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Circular Economy Indicators and Capital Structure Determinants of Small Agricultural Enterprises: Evidence from Serbia

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Abstract

This study examines the determinants of capital structure in small agricultural enterprises in Serbia, with a particular emphasis on the external context shaped by circular economy (CE) indicators. Using a balanced panel of 254 firms between 2014 and 2022 (2286 firm-year observations), we estimate random-effects models with panel-corrected standard errors. The dependent variable is financial leverage, while explanatory variables include internal firm characteristics (liquidity, debt ratio, profitability, and asset tangibility) and territory-level CE indicators (municipal waste generated per capita, municipal waste recycling rate, and greenhouse-gas emissions from production activities). The model is statistically significant ($\chi^2 = 82.49$; $p < 0.01$) and explains 33.7% of leverage variation. The results show that debt ratio positively and strongly relates to leverage, whereas profitability exhibits a negative and significant association, consistent with the pecking-order theory. Regarding the CE context, higher waste generation and higher GHG emissions are associated with lower leverage, while a higher recycling rate has a positive, marginal effect, suggesting that improved circular performance may ease access to external finance by lowering perceived risk among creditors. These findings highlight that environmental performance and local circularity conditions matter for financing decisions in agriculture. Policy implications include promoting CE practices and local recycling capacities to support sustainable financing. Future research should test dynamic specifications and enterprise-level CE metrics.

Keywords: capital structure; leverage; small agricultural enterprises; panel regression; circular economy indicators; Serbia; sustainability finance

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1. Introduction

Capital structure is a key financial indicator that directly affects liquidity, solvency, and long-term sustainability. A particularly important element here is the source of financing, as it directly shapes the capital structure through debt, equity issuance, and retained earnings [1]. The choice of an optimal capital structure is influenced by numerous factors, among which the most significant are the cost of debt and the proportion between debt and equity financing [2]. Previous studies [3–12] have primarily focused on the influence of traditional internal factors on capital structure, such as profitability, liquidity, asset tangibility, and firm size. Several theories explain capital structure patterns. According to the trade-off theory, firms balance the tax benefits of debt against the expected costs of bankruptcy and financial distress [2]. The pecking-order theory argues that profitable

firms prefer internal financing and therefore exhibit lower leverage [3], whereas firms with fewer internal funds rely more on external debt. The signaling theory suggests that capital structure conveys information to creditors and investors, where leverage may act as a signal of financial discipline but also of potential risk [4]. These theories imply clear expectations: profitability and liquidity should reduce leverage by lowering reliance on external funds, while indebtedness should increase leverage and tangibility should strengthen borrowing capacity through collateral. In the case of small agricultural enterprises, these mechanisms operate under specific conditions: limited collateral, dependence on seasonal cash flows, and high exposure to environmental risks all restrict access to external finance and make the financing decision particularly complex [13]. Under modern conditions, growing sustainability pressures and demands for CE alignment necessitate including external factors in the analysis. The CE represents a strategic framework for improving resource efficiency, reducing negative environmental impacts, and promoting long-term economic stability [14]. Some studies indicate that enterprises implementing CE principles exhibit specific patterns in their financial structure, including a different orientation toward debt and equity financing [15]. Empirical findings suggest that CE indicators, although primarily aimed at environmental goals, may indirectly affect financial strategies and access to capital [16]. Nonetheless, the number of studies that directly examine the relationship between CE indicators and capital structure remains limited, especially in sectors such as agriculture, which combines a high environmental footprint with the potential for transition toward sustainable business models [17].

The novelty of this study lies in incorporating context-level circular economy indicators to capture the environmental and circularity settings relevant for financing decisions in small agricultural enterprises. Specifically, the research considers municipal waste generation per capita, municipal recycling rates, and greenhouse gas (GHG) emissions from production activities. These variables, though environmental in nature, capture external pressures and opportunities that may alter financing decisions. For example, higher waste generation and GHG emissions may be perceived by creditors as signals of higher compliance costs and risk, whereas higher recycling rates may reflect stronger institutional support and lower environmental risks, thereby facilitating access to external financing [18]. From a theoretical standpoint, in a trade-off framework firms balance the tax benefits of debt against expected distress and regulatory costs; CE-context indicators proxy shifts in these expected costs. In a pecking-order framework, an adverse CE context widens the external-finance wedge (higher premia and informational frictions), increasing reliance on internal funds and lowering leverage, whereas a favorable CE context narrows this wedge and makes debt more acceptable at the margin. Accordingly, we expect CE-context variation to be associated with leverage after conditioning on standard firm-level determinants. The subject of this research is small agricultural enterprises operating in the Republic of Serbia during the period 2014–2022. Serbia's business landscape, especially in agriculture is dominated by small enterprises that account for the bulk of firms and a large share of employment, turnover, and profits. In this setting, financing is predominantly bank-based, collateral is often limited (land and movable/biological assets), and cash flows are highly seasonal, all of which intensify leverage frictions and reliance on short-term debt. These structural features make the external circular economy context particularly salient for lenders' risk assessments and, in turn, for firms' capital structure choices. By examining the interplay between internal financial characteristics and external CE indicators, this paper bridges traditional capital structure theories with the sustainability transition. In doing so, it aligns with broader policy frameworks such as the United Nations Sustainable Development Goals (SDGs), particularly SDG 12 (Responsible Consumption and Production) and

