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Did the Legal Form Matter for the Level of Bankruptcy Risk of Agricultural Enterprises During the COVID-19 Pandemic?

Keywords: agriculture; agricultural enterprises; bankruptcy; Z-score; COVID-19

JEL: G32; O13, O16; Q12

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Abstract

Theoretical background: Conducting an agricultural activity during the COVID-19 pandemic became difficult due to restrictions on movement, the requirement to maintain a social distance in interpersonal contacts, restrictions on direct sales of agricultural products at the farmer markets, and, above all, due to the inability to recruit foreign seasonal workers to work with the harvest. On the other hand, despite difficult external conditions, in the years of 2020–2021 the Polish agriculture significantly increased the value of the gross output and sales of its products on domestic and foreign markets.

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Purpose of the article: This study aims to examine the strength and direction of the impact of the COVID-19 pandemic on the risk of bankruptcy of agricultural enterprises in Poland, as well as to check whether the legal form of the enterprise has a significant impact on this relationship.
Research methods: The study was conducted based on financial data from the EMIS database on a sample of four thousand agricultural enterprises operating in Poland in 2014–2021. The Z-score for non-financial enterprises from EM countries was used to measure the level of enterprise bankruptcy risk. To assess the impact of the COVID-19 pandemic on the value of enterprises' Z-score, panel estimations with fixed effects, taking into account macroeconomic and enterprise-specific variables, were used.
Main findings: The research showed that for the entire group of agricultural enterprises, public support for the SME and agricultural sectors, increased exports and household spending on agri-food products during the COVID-19 pandemic had a positive impact on their resistance to the risk of bankruptcy. A positive impact was found in all groups of enterprises, being statistically significant in the case of limited liability companies and insignificant in the case of cooperatives, joint-stock companies and other legal forms. Moreover, the higher inflation rate of agricultural products and specific characteristics/parameters of enterprises, i.e. improved profitability of operations, an increase in assets and the share of equity in the financing structure, as well as an increase in the use of short-term financing, had a positive impact on reducing the risk of bankruptcy. The research conclusions can be used to optimally prepare agricultural enterprises to withstand possible future external shocks. This article contributes to the literature in the following areas: the impact of the COVID-19 pandemic on the level of bankruptcy risk of Polish agricultural enterprises, as well as the impact of the legal form of an agricultural enterprise on its resistance to bankruptcy in the face of a crisis shock.

Introduction

The COVID-19 pandemic has become the cause of one of the greatest crises in the modern history of the global economy. Its effects and administrative restrictions slowed down the development of the financial and real sectors, including agriculture. International Monetary Fund's estimations show that in 2020 the pandemic reduced the value of global GDP by 3.2%, the most in developed economies by 4.6%, while in emerging market countries by 2.1% (IMF, 2021). According to some central banks, these negative processes resulted in a significant deterioration of creditworthiness and bankruptcy of borrowers, mainly small and medium-sized enterprises (Alves et al., 2020; ECB, 2020; NBP, 2021). The research by Kaya (2022) indicates that the risk of insolvency of the European SME sector increased on average by 21%, which was due to, among others, problems in finding customers, increased production and labour costs and deteriorated access to financing.

Conducting an agricultural activity became difficult due to restrictions on movement, the requirement to maintain a social distance in interpersonal contacts, restrictions on direct sales of agricultural products at the farmer markets, and, above all, due to the inability to recruit foreign seasonal workers to work with the harvest. The Food and Agriculture Organization of the United Nations assessed that as a result of administrative epidemic restrictions, there were severe shortages of workers, mainly in fruit and vegetable cultivation, which resulted in a reduction in plantings and harvests. For Canada, the US and Europe, there was a shortfall of approx. 1 million migrant workers from Eastern European and African countries (FAO, 2020). The development of the

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vaccine against COVID-19 and the government support for business entities partially limited negative effects of the pandemic but did not eliminate the extraordinary risk to which enterprises, mainly from the SME sector, were still exposed (ECB, 2021).

On the other hand, despite difficult external conditions, the Polish agriculture significantly increased the value of the gross output and sales of its products during the COVID-19 pandemic period. The demand for agricultural production was stimulated, among others, by an increase in production of the food processing industry (much stronger than the entire economy), as well as an increase in export sales (Kozak, 2023). Additionally, the pandemic reshaped the organization of the economy and increased the usage of remote work as well as online school and academic education forcing people to eat more meals at home instead of in restaurants. In consequence, the structure of the sales of food and agricultural products changed (Johansson et al., 2024). Moreover, during the pandemic in some countries, including in Tanzania, the impetus for the development of agriculture appeared to be the decline in income from tourism. To compensate for financial losses, some enterprises began to engage in plant cultivation, animal breeding and fishing (Chebby et al., 2024).

