanish and Polish small companies had the greatest distress levels with amortization compared to companies from other countries.
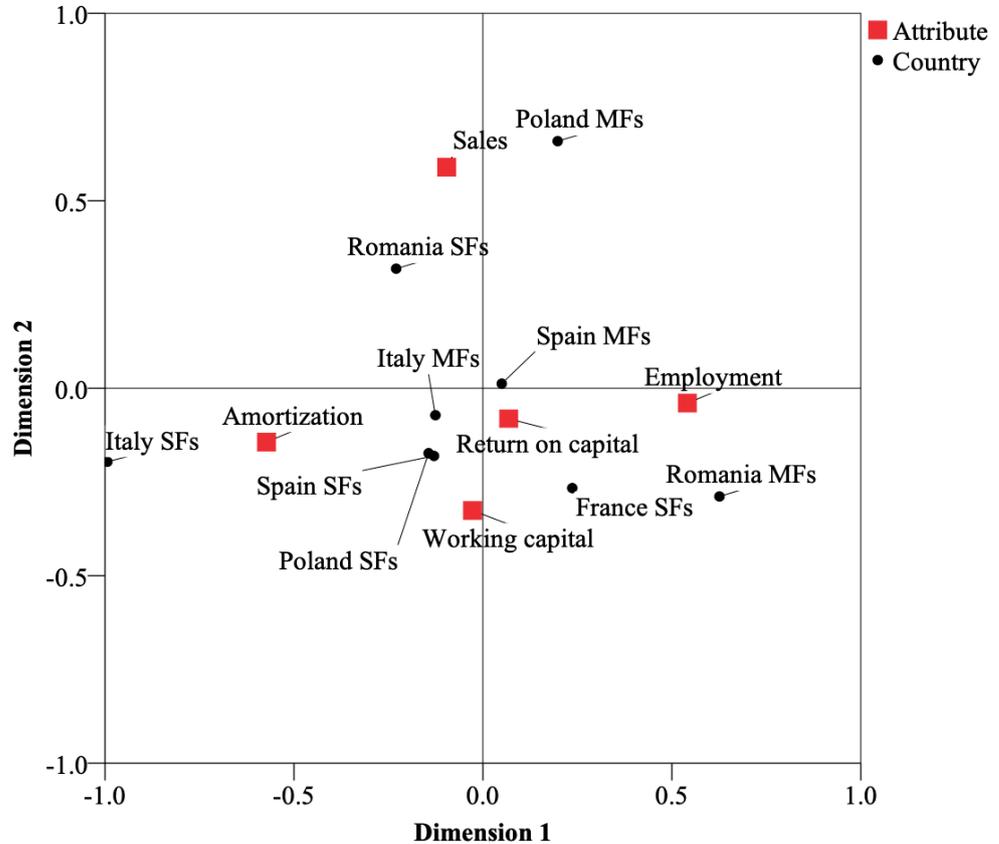
Figure 3 Multiple Correspondence Analysis
Source: self-research

The next step of the MCA involves reporting the summary statistics, as shown in Table 3. The two dimensions obtained cumulatively explained 88% of the dataset. Despite this high cumulative explanation, the singular values and the inertia indicate a low correlation between rows and columns, and the chi-square value of 1.345 is not statistically significant. Therefore, this result indicates that further investigation of the countries and their companies is required, which can be conducted using the

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Wilcoxon Signed Rank Test.

Table 3 Summary table of the multiple correspondence analysis

Dimension	Singular Value	Inertia	Chi Square	Sig.	Proportion of Inertia		Confidence Singular Value	
					Accounted for	Cumulative	Standard Deviation	Corr.
1	0.128	0.016			0.555	0.555	0.146	0.007
2	0.098	0.010			0.324	0.879	0.153	
3	0.053	0.003			0.095	0.974		
4	0.028	0.001			0.026	1.000		
Total		0.030	1.345	1.000[a]	1.000	1.000		

Source: self-research
Notes: Degrees of freedom were 32

4.2. Wilcoxon signed rank tests
4.2.1. Spain

In the results of the Wilcoxon signed rank test for the employment data, we can see that the Spanish micro and small firms show a statistically significant difference between the pre- and post-COVID-19 samples (see Table 5; micro firms: $Z=-4.240$; Sig.=0.000; small firms: $Z=-2.205$; Sig.=0.027). However, there is no statistically significant difference between Spanish micro firms ($Z=-0.363$; Sig.=0.717) and small firms ($Z=-0.235$; Sig.=0.814) when it comes to working capital. In other words, the pandemic did not have a statistically significant effect on the performance of companies in terms of working capital.

