DETERMINANTS OF PROFITABILITY OF AGRICULTURAL SMES IN VOJVODINA: THE ROLE OF ECO-EFFICIENCY AND CIRCULAR ECONOMY INDICATOR

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ABSTRACT

This study examines the determinants of profitability of small and medium-sized agricultural enterprises (SMEs) in Vojvodina during 2014–2023 using a balanced panel of 269 enterprises. The research tests the hypothesis that the circular economy indicator, measured as agricultural emissions intensity relative to gross value added, has a statistically significant effect on firm profitability. Profitability is measured by return on assets (ROA), while firm size, indebtedness, operational efficiency, liquidity, and asset tangibility are included as control variables. The empirical analysis is based on a fixed-effects panel regression with Driscoll–Kraay standard errors, while a two-step System GMM estimator is employed to assess robustness. The results confirm the research hypothesis, indicating that the circular economy indicator significantly affects profitability. The findings contribute to the literature by integrating a sector-level eco-efficiency indicator into a firm-level profitability model and provide implications for policies supporting the transition toward more sustainable agricultural production.

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Introduction

Agricultural production, as one of the central drivers of the primary sector, is of strategic importance for the economic system of the Republic of Serbia (Tekić et al., 2022). In this context, agriculture has multiple roles: it ensures food production and contributes to food security, affects employment and living standards in rural areas, contributes to exports, and supports overall regional development. Beyond its direct economic effects, agriculture also has broader social importance by preserving rural communities, sustaining populations in rural settlements, and preserving traditional and cultural identity. The importance of the sector is also reflected in employment data: according to the Serbian Business Registers Agency (SBRA), agricultural companies in the Autonomous Province of Vojvodina employed 14,786 workers in 2023 (SBRA, 2023). Within Serbia, Vojvodina stands out as a key agricultural region, with a solid productive capacity, favorable agro-ecological conditions, and a large number of agricultural enterprises. Vržina and Dimitrijević (2020) further emphasize the importance of Vojvodina as the central agricultural region in Serbia, noting that more than 53% of enterprises in the agriculture, forestry, and fishing sector are registered in Vojvodina. Therefore, the performance of agricultural enterprises in Vojvodina is important not only for the region itself, but also for the overall stability and competitiveness of Serbian agriculture.

However, agricultural business activity is subject to specific constraints and risks: pronounced seasonality, slower capital turnover, dependence on natural factors and weather conditions, and substantial exposure to volatility in input and output prices, while the sector is also strongly shaped by agricultural policy and subsidy systems (Dašić et al., 2022). In such an environment, business results may fluctuate considerably across years, and individual shocks (e.g., droughts, floods, diseases, increases in energy or fertilizer prices) can quickly jeopardize liquidity and profitability. Moreover, agriculture has a pronounced macroeconomic and social relevance in Serbia through its contribution to GDP, employment, and rural development, as well as by reducing the need for food imports and supporting economic stability in rural communities (SORS, 2023; Volk et al., 2014). The economic environment in Serbia is also characterized by a specific transition path, marked by a prolonged period of privatization and restructuring in the early 2000s. Between approximately 2001 and 2007, a large share of formerly state-owned enterprises and agricultural cooperatives were transferred into private hands, often under weak institutional frameworks and fragmented ownership structures. This process contributed to persistent uncertainty, fragmented land holdings, and underdeveloped support systems for small and medium enterprises, including those in agriculture. As a result, many agri-SMEs in Vojvodina inherited outdated infrastructure, limited access to capital, and relatively low managerial capacity, which constrained their investment in efficiency-enhancing technologies. These structural legacies may have indirectly slowed the adoption of eco-efficiency practices and circular-economy-oriented resource management, which in turn could affect profitability. For these reasons, the need for systematic monitoring of profitability

and financial sustainability is particularly pronounced among small and medium-sized enterprises (SMEs), which typically have smaller financial buffers, limited access to long-term financing, and more difficulty obtaining the investment capital necessary for technological upgrading. In practice, SMEs serve as a key structural component of regional agribusiness through production volumes, processing capacities, and their role in local supply chains; therefore, understanding the determinants of their profitability is crucial for designing effective development measures. Although previous studies have extensively examined the financial determinants of agricultural enterprises' profitability, empirical evidence concerning the relationship between circular economy indicators and the profitability of agricultural SMEs remains limited, particularly in Serbia. To address this research gap, the present study examines agricultural SMEs operating in Vojvodina during the period 2014–2023. Its objective is to determine whether the circular economy indicator, operationalised as the emissions intensity of agricultural production, affects profitability measured by return on assets, while controlling for firm size, indebtedness, operational efficiency, liquidity, and asset tangibility. Accordingly, the following research hypothesis is formulated:

H1: The circular economy indicator has a statistically significant effect on the profitability of agricultural SMEs in Vojvodina.