These problems raise questions about the strength and direction of the impact of the COVID-19 pandemic on the risk of bankruptcy of agricultural enterprises in Poland. Additionally, to obtain more practical knowledge about the level of resistance to extreme crisis conditions, it seems important to examine whether the level of risk of bankruptcy of an enterprise depends on its legal form. The study was conducted based on financial data from the EMIS database and covered nearly four thousand agricultural enterprises operating in Poland in 2014–2021. To measure the level of risk of enterprise's bankruptcy the Z-score index developed by Altman for non-financial enterprises from the emerging countries was used (Altman et al., 2017). This article contributes to the literature in the following areas: the impact of the COVID-19 pandemic on the level of bankruptcy risk of Polish agricultural enterprises, as well as the impact of the legal form of an agricultural enterprise on its resistance to bankruptcy in the face of a crisis shock.

Literature review

Most studies to date have focused on assessing the impact of the COVID-19 pandemic on the macroeconomic situation of regions, the enterprises' production volume, as well as the level of employment and the situation of micro-enterprises (Fernández, 2021). Among others, Fernández et al. (2021), examining the impact of COVID-19 on a group of 4,000 companies in Spain, noted that the factors worsening their financial situation were restrictions on the movement of people and difficulties in employing workers on temporary contracts. In turn, Blanco et al. (2020) examining 8,000 Spanish companies, stated that the administrative restrictions introduced during the COVID-19 pandemic significantly reduced the profitability and financial liquidity of enterprises,

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especially from the SME sector, thus increasing the risk of their bankruptcy. According to Juergensen et al. (2020), during the pandemic, the inability to use the scale effect reduced the SME sector's resilience to liquidity disruptions and the risk of bankruptcy. Although public aid programs improved the financial situation of enterprises and their employees, the losses incurred became a significant source of increased risk. In Poland, Boratyńska (2022), examining restructuring processes in 2018–2021, found that during the COVID-19 pandemic the number of company bankruptcies decreased, while the number of announcements of the commencement of company restructuring proceedings increased. The most affected by the need for restructuring were enterprises operating in the fields of wholesale and retail trade, industrial processing and construction.

The inequality in access to public aid was an additional factor increasing the risk of bankruptcy of the SMEs. OECD (2021) studies showed that in the member countries, micro and small enterprises were, on average, less protected by the public aid programs. The smallest entities, including start-ups, individual entrepreneurs, enterprises run by women and ethnic minorities, received less aid or one conditional on several additional requirements. A similar phenomenon was observed in agriculture. Mutegi et al. (2024), analysing the impact of the pandemic on medium-scale farms in Sub-Saharan Africa, found that restrictions related to the COVID-19 pandemic in the use of improved seeds, fertilizers and access to advisory services have hit the poorest farms the hardest, leading to even greater social stratification in these countries.

Studies on the impact of the COVID-19 pandemic on the situation in agriculture in most cases concerned changes in the volume of the gross agricultural production or its individual segments. Cortignani et al. (2020) examining the agricultural labour market in Italy in the first quarters of 2020 found that, regardless of the size and type of agricultural activity, the pandemic contributed to a significant decrease in the income of farms employing temporary workers. To reduce losses, some farms engaged in new types of crops, enabling greater use of the work of family members and permanent employees. Similarly, Kumar et al. (2020) found that disruption of agricultural supply chains and limitation of labour due to health restrictions have disturbed farm operations in India, regardless of their size. However, the greatest losses were suffered by labour intensive agricultural enterprises, including those specializing in dairy farming, floriculture, fruit production, fishing, and poultry farming.

In turn, Wang et al. (2020) found that the dairy industries in China and the United States were similarly harmed by the COVID-19 pandemic because of significant declines in milk prices, disruptions and difficulties in moving milk through supply chains, labour shortages, increased production costs, and lack of working capital. Additionally, milk processing was limited by widespread road closures in China, and in the United States by schools, restaurants, and hotels closures. Gu and Wang (2020), examining the impact of the COVID-19 pandemic on the performance of cooperatives specializing in vegetable production in Shanghai, found that the pandemic affected almost all stages of the vegetable supply chain. Additionally, it had a greater impact on the sales stage, contributing to a greater differentiation between their field price

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and market price. The pandemic has also highlighted the difference in sales prices between traditional and e-commerce channels, causing a significant decline in the income of small-holder farmers, leading to their increased poverty. Additionally, Du et al. (2020), examining family farms in China, found that the factors increasing the negative effects of the COVID-19 pandemic included, among others: closure of villages, farmers' limited knowledge about the transmission of the pandemic, as well as their age and education and the number of years of the farm's existence.