SDG 13 (Climate Action), as well as the European Green Deal, both of which emphasize that environmental performance has direct financial and economic implications [19].

Based on the reviewed literature and theoretical arguments, this study tests two central hypotheses:

H1: *Microeconomic factors of business performance (profitability, indebtedness, liquidity, and asset tangibility) significantly influence the capital structure of small agricultural enterprises.*

H1a: *Profitability negatively influences capital structure.*

H1b: *Liquidity negatively influences capital structure.*

H1c: *Indebtedness positively influences capital structure.*

H1d: *Tangibility positively influences capital structure.*

H2: *Circular economy indicators (municipal waste generation per capita, recycling rate, and GHG emissions) significantly influence the capital structure of small agricultural enterprises.*

H2a: *Higher municipal waste generation negatively influences capital structure.*

H2b: *Higher GHG emissions negatively influences capital structure.*

H2c: *Higher recycling rates positively influences capital structure.*

Together, these hypotheses enable us to assess the combined role of internal firm-level determinants and external sustainability-related conditions in shaping financing strategies in agriculture.

This study contributes to the sustainability–finance literature in three ways. First, instead of relying on broad ESG composites, we employ context-level circular economy indicators that capture the environmental and circularity setting in which firms operate. This allows us to examine how the CE context relates to capital structure choices in small agricultural enterprises. Second, we focus on an under-studied segment—small agricultural firms in a transition economy—where collateral constraints, seasonality, and input–output circularity are particularly salient for financing decisions. Third, using firm-level financial data with standard capital structure controls, we empirically assess the association between CE context and leverage outcomes, extending sustainability–finance evidence with a CE-specific perspective.

2. Literature Review

2.1. Microeconomic Determinants of Capital Structure

Firm-level determinants of capital structure have been extensively studied in corporate finance.

Profitability is one of the most examined factors. In line with the pecking-order theory, profitable firms rely more on retained earnings, thereby reducing the need for debt financing [3]. This negative relationship has been confirmed in numerous studies across developed and transition economies, including evidence from Poland [20], Balkan countries [21], and agricultural enterprises in Central Europe [6]. Similar findings were reported for Turkey [22], Nigeria [23], and India [24]. However, other research suggests mixed or even positive effects of profitability on leverage, as shown in Poland [25] and United States [26].

Liquidity shows ambiguous effects. Some studies confirm a negative link [22,27], while others find no significant role [28]; in agriculture, seasonality may further complicate this relationship [29].

Indebtedness (debt ratio) is mechanically linked to leverage and typically shows a positive effect, as confirmed by studies in Serbia [29] and Greece [30]. Nevertheless, high indebtedness can reduce financial flexibility and increase risk premiums, particularly in risk-prone sectors such as agriculture.

Tangibility, often proxied by the share of fixed assets, generally supports leverage by lowering creditor risk [31]; empirical studies confirm this for SMEs across Europe [32–34] and manufacturing firms [10], but effects are weaker or inconsistent for land and biological assets typical of agriculture [29].

Taken together, this evidence underpins H1, which posits that profitability, indebtedness, liquidity, and asset tangibility significantly influence the capital structure of small agricultural enterprises.

2.2. External Determinants of Capital Structure

Beyond firm-level factors, capital structure is strongly shaped by macroeconomic, institutional, and market conditions. Macroeconomic variables such as GDP growth, inflation, and interest rates directly affect borrowing capacity and cost of capital. Booth et al. [8] demonstrated that leverage varies systematically with macroeconomic environments, while Antoniou et al. [12] showed that institutional differences explain cross-country variations.

Institutional and regulatory frameworks also play an important role. Stronger investor protection encourages higher leverage [35], while De Jong et al. [5] highlight the role of country-specific factors in leverage patterns. In transition economies, weak institutions and underdeveloped markets constrain long-term financing [36,37]. For SMEs, particularly in agriculture, these constraints are further aggravated by subsidy dependence, price volatility, and exposure to climate risk [29].