Literature review

Profitability is widely regarded as a fundamental indicator of business success and sustainability (Novaković et al., 2025). The literature emphasizes that profitability results from the simultaneous influence of multiple internal and external factors, most commonly financial structure (indebtedness/leverage), liquidity, firm size, efficiency of asset use, and asset structure (tangibility/capital intensity). Numerous international studies in the field of agriculture highlight the relevance of these determinants: Suardi and Noor (2015) find that capital-structure indicators may negatively affect profitability; Jacob and Collins (2016) report a positive impact of liquidity and firm size, while tangibility may have a negative effect; Shamsuddin et al. (2017) confirm that a combination of liquidity, asset turnover, and firm size shapes cooperatives' financial performance. Evidence for U.S. cooperatives further suggests that revenue growth can be a key positive factor, whereas uncertainty and capital intensity may negatively affect profitability (Singh et al., 2019). Similarly, Xu et al. (2021) show that leverage and short-term indebtedness negatively influence the profitability of agricultural enterprises, while firm size and sales (i.e., sales growth/efficiency) are among the factors with a stable positive effect.

Within the domestic literature, the findings are mostly consistent with international studies while preserving sensitivity to region-specific characteristics. For medium and large agricultural enterprises in Vojvodina, Andrašić et al. (2018) show that profitability (ROA) is significantly associated with internal financial and market factors (e.g., liquidity, leverage, market share, revenue growth), as well as with factors such as insurance and exports. For the Republic of Serbia, Milašinović and Mitrović (2020)

identify total asset efficiency as a key positive determinant of profitability, while certain capital-structure indicators may act as constraints. Additionally, Mutavdžić et al. (2021) confirm that indebtedness can negatively affect profitability, whereas turnover/productivity indicators may improve it. In recent panel analyses for Serbia, Tekić et al. (2022) and Novaković et al. (2025) confirm that microeconomic indicators such as indebtedness, asset turnover, liquidity, and tangibility, along with selected macroeconomic controls, represent relevant determinants of profitability in the agri-food sector. The reviewed literature provides a sound basis for the inclusion of selected variables and justifies the use of a panel approach to analyze the profitability determinants of agricultural SMEs in Vojvodina.

Simultaneously, the assessment of agricultural performance is becoming more closely framed by sustainability considerations and environmental constraints. Modern agribusiness faces growing pressure to reduce negative environmental impacts, including pollutant emissions, land degradation, water eutrophication, and biodiversity loss (Silvestri et al., 2022). In this context, the circular economy (CE) has become an increasingly important framework for transforming production systems toward greater sustainability (Silvestri et al., 2022; Xia & Ruan, 2020). In agriculture, the circular economy is commonly associated with closing material and energy loops, reducing waste, improving resource management, and lowering emission intensity (Silvestri et al., 2022; Xia & Ruan, 2020). The key idea is that equal or greater economic value can be achieved with lower environmental costs, which is often operationalized through eco-efficiency and the use of indicators that link economic and environmental dimensions (Silvestri et al., 2022; Stevanović et al., 2025).

Nevertheless, the relationship between circularity (i.e., eco-efficiency) and profitability lacks complete clarity. Improving eco-efficiency can increase competitiveness through input savings, reduced losses, process optimization, and higher resource productivity, yet the transition to circular practices may require additional investment, technological change, organizational adjustments, and compliance costs (Silvestri et al., 2022; Xia & Ruan, 2020). Therefore, in the short run, higher profitability may be associated with more intensive production patterns that increase environmental pressure, indicating a possible trade-off between profitability and environmental performance. This issue is especially relevant for SMEs, which often lack sufficient capital and knowledge to rapidly adopt cleaner technologies and circular business models without external support (Xia & Ruan, 2020). On the other hand, empirical evidence suggests that adopting CE principles can lead to better financial outcomes in rural settings and that CE firms may achieve higher profitability and resilience than comparable non-CE firms (Serrano Magdalena et al., 2025).