Priyadarshini and Abhilash (2021) draw attention to the particular importance of the problem of interrupting supply chains. Examining the situation of agricultural producers in India, they found that due to the blockage of numerous roads, producers of fresh and perishable products suffered the greatest losses, opposite to producers of shelf-stable products who did not see a significant impact of the pandemic. Kumar et al. (2021) found that the negative effects of the pandemic on Indian agriculture were mainly due to the lack of migrant labour, the decline in agricultural wages, and the closure of rural markets. The resulting decline in food supply often led to a drastic increase in food prices in cities, leading to a strong impoverishment of the poorest social groups.

Investigating the problems of vegetable farming caused by the pandemic, Ogada et al. (2021) indicate that the decline in production of this sector in Kenya resulted from limited access to means of production, labour, and food markets in cities. Blazy et al. (2021) found that administrative restrictions imposed during the pandemic made it difficult to conduct marketing through conventional channels and limited farms' access to means of production and the labour market. Therefore, farmers have adapted to greater self-sufficiency by reducing the area of cultivation and increasing its diversification. In some cases, the COVID-19 pandemic has become an opportunity for development for some enterprises in the agricultural sector. Nielsen et al. (2023) found that the pandemic had a positive impact on the aquaculture sector in Denmark and Spain. They point out that the pandemic has changed the sales structure, increasing the share of cheaper varieties at the expense of more exclusive ones, more often ordered by restaurants and hotels.

A limited group of articles presents the research results on the impact of COVID-19 on the level of resistance to bankruptcy of agricultural enterprises. Mirza et al. (2023) using the Altman model (Altman et al., 2017) to measure the risk of bankruptcy of SMEs in 15 EU countries found that in the case of the "A – Agriculture, Forestry and Fisheries" sector in the period of the years 2019–2020 the probability of bankruptcy increased from 6.7 to 9.4%. In turn, Hatab et al. (2020), examining 166 small and medium-sized agricultural enterprises in Egypt, noted that a significant share of export sales, modernization of equipment and maintaining a high level of financial liquidity of agricultural farms allowed to limit losses caused by the pandemic and reduce the risk of bankruptcy. The problem of proper risk management was also noticed by Shafi et al. (2020) when examining small and medium-sized agricultural enterprises in Pakistan. Their research showed that 83% of SMEs were not prepared to conduct business in the conditions of the pandemic crisis.

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In Slovakia, Vavrek et al. (2021) using the Altman Z-score model showed that during the pandemic agricultural cooperatives were characterized by significantly weakened resistance to the risk of bankruptcy. Similarly, Srebro et al. (2021), using the Altman Z-score model, found that during the COVID-19 pandemic, agricultural companies listed on the Belgrade Stock Exchange decreased their financial stability and became more exposed to the risk of bankruptcy.

Among the few studies on the impact of the COVID-19 pandemic on the risk of bankruptcy of enterprises in Poland, Nehrebecka (2021), examining the quality of loan portfolios of Polish banks and the risk of bankruptcy of enterprises from all sections of the economy, including agriculture, found that during the pandemic, the probability of insolvency among large and medium-sized enterprises increased 1.5 times, and in the case of small enterprises, it increased 3 times. In turn, Szczepaniak et al. (2020), examining the effects of the COVID-19 pandemic among food enterprises in the first months of its presence in Poland, found that state aid programs, as well as the growing domestic and foreign demand for the Polish food products and the continuing price competitiveness of Polish food exports reduce the probability of their bankruptcy. Similarly, Jędruchniewicz et al. (2024), examining the channels and mechanisms of the impact of the COVID-19 pandemic on agriculture in Poland, state that the launch of public aid programs aimed mainly at microenterprises, the SME sector and agriculture, the increase in the share of expenditure on agri-food products in household budgets and maintaining a high share of agri-food product exports allowed for an increase in sales of agricultural products during the COVID-19 pandemic.

In addition, it should be noted that, according to Statistics Poland data, in 2014–2021, approx. 14.5 million ha of agricultural land were used in Poland, including approx. 11 million ha of arable land. Gross agricultural output and the output per 1 ha of agricultural land had an upward trend, including the period of the COVID-19 pandemic (Table 1). The share of plant products in the gross production gradually increased, reaching 52.3% in 2021. In addition, the value of exports of plant-based and animal-based products increased from PLN 47.1 billion in 2014 to PLN 62.9 billion in 2019 and PLN 77.1 billion in 2021.