Table 4 The Wilcoxon signed rank test for the impact of the COVID-19 pandemic on employment and working capital of Spanish micro and small firms

Employment	Micro firms					Small firms				
	N	Mean rank	Sum of ranks	Test statistics		N	Mean rank	Sum of ranks	Test statistics	
				Z	Sig.				Z	Sig.
Negative Ranks	15	20.53	308.00	−4.240	0.000	9	15.06	135.50	−2.205	0.027
Positive Ranks	43	32.63	1403.00			22	16.39	360.50		
Ties	7					0				
Total	65					31				

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Working capital	Micro firms					Small firms				
Negative Ranks	36	31.33	1128.00	–0.363	0.717	14	16.86	236.00	–0.235	0.814
Positive Ranks	29	35.07	1017.00			17	15.29	160.00		
Ties	0					0				
Total	65					31				

Source: self-research

4.2.2. Italy

For all Italian micro and small firms, a statistically significant difference was found between the pre-and post-COVID-19 period in both employment and working capital (see Table 5). The statistical significance was slightly lower in the case of the working capital of Italian small firms (Z=–2.381; Sig.=0.017).

Table 5 The Wilcoxon signed rank test for the impact of the COVID-19 pandemic on employment and working capital of Italian micro and small firms

	Micro firms					Small firms				
	N	Mean rank	Sum of ranks	Test statistics		N	Mean rank	Sum of ranks	Test statistics	
Employment				Z	Sig.				Z	Sig.
Negative Ranks	30	31.0	930.0	–3.693	0.000	19	22.6	429.0	–3.158	0.002
Positive Ranks	53	48.2	2,556.0			38	32.2	1224.0		
Ties	3					1				
Total	86					58				
Working capital	Micro firms					Small firms				
Negative Ranks	30	35.1	1,053.0	–3.520	0.000	24	22.8	548.0	–2.381	0.017
Positive Ranks	56	48.0	2,688.0			34	34.2	1163.0		
Ties	0					0				
Total	86					58				

Source: self-research

4.2.3. France

Table 6 shows the results of the Wilcoxon signed rank test of the small French firms. In terms of employment, there was no statistically significant difference between the pre-and post-COVID period (Z=–0.895; Sig.=0.371). However, there was a

statistically significant difference in terms of working capital (Z=–2.671; Sig.=0.008).

Table 6 The Wilcoxon signed rank test for the impact of the COVID-19 pandemic on employment and working capital of French micro and small firms

| | Employment | | | | | Working capital | | | | |
| | N | Mean rank | Sum of ranks | Test statistics | | N | Mean rank | Sum of ranks | Test statistics | |
				Z	Sig.				Z	Sig.
Negative Ranks	15	15.4	230.5	– 0.895	0.371	11	11.9	131.0	– 2.671	0.008
Positive Ranks	18	18.4	330.5			22	19.6	430.0		
Ties	0					0				
Total	33					33				

Source: self-research

4.2.4. Poland

The Polish micro firms showed no statistically significant difference in their employment dynamics (Z=–1.687; Sig.=0.092), but the same was not true for the small firms (Z=–2.774; Sig.=0.006; see Table 7). The Polish micro firms showed a statistically significant difference in the dynamics of their working capital before and after the pandemic (Z=–2.354; Sig.=0.019), but the same was not true for the small firms (Z=–1.905; Sig.=0.057).