Although interest in circular economy and sustainability in agriculture is increasing, empirical evidence directly linking circularity indicators to firm profitability remains limited, particularly in Serbia (Novaković et al., 2026). One key reason is the lack of firm-level environmental performance data for large samples of SMEs; therefore, studies often rely on sectoral or macro indicators that describe the environmental "context" in

which firms operate (Novaković et al., 2025; Novaković et al., 2026). Such an approach enables the inclusion of environmental intensity in profitability models even when firm-level emission data are unavailable, but it requires careful interpretation because the indicator reflects sector-level changes over time rather than differences between firms within the same year (Stevanović et al., 2025; Novaković et al., 2026).

Considering the aforementioned, the subject of this study is agricultural SMEs in Vojvodina that operated from 2014–2023. The objective is to empirically determine the extent to which the circular economy indicator (CE), operationalised as emission intensity in agriculture (emissions/GVA), as well as selected internal firm indicators-size, indebtedness, operational efficiency (asset turnover), liquidity, and asset tangibility-affect profitability measured by ROA. In this way, the study aims to provide reliable empirical evidence on the "profitability–environment" relationship among agricultural SMEs in Vojvodina and to offer a basis for policy recommendations that can improve business performance while supporting the transition toward a circular economy.

Materials and methods

The analysis focuses on agricultural small and medium-sized enterprises (SMEs) operating in the Autonomous Province of Vojvodina (Serbia). According to the Serbian Business Registers Agency (SBRA, 2023), by the end of 2023, there were 374 small and 89 medium-sized agricultural enterprises operating in Vojvodina. Firm-level financial data were obtained from the annual financial statements reported to the SBRA (2026).

To construct a consistent panel suitable for econometric analysis, the initial sample was filtered in several steps. First, enterprises that did not operate continuously during 2014–2023 were excluded to ensure comparability. Second, companies with extreme ROA values were removed to reduce the influence of outliers and atypical accounting patterns on regression results. Once the data had been cleaned, the final sample consisted of 269 agricultural SMEs observed over the period 2014–2023.

The study combines firm-level financial indicators with a sector-level circular economy indicator to examine profitability determinants among agricultural SMEs in Vojvodina (Table 1). The dependent variable was return on assets (ROA), which captures firm profitability and it was calculated as net profit divided by total assets (reported in decimal form). The set of explanatory variables includes standard enterprise characteristics frequently used in profitability models: firm size (SIZE), the indebtedness ratio (DEBT), operational efficiency measured by asset turnover (OEFF), the liquidity ratio (LIQ), and asset tangibility (TANG).

Table 1. Descriptive statistics for applied models in agricultural companies

Variable	Description	Unit of analysis	Expected sign
ROA	Net profit/ average total assets	Firm level	—
SIZE	ln(total assets)	Firm level	+ / −
DEBT	Total liabilities/total assets	Firm level	−

Variable	Description	Unit of analysis	Expected sign
OEFF	Operating revenues/average total assets	Firm level	+
LIQ	Current assets/Current liabilities	Firm level	+ / −
TANG	Fixed assets/total assets	Firm level	+ / −
CE	Total air pollutant emissions in agriculture/ agricultural GVA	Year/sector level	±

Source: Authors' calculations.

Firm size is included to control for scale effects in performance, while the indebtedness ratio reflects the firm's financing structure and the potential burden of liabilities on profitability. Operational efficiency (asset turnover) captures a firm's ability to generate revenue from its asset base, and the liquidity ratio reflects working capital conditions that may support or constrain day-to-day operations. Asset tangibility measures the degree of capital intensity and may influence profitability through fixed costs, depreciation, and the utilization of tangible assets. The key explanatory variable is the circular economy indicator (CE), constructed as air pollutant emissions in agriculture relative to agricultural gross value added (emissions/GVA). Emission data were taken from the online database of the Statistical Office of the Republic of Serbia for activity KD2010: 01 (Agricultural production, hunting and related service activities) and include nitrogen oxides (NOx)**,** non-methane volatile organic compounds (NMVOC), sulphur dioxide (SO_2), particulate matter $PM_{2.5}$ and PM_{10}, carbon monoxide (CO), and ammonia (NH_3)(SORS, 2023). In line with the ratio-based eco-efficiency logic used in environmental-efficiency analyses of Serbian agricultural enterprises (Stevanović et al., 2025), CE is interpreted as an emissions-intensity measure: higher CE values indicate lower eco-efficiency, i.e., higher environmental intensity per unit of value created. Since firm-level emission data are not available, CE is measured at the sector-year level and assigned uniformly to all firms within the same year. This approach treats the environmental intensity of agricultural production as a contextual factor affecting firms operating under the same institutional, technological, and regulatory environment.