Table 1. Gross agricultural output and exports of food and agricultural products

Year	Gross agricultural output (PLN bn)	Gross output per 1 ha (PLN)	Plant products in gross output (%)	Exports of plant-based products (PLN bn)	Exports of animal-based products (PLN bn)
2014	105.3	7,236	51.0	18.0	29.1
2015	98.6	6,782	50.1	19.8	30.5
2016	103.4	7,107	50.7	19.2	32.8
2017	115.6	7,908	48.5	18.9	38.7
2018	112.6	7,679	46.9	19.0	40.7
2019	119.6	8,145	47.5	20.6	42.3
2020	126.6	8,467	51.1	25.7	42.4
2021	135.7	9,077	52.3	29.5	47.6

Source: (Statistics Poland, 2022).

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Based on the results of the literature research on the subject, the following research hypotheses were formulated:

Hypothesis 1: Public support for the SME and agricultural sectors, increased exports and household spending on agri-food products during the COVID-19 pandemic have a positive impact on the resistance of agricultural enterprises to the risk of bankruptcy.

Hypothesis 2: The level of resistance of agricultural enterprises to the risk of bankruptcy depends on their legal form.

Research methods

Research on the risk of bankruptcy began in the first half of the 20th century. Fitzpatrick (1932), Smith and Winakor (1935) and Merwin (1942) used simplified statistical methods to measure the financial situation, most often in the form of an indicator. Altman (1968) was one of the first to use a larger number of indicators to establish a single indicator of the risk of bankruptcy. To improve the effectiveness of the bankruptcy risk measuring, this model has been improved several times and adapted, among others, to various types of enterprises and groups of countries in which they operate (Altman, 1983; Altman et al., 2017).

The first model developed by Altman (1968) was:

$$Z = 1.2X_1 + 1.4X_2 + 3.3X_3 + 0.6X_4 + 0.999X_5 \quad (1)$$

where: X_1 – working capital / total assets, X_2 – retained earnings / total assets, X_3 – operating earnings / total assets, X_4 – market value of equity / book value of debt, X_5 – sales / total assets.

The value of the Z-score index allows to classify a company according to the probability of bankruptcy in the near future:

- $Z > 2.99$ – the company is located in a safe (green) zone;
- $1.81 < Z < 2.99$ – the company is located in the intermediate (grey) zone;
- $Z < 1.81$ – the company is in a danger zone and there is a high risk of bankruptcy in the next period.

To enable the assessment of the risk of unlisted companies in EM countries, Altman et al. (2017) proposed another four-component Z-score. In this model, a constant component of 3.25 was added and the Z-score value is determined according to the following formula:

$$Z = 3.25 + 6.56X_1 + 3.26X_2 + 6.72X_3 + 1.05X_4 \quad (2)$$

At the same time, the Z-score limits were changed to 3.75 and 5.85, respectively. Due to the fact that Poland belongs to the group of EM countries, similarly to An-

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tonowicz and Antonowicz (2022), the Z-score indicators applied to analysis of the impact of the COVID-19 pandemic on the resistance of agricultural enterprises to the risk of bankruptcy, were calculated in accordance with equation (2).

Knowing the Z-score values, the two-sided *t*-test was employed to identify meaningful distinctions between the average Z-score values before (2014–2019) and during (2020–2021) the COVID-19 pandemic. In the next stage, to observe the impact of the pandemic on enterprises' Z-score the panel estimations with fixed-effects were applied according to the model:

$$Z\text{-}score_{it} = \beta x_{it} + \theta macro_t + \gamma covid_t + f_i + \varepsilon_{it} \quad (3)$$

where: for the time *t* and firm *i*:x_{it} – firm-level explanatory variables: *assets* – natural logarithm of the real value of entity's assets adjusted by the GDP deflator, *leverage* – ratio of equity to assets, *roa* – return on assets, *eff_assets* – efficiency of assets measured as ratio of sales to assets, *short_liab* – the share of short-term liabilities in total liabilities; $macro_t$ – macroeconomic variables: *gdp* – the real GDP growth rate, *inflation* – the annual inflation rate of agricultural production; $covid_t$ = 1 in 2020 and 2021 and 0 in remaining years.

Results

The statistical tests of the panel models have revealed that the model does not fulfil conditions of homoscedasticity and lack of autocorrelation. To correct for this bias, the standard error estimates were applied, which are robust to some types of misspecifications. In the context of fixed effects estimation, they specifically allow for the within-group correlation (here, group means each firm), relaxing the usual requirement for independence of observations.