Table 7 The Wilcoxon signed rank test for the impact of the COVID-19 pandemic on employment and working capital of Polish micro and small firms

| | Micro firms | | | | | Small firms | | | | |
| | N | Mean rank | Sum of ranks | Test statistics | | N | Mean rank | Sum of ranks | Test statistics | |
Employment				Z	Sig.				Z	Sig.
Negative Ranks	9	7.4	67.0	– 1.687	0.092	15	20.1	302.0	–2.774	0.006
Positive Ranks	12	13.7	164.0			32	25.8	826.0		
Ties	1					0				
Total	22					47				
Working capital	Micro firms					Small firms				
Negative Ranks	5	10.8	54.0	– 2.354	0.019	17	22.6	384.0	–1.905	0.057
Positive Ranks	17	11.7	199.0			30	24.8	744.0		
Ties	0					0				

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Total	22					47				

Source: self-research

4.2.5. Romania

The last report on the results of the Wilcoxon signed rank test refers to the Romanian micro and small firms in terms of employment (see Table 8). In both cases, there was a statistically significant difference between the pre- and post-COVID-19 periods.

Table 8 The Wilcoxon signed rank test on the impact of the COVID-19 pandemic on employment in Romanian micro and small firms

	Micro firms					Small firms				
	N	Mean rank	Sum of ranks	Test statistics		N	Mean rank	Sum of ranks	Test statistics	
				Z	Sig.				Z	Sig.
Negative Ranks	4	4.4	17.5	− 3.119	0.002	13	22.5	293.0	− 3.026	0.002
Positive Ranks	15	11.5	172.5			35	25.2	883.0		
Ties	0					0				
Total	19					48				

Source: self-research

Table 9 summarizes the results of the Wilcoxon signed rank test. Put simply, only French small firms and Polish micro were an exception to the statistically significant differences in employment between the pre-and post-COVID-19 periods. There were statistically significant differences in working capital for Italian micro and small firms, French small firms and Polish micro firms.

Table 9 Summary of the Wilcoxon signed rank test on company sizes and selected countries in the European Union

	SP MFs	SP SFs	ITA MFs	ITA SFs	FRA SFs	POL MFs	POL SFs	ROM MFs	ROM SFs
Employment	+	+	+	+	−	−	+	+	+
Working capital	−	−	+	+	+	+	−	N/A	N/A

Source: self-research

Notes: + indicates the "presence of a statistically significant difference between the pre-COVID-19 period and the post-COVID-19 periods"; – indicates the "absence of a statistically significant difference between the pre-COVID-19 period and the post-COVID-19 periods"

4.3. Effect sizes

Finally, the effect sizes were estimated, as shown in Figure 4. The lowest effect size for employment was found for French small firms, while the highest effect size was found for Romanian micro firms. All other classifications of firms had similar—medium effect sizes. The lowest effect size for working capital was found for Spanish micro and small firms. The highest effect size was found for Polish micro firms.
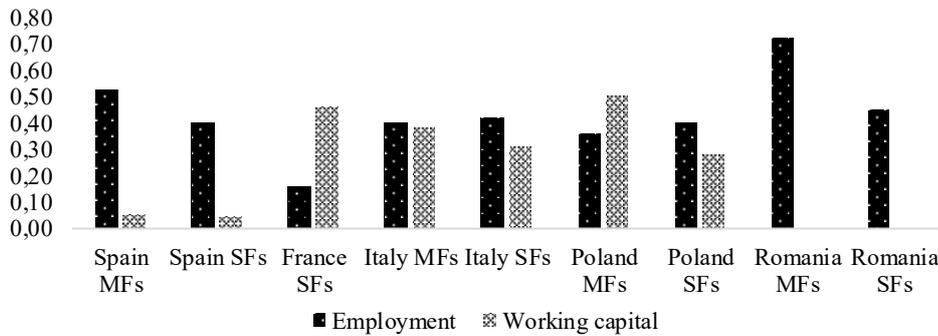
Figure 4 Effect sizes by employment and working capital in micro and small firms
Source: authors' own construction based on the analysis