The empirical strategy combines descriptive statistics and panel econometric methods to identify the determinants of profitability and assess the role of circular economy performance among agricultural SMEs in Vojvodina. First, descriptive statistics were computed to summarize the dataset and to detect heterogeneity and potential outliers typical of accounting-based firm data (Gujarati & Porter, 2009). Next, Pearson correlation coefficients were calculated to provide an initial view of linear associations among variables, while multicollinearity was formally assessed using variance inflation factors (VIF) and tolerance values (TOL = 1/VIF).

Before estimating the main models, we tested key panel-data assumptions and selected an appropriate inference strategy. Heteroskedasticity was examined using the Breusch–Pagan approach (Breusch & Pagan, 1979). Serial correlation was assessed using Wooldridge's test for autocorrelation in fixed-effects panels (Wooldridge, 2010), complemented by Breusch–Godfrey checks in pooled specifications (Breusch, 1978;

Godfrey, 1978). Cross-sectional dependence was evaluated using Pesaran's CD test (Pesaran, 2004). Since the diagnostics indicated heteroskedasticity, serial correlation, and strong cross-sectional dependence, coefficient inference based on conventional standard errors would be unreliable. Therefore, the baseline results are reported within a fixed-effects framework using Driscoll–Kraay standard errors, which are robust to heteroskedasticity, autocorrelation, and general forms of cross-sectional dependence in panels (Driscoll & Kraay, 1998; Baltagi, 2021).

To reduce the risk of spurious regression, the stationarity properties of the variables were also examined. Because the time dimension is relatively short (T = 10) and standard panel unit-root routines proved unstable in our computing environment, we applied a Fisher-type procedure that combines firm-level ADF tests (panel Fisher-ADF) (Maddala & Wu, 1999; Choi, 2001). Individual ADF p-values were obtained via Monte Carlo simulation under the unit-root null with the same sample length and lag specification. Overall, the results supported predominantly level estimation.

The baseline profitability model is specified as:

$$ROA_{it} = \alpha + \beta_1 SIZE_{it-1} + \beta_2 DEBT_{it} + \beta_3 OEFF_{it} + \beta_4 LIQ_{it} + \beta_5 TANG_t + \beta_6 CE_t + \varepsilon_{it}$$

where ROAit denotes return on assets of firm i in year t, *CEt* is the sector-level circular economy indicator, and ε_{it} ε_{it} is the idiosyncratic error term. The choice between fixed-effects and random-effects estimators was guided by the Hausman test (Hausman, 1978), which favored fixed effects.

As an additional robustness check addressing dynamic persistence in profitability and potential endogeneity of firm-level regressors, we estimated a two-step System GMM model (Arellano & Bond, 1991; Blundell & Bond, 1998). To mitigate instrument proliferation, we employed a restricted instrument strategy with collapsed instruments and limited lag depth (Roodman, 2009). Model adequacy was evaluated using the Arellano–Bond AR(1) and AR(2) tests for serial correlation in differenced residuals (with AR(2) expected to be insignificant) and the Sargan test of overidentifying restrictions, interpreted cautiously given its sensitivity under heteroskedasticity and dependence structures (Baltagi, 2021; Roodman, 2009). All analyses were performed in software package R 4.5.2.

Results

Table 2 reports descriptive statistics for the variables used in the empirical analysis. The dataset contains 2,690 firm–year observations for agricultural small and medium-sized enterprises in Vojvodina over the period 2014–2023.