Prior to estimations, the outlier observations for Z-score values were identified using the rule of 1.5 times the interquartile range of the data. All observations below the first quartile decreased by 1.5 times interquartile range (Q1 – 1.5·IQR) and above the third quartile enlarged by 1.5 times interquartile range (Q3 + 1.5·IQR), were discarded.

The research sample includes agricultural enterprises operating in seven legal forms (Table 2) of which the most common was the limited liability company (LLC), followed by the cooperative. The panel models were estimated separately for the entire sample, limited liability companies, cooperatives, joint stock companies, and enterprises with remaining legal forms aggregated in the category of "Others".

Based on equation (2) Z-score values were calculated for each sample year and for each group of companies. Figure 1 shows the average values of the Z-score for enterprises depending on their legal form in individual years. Throughout the entire period, cooperatives performed the best with the highest Z-score values of approx. 14. The Z-score values of limited liability companies and joint stock companies, although noticeably different in the pre-pandemic period, have increased on average during

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the years of the COVID-19 pandemic and became similar in 2021. A one-off drop in the Z-score for joint-stock companies in 2016 resulted from the limited number of these enterprises in the sample, i.e. 3 compared to the average of 14 in other years. The values of Z-score of the group "Others" were not changed significantly before and after the outbreak of the COVID-19 pandemic.

Table 2. Number of observations by legal form

	Limited liability companies	Joint stock companies	Coopera-tives	Others			
				General partnerships	Limited partnerships	Limited joint-stock partnerships	Associa-tions
2014	1,083	12	274	11	4	7	2
2015	1,036	14	232	9	5	8	-
2016	306	3	71	5	6	-	-
2017	1,167	15	229	42	26	5	3
2018	1,762	18	331	54	37	12	4
2019	1,820	17	343	53	45	12	6
2020	1,834	20	350	53	49	10	5
2021	1,912	20	352	58	51	13	6
No. of ob-servations	10,920	119	2182	285	223	67	26

Source: Authors' own study based on EMIS data.

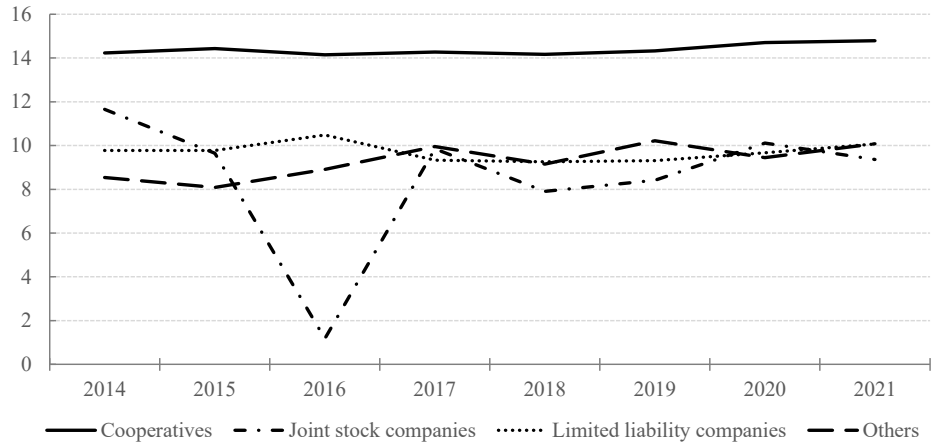


Figure 1. Average Z-score values by the company legal form

Source: Authors' own study based on the EMIS data.

Table 3 presents descriptive statistics for the main legal forms tested in the research. Joint-stock companies are the largest agricultural enterprises in terms of assets, but they are characterized by the lowest sales-to-assets ratio and the lowest profitability. By far the largest group of enterprises are limited liability companies.

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In terms of the size of assets, the ratio of sales to assets and their profitability, they are placed between joint-stock companies and cooperatives. Cooperatives are the smallest in terms of the asset size, but they are characterized by the highest profitability, the share of equity in the financing structure, and the share of short-term liabilities in total liabilities.