5. Discussion

This paper aimed to comparatively assess the impact of the COVID-19 pandemic on the performance of firms in the selected EU countries in the case study of two economic sectors, namely agricultural and chemical retailers. Using microdata from the Orbis database, we analyzed micro and small companies in Spain, Italy, France, Poland and Romania in terms of employment, working capital, ROC, amortization and sales. The selection of these countries and variables was crucial for our understanding and empirical analysis, as it allowed us to identify both statistically significant and non-significant results. Focusing on these firms is particularly important because they play a crucial role in the wider supply chain, especially in the context of the EU's agricultural and industrial sectors. By analyzing firm-level performance in these industries, our study contributes to a deeper understanding of how sector- and country-specific factors influence economic resilience in times of crisis such as the COVID-19 pandemic. This focus fills a notable gap in the literature, where aggregate data often obscures the nuanced impact on non-specialized firms, and thus provides more actionable insights for policymakers and industry stakeholders. In short, the results suggest that the impact of the pandemic was

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heterogeneous and influenced by the different institutional and economic systems of the selected countries, which can be estimated using non-parametric methods.

To elaborate on the results, Figure 5 shows the average values for employment and working capital before and after COVID for the selected countries in the sample. Since the Wilcoxon signed rank test does not give an indication of the direction of the observed differences, these visual representations and the subsequent interpretations are key to understanding the implications of our results.
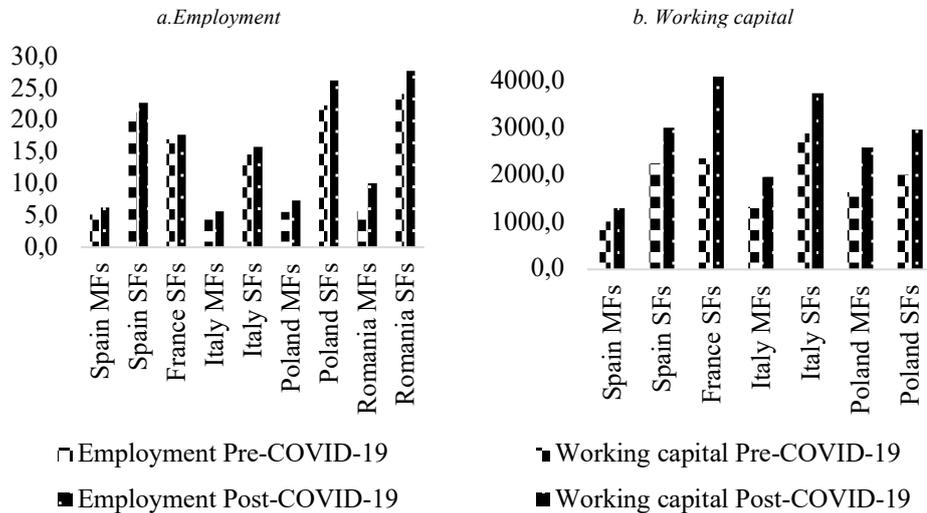
Figure 5 Average values for employment and working capital before and after the introduction of COVID-19 in the selected countries of the European Union
Source: Orbis

An interesting finding of our study is the statistically significant difference in the employment of micro and small firms in Spain when comparing pre-and post-COVID-19 data, while the level of working capital shows no significant changes. Although this may suggest that despite the challenges posed by the pandemic, workforce retention was prioritized, some studies suggest that many workers in Spanish micro and small companies were not adequately protected (Salas-Nicas et al., 2020).

Possible explanations for this discrepancy could be government support programs that mitigated job losses (Winters, 2023), the difficulty of replacing skilled workers, or a delayed response to the crisis, with firms initially focusing on survival. Furthermore, Chislett (2021) argued that the unprecedented support money from the

EU played an important role in Spain's rapid recovery, contributing to productivity gains and increases in output. This could explain why both employment and working capital showed an upward trend in the post-COVID-19 period, even though the latter did not reach statistical significance in the Wilcoxon signed rank test.

The statistically significant increase in employment and working capital of Italian micro and small firms in the post-COVID period could indicate a complex adjustment strategy within the economy to cope with the crisis. On the one hand, agricultural and chemical retailers may have experienced a surge in demand or adapted their business models, increasing the need for additional staff. This could also explain the need for more working capital, possibly to manage inventories or to make higher investments for business adjustments.