Table 2. Descriptive statistics

Variable	Mean	Median	Min	Max	SD	Q1	Q3
ROA	0.026	0.022	-9.111	2.524	0.194	0.006	0.052
SIZE	5.487	5.464	0.845	7.007	0.627	5.018	5.939
DEBT	0.500	0.473	0.000	32.71	0.708	0.213	0.732
OEFF	0.296	0.157	0.000	9.209	0.489	0.042	0.369
LIQ	1.071	1.460	0.000	6.630	0.723	1.030	2.800
TANG	0.454	0.458	0.000	1.000	0.269	0.237	0.678
CE	0.143	0.143	0.086	0.189	0.032	0.118	0.173

Source: Authors' calculations

Over the period 2014–2023, the average profitability of agricultural SMEs in Vojvodina, measured by ROA, is 0.026, which corresponds to approximately 2.62% (ROA is reported in decimal form). The range of ROA is wide (from −9.111 to 2.524), indicating substantial differences in business performance across firms and the presence of extreme values in certain years. Firm size (SIZE) has an average value of 5.4871, and its variation suggests that the sample includes both smaller and medium-sized enterprises with different scales of operation. The financial structure, measured by the indebtedness indicator (DEBT), averages 0.500, implying that liabilities represent an important source of financing for a typical enterprise. Operational efficiency, captured by the total business assets turnover ratio (OEFF), has a mean value of 0.296, indicating a relatively moderate level of asset turnover among agricultural firms. The liquidity ratio (LIQ) averages 1.071. Asset tangibility (TANG) averages 0.454, which is consistent with the more capital-intensive nature of agricultural production. Finally, the circular economy indicator (CE), defined as the ratio of emissions to agricultural gross value added, has an average value of 0.143 and varies over time at the sector level, reflecting changes in the environmental intensity of value creation in agriculture during the observed period.

To obtain a preliminary insight into bivariate relationships among the variables, we computed the Pearson correlation matrix reported in Table 3. This step helps to (i) describe simple associations between profitability, firm-level financial indicators, and the circular economy measure and (ii) provide an initial check for potential multicollinearity before estimating panel regression models.

Table 3. Correlation matrix

	ROA	SIZE	DEBT	OEFF	LIQ	TANG	CE
ROA	1.000	0.127	-0.833	0.046	0.013	0.000	0.024
SIZE	0.127	1.000	-0.272	-0.120	-0.023	0.529	-0.120
DEBT	-0.833	-0.272	1.000	-0.026	-0.031	-0.242	0.015
OEFF	0.046	-0.120	-0.026	1.000	-0.015	-0.005	0.028
LIQ	0.013	-0.023	-0.031	-0.015	1.000	-0.028	-0.007
TANG	0.000	0.529	-0.242	-0.005	-0.028	1.000	-0.051
CE	0.024	-0.120	0.015	0.028	-0.007	-0.051	1.000

Source: Authors' calculations

In bivariate terms, profitability (ROA) is strongly negatively correlated with the indebtedness ratio (DEBT) (r = -0.833), indicating that more indebted firms tend to exhibit lower profitability. Given that correlation analysis reflects only pairwise associations, in the next step we formally assessed potential multicollinearity among regressors by computing variance inflation factors (VIFs) and their corresponding tolerance values (TOL = 1/VIF), reported in Table 4.

Table 4. Multicollinearity diagnostics (VIF and tolerance)

Variable	VIF	TOL (=1/VIF)
SIZE	1.457	0.686
DEBT	1.350	0.741
OEFF	1.023	0.978
LIQ	1.011	0.989
TANG	1.667	0.600
CE	1.016	0.984

Source: Authors' calculations

The results indicate no multicollinearity problems: all VIF values are low (approximately 1.01–1.67) and all tolerance values are high (0.60–0.99), suggesting that the explanatory variables are not highly correlated in a way that would distort coefficient estimates.

Before estimating the main panel regression models, we conducted a set of diagnostic tests to verify key assumptions and to determine the appropriate inference strategy. Specifically, we tested for heteroskedasticity, serial correlation, and cross-sectional dependence (Table 5).