Table 3. Descriptive statistics

Limited liability companies						
	N	Mean	Median	*SD*	Min	Max
Z-score	10,920	9.62	8.62	6.71	-9.45	31.94
assets	11,150	13.88	5.72	43.52	-.28	1481.25
eff_assets	11,138	.92	.39	9.04	-.8	846
roa	11,150	2.13	2.84	131.24	-12447.05	1368.07
leverage	11,138	.47	.56	.44	-9	12.83
short_liab	11,137	47.87	39.12	145.82	-949.24	14070.26
Cooperatives						
	N	Mean	Median	*SD*	Min	Max
Z-score	2,182	14.42	13.43	6.31	-8.51	31.91
assets	2,208	6.99	3.25	23.21	-1.57	408.41
eff_assets	2,208	1.28	.61	4.42	-3.21	88
roa	2,208	14.81	13.71	15.72	-138.81	124.72
leverage	2,208	.71	.76	.31	-1.07	9.21
short_liab	2,204	66.84	71.28	193.27	-75.82	8774.62
Joint stock companies						
	N	Mean	Median	SD	Min	Max
Z-score	119	9.23	8.334	6.72	-8.74	28.15
assets	119	32.77	13.81	43.59	.307	166.87
eff_assets	119	.76	.21	1.25	0	6.47
roa	119	-5.34	.44	29.77	-180.64	49.02
leverage	119	.51	.57	.31	-.52	.94
short_liab	119	49.79	48.36	38.04	0	100
Others						
	N	Mean	Median	SD	Min	Max
Z-score	601	9.65	8.39	5.73	-5.71	29.81
assets	611	21.53	10.66	47.52	-.05	501.36
eff_assets	611	1.24	.86	2.05	0	17.51
roa	611	8.23	3.91	19.32	-61.31	131.74
leverage	611	.48	.51	.32	-.94	1
short_liab	611	54.86	53.56	36.38	0	100

N – number of observations; *SD* – standard deviation; assets – natural logarithm of million PLN; eff_assets – sales to assets; roa – return on assets [%]; leverage – equity to assets; short_liab – short-term liabilities to long-term liabilities [%].

Source: Authors' own study based on EMIS data.

The two-sided *t*-tests for the alternative hypothesis of "mean Z-score (pre-covid) < mean Z-score (covid)" were conducted for the full sample of enterprises and sub-samples divided according to legal form. The results of the tests show that the mean value of the Z-score for the COVID-19 pandemic period is statistically and significantly higher

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than for the pre-pandemic period (Table 4). Such direction of dependency occurs in the full sample as well as in the groups of cooperatives and limited liability companies. In case of joint stock companies and other companies the mean value of the Z-score for the COVID-19 period is also higher than for the pre-COVID period but the difference is not statistically significant. The results of the *t*-test have confirmed the hypothesis 1 stated that all circumstances and conditions caused by the COVID-19 pandemic had a positive impact on the resistance of agricultural enterprises to the risk of bankruptcy.

Table 4. Results of *t*-tests

Sample	Observations	Mean	Standard deviation	Sample	Observations	Mean	Standard deviation
Full sample				Limited liability companies			
Pre-covid	9,089	10.26	6.72	Pre-covid	7.17	9.48	6.59
Covid	4,733	10.59	7.06	Covid	3.74	9.87	6.95
t-statistic	-2.629			*t*-statistic	-2.820		
Pr(T < t)	0.0043			Pr(T < t)	0.0024		
Cooperatives				Joint stock companies			
Pre-covid	1.48	14.27	6.22	Pre-covid	79	8.96	6.71
Covid	702	14.74	6.51	Covid	40	9.74	6.79
t-statistic	-1.617			*t*-statistic	-0.587		
Pr(T < t)	0.0531			Pr(T < t)	0.279		
Others							
Pre-covid	356	9.55	5.41				
Covid	245	9.78	6.18				
t-statistic	-0.461						
Pr (T < t)	0.3226						

t-test on equality of means; null hypothesis: mean(pre-covid) and mean(covid) are equal, alternative hypothesis: mean(pre-covid) < mean(covid).

Source: Authors' own study based on EMIS data.

The aim of the next stage of the research was to additionally confirm the first hypothesis and to check the second hypothesis indicating that the nature of the impact of the COVID-19 pandemic on agricultural enterprises depends on their legal form. For this purpose, panel estimation with fixed effects was used, covering the full research sample as well as individual groups of enterprises by their legal forms.

Table 5. Panel model estimations

Specification	Full sample	Limited liability companies	Cooperatives	Joint stock companies	Others
covid	0.468*** (0.105)	0.511*** (0.135)	0.225 (0.187)	0.033 (0.426)	0.184 (0.210)
assets	-0.011 (0.174)	-0.187 (0.206)	1.792*** (0.427)	-1.260* (0.682)	-0.098 (0.306)
eff_assets	-0.007 (0.005)	-0.009 (0.006)	0.125** (0.053)	0.095 (0.409)	0.074 (0.108)