Alternatively, government support programs could have provided a financial safety net that would have allowed firms to retain their workforce while maintaining a higher level of working capital as a precaution against the ongoing uncertainty. Some Italian micro and small firms, such as those in the wine industry, have shown that during COVID-19, companies have tried to "reinvent" themselves (Bressan et al., 2021). This reinvention requires both human resources and capital to improve performance at the company level.

French firms, particularly in agriculture, the chemical industry and non-specialized retail, may have avoided significant layoffs during COVID-19 due to a combination of factors. France has strong labor laws, and unions play an important role in protecting workers (Laroche and Wechtler, 2011), which may explain the lack of statistically significant differences in employment between the pre-and post-COVID-19 periods. Askenazy et al. (2024) point out that many French firms have used a variety of strategies to retain their workforce during the pandemic.

State support programs such as wage subsidies and strict labor laws probably helped to retain workers. The essential nature of these sectors and the specialized skills required of their employees may have prevented further layoffs. In addition, the social and cultural emphasis on job security in France may have influenced the decision of these companies to retain their employees during the pandemic.

While government support and labor regulations may have helped French firms retain their employees, as indicated by the lack of a statistically significant difference in the Wilcoxon signed rank test, these factors likely had a weaker impact on working capital. Wage subsidies and furlough schemes generally target employee-related costs but have no direct impact on the liquid resources a company needs for day-to-day operations (working capital). Stricter labor laws could make layoffs more difficult, but would not directly impact a company's ability to access or manage working capital. As a result, French firms may have struggled to maintain adequate working capital during the COVID-19 pandemic despite retaining their workforce. In fact, Brussevich et al. (2022) found that medium-sized French firms with higher

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inventories and greater automation were more resistant to crises. Interestingly, government measures such as trade bans and advertising campaigns had little overall impact on the trade flows of French firms (Brussevich et al., 2022). This suggests that while employment-focused government support can help maintain employment, it may not directly address the broader financial challenges faced by firms during economic disruptions.

Another aspect of the results concerns the contrasting results in terms of changes in employment and working capital in Polish micro and small firms before and after COVID-19. Although speculative, several reasons could explain these differences. In the case of micro firms, they might have limited capacity to expand their workforce despite increased demand (Adamowicz, 2022). Therefore, they may have chosen to manage the workload with existing staff or outsource certain tasks. The statistically significant change in working capital suggests that the micro firms have pursued a deliberate strategy. They may have increased their inventories or receivables to cope with possible supply chain disruptions or fluctuations in customer payments (Zimon et al., 2021). Strong government support programs in Poland may have been specifically aimed at preserving jobs in micro firms and helped to prevent layoffs despite the general economic challenges (Sobanski, 2021). Polish small firms may have adapted their business models in response to the post-COVID-19 landscape, resulting in changing employment needs. They may have filled new positions or cut jobs in response to changing market dynamics. It is possible that their working capital management was already efficient before the COVID-19 crisis, so they did not need to make major adjustments even if employment figures fluctuated. In addition, the impact of the pandemic on working capital may be more gradual for small firms, suggesting that the effects unfold over a longer period of time.

There is a statistically significant difference in employment between the analyzed periods for both micro and small Romanian companies. The COVID-19 pandemic has led to significant shifts in employment in these firms. This result may be surprising, but it can be explained if we take into account the particular challenges and adjustments that these companies have faced (Antonescu, 2020). On the one hand, the pandemic may have forced some firms to downsize due to closures or economic downturns. On the other hand, the crisis may have encouraged innovation and entrepreneurial change, creating new opportunities and an increased need for additional staff.

Firms that have moved their operations online or adapted their product offerings to meet changing consumer demand may have experienced an increase in business volume that required more employees. In addition, government support programs or small business lending opportunities during the pandemic may have provided the

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necessary resources to expand and hire additional employees (Dascalu, 2020). These different responses illustrate the multi-layered impact of the pandemic on employment in Romanian micro and small firms.

In summary, we were able to quantify the impact of COVID-19 on firms operating in the agricultural and chemical sector in Europe using non-parametric methods. A non-parametric approach becomes necessary when the data set is not normally distributed. This aspect is sometimes ignored in the studies on the impact of the COVID-19 pandemic at the firm level. In addition, the different impacts of the pandemic on firms in different parts of Europe can be attributed to different factors (e.g. government support, business models, geographical proximity to major markets). Overall, the pandemic may have different impacts on employment and capital depending on the size of firms.