Table 5. Diagnostic tests (heteroskedasticity, serial correlation, and cross-sectional dependence)

Test	Null hypothesis (H0)	Test statistic	p-value	Conclusion
Breusch–Pagan (heteroskedasticity)	Homoscedastic errors	BP = 7.365	0.007	Reject H0 → heteroskedasticity
Wooldridge test (serial correlation in FE)	No first-order serial correlation	F = 14.931	0.000	Reject H0 → serial correlation
Breusch–Godfrey AR(1) (pooled OLS)	No serial correlation (AR1)	LM = 72.394	<0.001	Reject H0 → serial correlation
Breusch–Godfrey AR(2) (pooled OLS)	No serial correlation (AR2)	LM = 115.926	<0.001	Reject H0 → serial correlation
Pesaran CD (cross-sectional dependence)	Cross-sectional independence	CD = 38.593	<0.001	Reject H0 → CSD present

Source: Authors' calculations

The diagnostic results indicate that the error structure deviates from the classical panel assumptions. We find evidence of heteroskedasticity, serial correlation, and strong cross-sectional dependence ($p<0.05$). In addition, we examined the stationarity properties of the variables using panel unit root tests (Table 6).

Table 6. Panel unit root tests (Fisher-ADF)

Variable	Fisher statistic	df	p-value	Stationarity inference
ROA	1225.422	538	<0.001	Stationary (I(0))
SIZE	577.386	536	0.105	Non-stationary / inconclusive
DEBT	641.732	538	0.00135	Stationary (I(0))
OEFF	1096.812	538	<0.001	Stationary (I(0))
LIQ	735.914	538	<0.001	Stationary (I(0))
TANG	689.889	536	<0.001	Stationary (I(0))

Source: Authors' calculations

Overall, the results indicate that the main variables used in the profitability model are stationary in levels. The only exception is SIZE, for which the Fisher-ADF test does not reject the unit-root null at conventional significance levels ($p = 0.105$). Given that firm size is a standard control in profitability models and is already expressed in logarithmic form, we retain SIZE in levels in the baseline specification and additionally verify robustness using alternative specifications when appropriate. CE is a sector-level (time-varying) indicator that is identical across firms within the same year; therefore, it is treated as a macro-level regressor in the panel models and cannot be jointly identified with a full set of year fixed effects.

Next, we estimated pooled OLS, fixed-effects (FE), and random-effects (RE) panel specifications to identify the appropriate estimator. The Hausman test strongly rejected the null hypothesis of RE consistency ($\chi^2(7) = 44.804$, $p = 0.000$), indicating that unobserved firm-specific effects are correlated with the regressors. Consequently, the FE framework was selected as the baseline estimator.

Given the diagnostic evidence of heteroskedasticity, serial correlation, and strong cross-sectional dependence, coefficient inference based on conventional standard errors would be unreliable. Therefore, in the subsequent analysis we report FE estimates with Driscoll–Kraay standard errors, which are robust to heteroskedasticity, autocorrelation, and cross-sectional dependence, and treat these results as the primary basis for inference. Based on the Hausman test results and the diagnostic evidence of heteroskedasticity, serial correlation, and cross-sectional dependence, the final estimates are reported using a fixed-effects specification with Driscoll–Kraay standard errors. The results of the baseline FE model are reported in Table 7.

Table 7. Fixed-effects estimates with Driscoll–Kraay standard errors (baseline specification)

Variable	Coefficient	Robust SE (DK)	t-stat	p-value
SIZE	0.0204	0.0177	1.1484	0.2509
DEBT	-0.2740	0.0141	-19.4795	<0.001
OEFF	0.0201	0.0062	3.2291	0.0013
LIQ	-0.0001	0.0000	-2.7688	0.0057
TANG	-0.0938	0.0172	-5.4632	<0.001
CE	0.2394	0.0734	3.2591	0.0011

Source: Authors' calculations

The results indicate that the circular economy indicator (CE) is positive and statistically significant, suggesting that higher environmental intensity (higher emissions per agricultural GVA) is associated with higher profitability (ROA), consistent with a short-run profit–environment trade-off. Indebtedness (DEBT) exhibits a strong negative association with profitability, while operational efficiency (OEFF) is positively related to ROA. Tangibility is negatively associated with ROA, implying that more capital-intensive firms tend to achieve lower profitability. Liquidity shows a negative and statistically significant coefficient, indicating that higher liquidity is associated with lower ROA, potentially reflecting idle resources or conservative working-capital management.

As an additional robustness check addressing potential dynamic persistence in profitability and endogeneity concerns, we estimated a two-step System GMM model. We applied a restricted instrument strategy (collapsed instruments and limited lag depth) to mitigate instrument proliferation. The results are reported in Table 8.