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Specification	Full sample	Limited liability companies	Cooperatives	Joint stock companies	Others
roa	0.104*** (0.004)	0.102*** (0.004)	0.124*** (0.012)	0.107*** (0.006)	0.073*** (0.012)
leverage	6.519*** (2.458)	6.642** (2.873)	4.974 (3.327)	18.730*** (3.204)	14.267*** (1.548)
short_liab	0.001 (0.001)	0.004** (0.002)	-0.000 (0.000)	0.015 (0.017)	0.019** (0.008)
gdp	0.008 (0.010)	0.017 (0.012)	-0.037 (0.024)	-0.089 (0.084)	-0.009 (0.027)
inflation	0.023*** (0.004)	0.020*** (0.004)	0.042*** (0.013)	-0.046 (0.045)	-0.001 (0.010)
constant	6.202*** (1.037)	5.915*** (1.043)	6.947*** (2.202)	3.265 (3.411)	1.232 (1.088)
Observations	13,801	10,905	2,177	119	600
Groups	2,808	2,214	435	22	137
F-stat	110.650	121.763	52.712	280.174	37.139
R-squared	0.624	0.629	0.283	0.755	0.816

***, **, * represent 1%, 5% and 10% significance level.

Source: Authors' own study based on EMIS data.

The results of the panel estimations show that coefficients at the main variable of interest "covid" are positive and statistically significant for the full sample and for the group of limited liability companies (Table 5). Such relationship may result from the fact that the surveyed sample is dominated by enterprises in the form of limited liability companies, which are characterized by resistance to the risk of bankruptcy. Moreover, agricultural enterprises have increased the resistance to bankruptcy with the improvement in their asset profitability. It means that higher profits allowed enterprises to improve financial liquidity and accumulate additional capital buffers allowing them to absorb even increased shocks resulting from the difficulties that the pandemic have introduced in their business activities. The strongest impact of improvement of the asset profitability on the Z-score occurred in the case of cooperatives and the weakest one in the case of other agricultural enterprises – the group "Others". Moreover, the growth in equity-to-assets ratio also had a positive impact on the resistance to the risk of bankruptcy among all groups of agricultural enterprises (except cooperatives). In this case, the growing share of equity in financing enterprises allowed them to more safely survive external shocks disrupting their operations.

The estimation results also showed that in the case of cooperatives, an increase in the scale of operations, measured by the value of assets, improves their ability to resist external shocks. This means that cooperatives were able to use economies of scale most effectively to boost profits and increase their resilience to the risk of failure. Moreover, a positive sign of the coefficient of the sales-to-assets variable means that thanks to the increase in assets, cooperatives obtain higher revenues and, consequently, higher profits. This is also confirmed by the highest value of

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the return on assets achieved by the cooperatives in the sample. Such dependencies mean that increasing the scale of operations improves the company's resistance to the risk of bankruptcy.

The positive impact of the increase in the share of short-term liabilities in total liabilities in the group of limited liability companies may result from an increase in the share of enterprises financing with free short-term trade credit while limiting financing with a bank loan. The results of bank surveys conducted periodically by central banks, including the National Bank of Poland and the European Central Bank, indicate that the conditions for obtaining a loan by small and medium-sized enterprises are usually more difficult than in the case of large enterprises (Alves et al., 2020; ECB, 2020; NBP, 2021).

Inflation turned out to be a macroeconomic factor that had a significant statistically positive impact on the risk of bankruptcy of agricultural enterprises (except joint-stock companies and other types of companies). Such a relationship may result from the fact that price increases allow enterprises to obtain higher sales revenues and, consequently, higher profits and a higher ability to absorb shocks resulting from the COVID-19 pandemic. Unexpectedly, the GDP growth does not seem to affect agriculture companies' stability.

Discussions

The research conducted so far has been focused mainly on the impact of the COVID-19 pandemic on the functioning of non-financial enterprises and the pace of regional development. The presented study is one of the few focusing on the impact of the pandemic on the risk of bankruptcy of agricultural enterprises. The results obtained, to the authors' knowledge, are the first to confirm the hypothesis that during the COVID-19 pandemic, introduction of the public aid programs, changes in structure of the household spending, and better performance of the agricultural sector had a positive impact on the resistance of agricultural enterprises to bankruptcy. The direction of the impact of the pandemic on the situation of agricultural enterprises is opposite to results obtained by Vavrek et al. (2021) and Srebro et al. (2021) for Slovak and Serbian agricultural enterprises, respectively, what may result, among others, from: the cost and quality competitiveness of the Polish food on the domestic and foreign markets (Szczepaniak et al., 2020), the growing demand for food becoming visible, among others, by an increase in the share of food expenses in household budgets. Public support, in the form of anti-crisis shields, significantly increased liquidity of the SME and agricultural sectors (Jędruchniewicz et al., 2024). Greater resistance of agricultural enterprises to the risk of bankruptcy may also be associated with much better results achieved by Polish agriculture during the COVID-19 pandemic than in the pre-pandemic period. The value of gross agricultural production increased from PLN 119.6 billion in 2019 to PLN 126.6 billion in

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2020 and PLN 134.8 billion in 2021. Similarly, the value of exported food products increased from PLN 102.4 billion in 2019 to PLN 106.3 billion in 2020 and PLN 132 billion in 2021 (Statistics Poland, 2022).