6. Concluding remarks

Numerous studies have attempted to compare the time before and post-COVID-19 periods in various EU countries. However, non-specialized retail companies in the agricultural and chemical industries have not been thoroughly analyzed using non-parametric econometric methods. Consequently, many studies focus on aggregate data and neglect the country-specific nuances. Our aim was to fill this gap by analyzing firm-level performance in five EU countries with different institutional and economic conditions. By focusing on individual company-level data, our study aims to provide a more detailed and accurate understanding of how different countries have adapted to the challenges posed by the pandemic.

The MCA analysis revealed considerable differences in their distress between various firm sizes and countries. While in countries such as Poland and Romania employment and sales were affected, in other countries such as Spain and Italy there were problems with ROC and working capital. These results suggest that country-specific factors play an important role in the distress of companies, which warrants further investigation. To better understand these dynamics, we examined the statistical significance of differences in key variables using the Wilcoxon signed rank test, focusing on the impact of the pandemic on firm performance.

The Wilcoxon signed rank test confirmed that the pandemic has had a significant impact on employment in most firms, both micro and small, in Spain, Italy and Romania. However, the impact on working capital varied by country and firm size. Only firms in Italy, small firms in France and micro firms in Poland exhibited statistically significant changes in working capital. These results highlight the uneven impact of COVID-19 across countries and firm sizes, with some firms experiencing distress in employment and others experiencing a deterioration in working capital.

The results of this study on non-specialized agricultural and chemical retail firms in

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Niftiyev, I., David, D., Pordea, D., (2025)
Non-Parametric Analysis of Retailer Performance in Selected EU Countries: Assessing the Impact of COVID-19

five different EU countries provide valuable insights for managers and policymakers. The research methodology, which goes beyond aggregate data and employs non-parametric tests such as MCA and Wilcoxon signed rank test, provides a more detailed understanding of firm-level variations in distress. The results show that the impact of the pandemic has varied significantly by firm size and country.

Managers in the most affected sectors and countries should prioritize measures to preserve jobs and manage working capital effectively. Policymakers, on the other hand, have a crucial role to play by developing targeted financial instruments and easing regulations to address the specific challenges faced by firms in different sectors and countries. By acknowledging the heterogeneous impact of the pandemic and introducing tailored support mechanisms, both managers and policymakers can help foster the recovery and resilience of these non-specialized firms in the post-COVID era.

It is also important to address some limitations and make suggestions for future research. First, our MCA analysis did not yield statistically significant results, and the graphical interpretations were sometimes difficult. Second, MCA generally assumes homoscedasticity, which is often not present in firm-level data, which affects the robustness of the analysis. Third, while the Wilcoxon signed-rank test is a powerful tool for analyzing pre- and post-data, its focus on direction of change rather than magnitude can complicate interpretation. For these reasons, future studies could use a different modeling approach, such as a panel data analysis compiled by Orbis, to identify more robust empirical patterns in the near future. By using panel data, researchers can gain a deeper understanding of trends and fluctuations over multiple time periods and improve the reliability of their results. In addition, more advanced statistical techniques could be used to address potential limitations and gain a clearer perspective on the impact of COVID-19 on firm-level performance in different sectors and countries.

Taking into account all the strengths and limitations of the present work, this study represents a methodological exercise using non-parametric methods. Relevant policies at the supranational level (i.e., EU) and at the micro level (i.e., municipal or company level) should always be considered using scenario approaches and simulations for future similar developments. Furthermore, integrating these non-parametric insights into decision-making processes can provide a more flexible and robust framework for dealing with uncertainties in implementation. By continuously refining these methods and incorporating real-time data, policymakers can better anticipate and respond to dynamic challenges at different levels of government.

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Author Contributions

Ibrahim Niftiyev conceived the study and was responsible for the design and development of the data analysis. Delia David was responsible for data collection and analysis. Daniela Pordea was responsible for the literature review section.

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