Table 8. Dynamic robustness: Two-step System GMM results (restricted instruments)

Variable/ Diagnostics	Coefficient	Robust SE	z-stat	p-value
lag(ROA, 1)	-0.0388	0.0045	-8.6969	<0.001
SIZE	0.0126	0.0065	1.9410	0.0523
DEBT	-0.0586	0.0328	-1.7857	0.0742
OEFF	-0.0175	0.0541	-0.3232	0.7466
LIQ	-0.0052	0.0117	-0.4464	0.6553
TANG	-0.0615	0.0257	-2.3975	0.0165
CE	0.1775	0.0436	4.0671	<0.001
Model diagnostics				
Sargan test $\chi^2(7)$	21.105	—	—	0.00362
Arellano–Bond AR(1)	—	—	—	0.000153
Arellano–Bond AR(2)	—	—	—	0.164

Source: Authors' calculations

System GMM results confirm the baseline conclusion from the fixed-effects model with Driscoll–Kraay standard errors. The circular economy indicator (CE) remains positive and highly significant, indicating that higher environmental intensity is associated with higher profitability even after accounting for dynamic effects. The AR(2) test does not reject the null of no second-order serial correlation, supporting the validity of the dynamic specification. Although the Sargan test rejects the overidentifying restrictions, this test can be sensitive under heteroskedasticity and cross-sectional dependence; therefore, the GMM estimates are interpreted primarily as robustness evidence. Overall, the stability of the CE coefficient across FE and System GMM specifications supports the robustness of the main finding.

Discussion

This study examined profitability determinants of agricultural SMEs in Vojvodina during 2014–2023, with a particular focus on whether a circular economy/eco-efficiency proxy (CE) is associated with firm profitability (ROA). The baseline fixed-effects model

with Driscoll–Kraay standard errors indicates that CE has a positive and statistically significant coefficient. These findings support the proposed research hypothesis (H1), confirming that the circular economy indicator has a statistically significant effect on the profitability of agricultural SMEs in Vojvodina. Given that higher CE values represent higher environmental intensity (lower eco-efficiency), this finding suggests that, in the observed period, higher emissions intensity at the sector-year level coincided with higher firm profitability. Substantively, the result is consistent with the idea of a short-run profit–environment trade-off, where profitability may be supported by more intensive production patterns and input use that increase environmental pressure. This interpretation fits the broader CE debate, which highlights that while eco-efficiency can improve competitiveness over longer horizons, the transition to circular practices may require investments and adjustment costs that can restrain short-run profitability.

In terms of firm-level determinants, indebtedness (DEBT) shows a strong and robust negative association with ROA in the baseline model, indicating that more indebted agricultural SMEs tend to achieve lower profitability. This result aligns with extensive empirical evidence emphasizing the negative impact of indebtedness on performance outcomes, including studies that report negative leverage effects in agricultural enterprises and cooperatives (Suardi & Noor, 2015; Xu et al., 2021; Tekić et al., 2022; Mutavdžić et al., 2021). In agriculture, this relationship can be particularly pronounced due to income volatility and seasonality, which raise the cost of servicing liabilities and increase financial vulnerability. Operational efficiency (OEFF) is positively related to profitability in the FE model, implying that firms which generate higher revenues per unit of assets tend to achieve higher ROA. This is in line with international and domestic studies that identify turnover/efficiency measures as critical drivers of profitability (Shamsuddin et al., 2017; Milašinović & Mitrović, 2020), and it also aligns with evidence for Serbian SMEs showing that turnover ratios are among the most stable positive determinants of profitability (Novaković et al., 2025; Tekić et al., 2022). The finding reinforces the managerial relevance of productivity-oriented strategies, better capacity utilization, and improved asset management. Asset tangibility (TANG) is negative and significant, suggesting that more capital-intensive companies tend to be less profitable, holding other factors constant. This outcome is consistent with findings where capital intensity or asset tangibility is associated with lower profitability, often attributed to higher fixed costs, depreciation burden, and underutilization of fixed assets (Jacob & Collins, 2016; Singh et al., 2019; Xu et al., 2021). In agricultural SMEs, high tangibility may also reflect rigid production structures and limited flexibility in adapting to shocks or market shifts, which can depress returns. Liquidity (LIQ) in the baseline model has a negative and significant coefficient. While some studies report a positive liquidity–profitability relationship in agriculture (Jacob & Collins, 2016), negative coefficients are also plausible in firm-level accounting data, particularly when high liquidity reflects idle resources, conservative working-capital policies, or weak investment opportunities rather than operational strength. In this context, the result suggests that excessive liquidity may be associated with lower profitability, highlighting