The research results indicating a positive impact of the increase in the assets' profitability and effectiveness in generating income on the resistance of enterprises to the risk of bankruptcy stem from the fact that high sales allow for maintaining adequate financial liquidity of agricultural enterprises. These results are consistent, among others, with the results obtained by Hatab et al. (2020), who indicated that in Egypt, the resilience of farms to disruptions caused by the COVID-19 pandemic increased due to the rise in their profitability and financial liquidity. This relationship is also confirmed by the obtained results, indicating that increasing the share of equity in the financing structure improves the company's resistance to the risk of bankruptcy. This is due to the fact that a decrease in the value of liabilities has a positive impact on the level of its financial capacity and liquidity and also allows it to safely survive the volatility of the external environment.

Research results indicating that in the case of cooperatives, an increase in the scale of operations, measured by the value of assets, increases resistance to the risk of bankruptcy is consistent, among others, with the results obtained by Mutegi et al. (2024) and OECD (2021). Their studies indicated that small enterprises and farms were most exposed to the disruptions introduced by the COVID-19 pandemic, including: difficulties in providing workers for harvesting, obtaining sowing seeds, accessing agricultural advice and also had difficult conditions in accessing public aid (OECD, 2021) or bank loans (Alves et al., 2020; ECB, 2020; NBP, 2021).

A novelty among studies on the situation of Polish agricultural enterprises during the pandemic is the demonstration of the positive impact of the increase in inflation and the share of short-term liabilities in total liabilities, which may be associated with improved liquidity and the use of free trade credit. The studies carried out so far have also not shown the lack of a statistically significant impact of GDP growth on the resistance to the risk of its decline. The lack of such a relationship may be due to the fact that during the COVID-19 pandemic, the results of agriculture and the enterprises operating in it were characterized by stability and positive dynamics, while the dynamics of Poland's GDP was characterized by significant variability, from 4.4% in 2019 to -2.0% in 2020 and 6.9% in 2021 (Statistics Poland, 2023).

Conclusions

The COVID-19 pandemic has introduced significant disruptions in the conduct of business and the ability of agricultural enterprises to sell their products. Due to the focus of a broad range of research on the impact of the pandemic on the activities of non-financial enterprises and their market capitalization, this work fills the gap by presenting the results of the study of the impact of the pandemic on the resistance

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of nearly four thousand Polish agricultural enterprises operating in 2014–2021 to the risk of bankruptcy measured by the Altman method. Data on enterprises, mainly operating in the form of limited liability companies and cooperatives, come from the EMIS database, and macroeconomic data from the Statistics Poland. The impact of the COVID-19 pandemic on the value of Z-score was examined using the fixed-effects panel regression method.

The research showed that during the COVID-19 pandemic, in case of the entire group of agricultural enterprises, implementation of public aid programs, change in work organization, increase in exports and household spending on agri-food products have increased resistance to the risk of bankruptcy. However, these factors increased the resistance to bankruptcy of limited liability companies only, and in the case of other legal forms of enterprises it had no statistically significant impact. Such directions of dependencies indicate that limited liability companies have properties that make them easier to withstand and even to take advantage from disturbances caused by significant external shocks.

The increase in agricultural product inflation, as well as the increase in profitability, improving the liquidity and solvency of enterprises, also had a significant positive impact on the resistance of enterprises to the risk of bankruptcy. In addition, the characteristic features of individual legal forms of enterprises determine their individual impact on the Z-score value. Cooperatives showed greater resilience due to asset growth and revenue generation efficiency. In turn, the increase in the share of equity capital improves the resilience of all enterprises, except cooperatives.

The research conclusions can be used to optimally prepare agricultural enterprises to withstand possible future external shocks. Research indicates the importance of diversification of enterprises in terms of legal form for their resistance to the risk of bankruptcy in extreme macroeconomic and sanitary conditions, as well as the importance of maintaining an appropriate structure of assets and liabilities of enterprises that makes it easier to resist shocks.

The authors are aware of some weaknesses of the study, resulting largely from the imperfections of the database, including: from the inequality of time series of variables characterizing enterprises, as well as significant differences in the size of the studied enterprises.

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