the importance of balancing solvency with efficient capital allocation. Finally, firm size (SIZE) is not statistically significant in the baseline model. This indicates that after controlling for firm fixed effects and the remaining financial indicators, scale differences within the SME segment do not systematically explain profitability. This contrasts with some studies that find size effects in agriculture (Jacob & Collins, 2016; Shamsuddin et al., 2017), but it may reflect the relatively narrow size dispersion among SMEs, as well as the dominance of firm-specific unobserved factors captured by fixed effects.

The dynamic System GMM results serve as an additional robustness check. The CE coefficient remains positive and statistically significant, supporting the stability of the main conclusion regarding the profitability–environment relationship. However, some coefficients at the company-level appear weaker and no longer retain statistical significance, which is not uncommon when dynamic specification, instrumentation, and short time dimension are considered. Importantly, while AR(2) does not indicate problematic second-order serial correlation, the rejection of the Sargan test suggests caution in interpreting the GMM estimates as definitive; therefore, the GMM results are best viewed as robustness evidence rather than the primary basis for inference.

Several limitations should be considered when interpreting the findings. First, the circular economy indicator (CE) is constructed at the sector-year level and assigned uniformly to all firms within a given year. As a result, the model captures how changes in sector-level emissions intensity over time relate to profitability, but it cannot identify differences in eco-efficiency between firms operating in the same year. Future research would benefit from firm-level environmental indicators (e.g., energy use, fertilizer intensity, waste streams, or firm-specific emissions), which would enable a clearer assessment of how eco-efficiency strategies affect profitability within the SME population. Second, the analysis focuses primarily on internal firm indicators and a CE proxy, but other relevant drivers, such as subsidies**,** insurance**,** export orientation**,** technology adoption**,** and climate risk exposure, were not explicitly modeled. Prior evidence suggests that such factors can be important in agricultural performance models (e.g., Andrašić et al., 2018). Future research could incorporate these variables and explore their effects. Third, the short time dimension (T = 10) constrains both stationarity testing and dynamic modeling. While the FE with Driscoll–Kraay standard errors provides robust inference under heteroskedasticity, serial correlation, and cross-sectional dependence, dynamic GMM results can be sensitive to instrument choice and diagnostic performance. Future work could consider alternative dynamic estimators, refined instrument, or longer time series as data become available.

Conclusions

This study examined the determinants of profitability of agricultural SMEs in Vojvodina over the period 2014–2023, with particular emphasis on the role of a circular economy indicator as a proxy for eco-efficiency. The empirical findings support the proposed research hypothesis (H1), confirming that the circular economy indicator has a statistically significant effect on the profitability of agricultural SMEs in Vojvodina. The

positive relationship between the circular economy indicator and profitability suggests the existence of a short-run trade-off between financial performance and environmental performance, indicating that higher environmental intensity was associated with higher profitability during the observed period. This finding contributes to the existing literature by extending conventional profitability models through the integration of a sector-level circular economy indicator into the analysis of agricultural SMEs. The findings also indicate that profitability is influenced by firms' financial characteristics, highlighting the importance of prudent debt management, efficient asset utilization, and balanced liquidity management for improving business performance. Rather than viewing environmental sustainability and profitability as mutually exclusive objectives, the results suggest that the transition toward more eco-efficient production may require targeted policy support that helps SMEs overcome the short-term costs of adopting cleaner technologies and circular business practices. From a policy perspective, the findings imply that accelerating the transition toward circular and eco-efficient agricultural production may require measures that lower adjustment costs for SMEs, such as targeted investment support for cleaner technologies, advisory services, and financing instruments that facilitate sustainable business transformation. For managers, the results emphasize the importance of improving operational efficiency, maintaining sustainable debt levels, optimizing asset utilization, and preparing for the gradual adoption of circular economy practices that can enhance long-term competitiveness and sustainability.

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Conflict of interests

The authors declare no conflict of interest.

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