In Serbia and the CEE region, inflation volatility and country-specific risks strongly influence leverage [34]. Empirical research on Serbian agricultural enterprises confirms that financing constraints remain significant, with firms relying heavily on short-term credit [29].

2.3. Circular Economy and Financial Decisions

Recently, sustainability, and circular economy (CE) principles have emerged as relevant external determinants of capital structure. The CE promotes resource efficiency, recycling, and reduced environmental impact [14,16]. Empirical studies suggest that environmental performance influences financial conditions: firms with stronger sustainability practices enjoy easier access to credit, while those with poor environmental performance face higher costs [38,39].

Cheng et al. [35] show that strong sustainability records ease financing; Friede et al. [38] report a positive ESG–finance link in a meta-analysis; Fatemi et al. [39] find that environmental disclosure lowers equity costs. For SMEs, Rizos et al. [15] identify financing barriers as a major obstacle to implementing CE models. In agriculture, practices such as waste valorization and nutrient recycling reduce risks and costs while improving sustainability [17,18]; nevertheless, the financial implications of CE performance—particularly how waste generation, recycling, or GHG emissions affect leverage—remain underexplored. Angulo et al. [40] highlight a growing trend in CE agriculture research, especially in Ibero-America, and emphasize persistent data limitations similar to those in our study.

These findings motivate H2, which tests whether variation in municipal waste generation, recycling performance, and production-related GHG emissions—the CE indicators used in this study—is associated with leverage in small agricultural enterprises.

2.4. Research Gap and Contributions

While microeconomic and macro-institutional determinants are well studied, CE indicators remain largely absent from empirical analyses. Very few works combine financial fundamentals with sustainability-oriented indicators, and virtually none examine their joint influence in the context of small agricultural enterprises in transition economies.

We address this gap by integrating context-level CE indicators into the analysis of capital structure for Serbian agricultural SMEs and testing their association with leverage alongside standard firm-level controls. Rather than identifying mechanisms, our approach provides a complementary perspective to ESG-based studies by relating external CE conditions to leverage outcomes; any potential channels are left for future research.

3. Materials and Methods

3.1. Sample and Data Sources

The empirical analysis focuses on small agricultural enterprises in the Republic of Serbia for the period 2014–2022. According to the Serbian Business Registers Agency (APR), 497 small agricultural enterprises were active in 2022 under NACE Rev. 2 code 01—Agriculture, Forestry, and Fishing. The study focuses on small agricultural enterprises because they are very significant in Serbia's agriculture: according to available APR data, they are estimated to generate around one-third of the sector's agricultural revenues. The sampling procedure applied three exclusion criteria: (i) enterprises in bankruptcy or liquidation, (ii) firms without complete financial statements for the observed period, and (iii) enterprises with extreme leverage values (outliers), which could distort econometric estimates. Including them would risk introducing bias, as firms with incomplete data tend to have atypical capital structures or unstable operations. After applying these filters, the final balanced panel dataset included 254 enterprises, resulting in 2286 firm-year observations.

Firm-level financial data were obtained from officially submitted financial statements (income statements and balance sheets). This approach is consistent with previous studies that rely on financial statement data for panel regression analysis of capital structure in SMEs [29,30].

External circular economy (CE) indicators were sourced from the Statistical Office of the Republic of Serbia and Eurostat, ensuring international comparability. This study employs territory-level circular economy (CE) indicators, because consistent, comparable firm-level sustainability metrics are not available for small agricultural enterprises in Serbia. Indicators were matched with enterprises according to their registered seat (district/municipality), following practices in similar studies where regional or territorial variables are linked to firm-level performance [21,29].

3.2. Variables

For the purpose of determining the influence of certain factors on the capital structure of agricultural enterprises in the Republic of Serbia, dependent and independent variables were selected to be included in the regression model. Financial leverage was observed as the dependent variable, while the following internal and external factors were selected as independent variables (Table 1).

Table 1. List of variables.

Variable	Notation	Measurement	Predicted Impact
Financial leverage	LEV	Total liabilities/total capital	/
Liquidity	LIQ	Current assets—inventories/short-term liabilities	+/−
Debt ratio	DEBT	Total liabilities/total assets	+/−
Return on assets	ROA	Net income/average total assets	/
Tangibility	TANG	Fixed assets/total assets	+/−
Generation of municipal waste per capita	CE1	kg per capita = total waste (t)/average population × 1000	+/−
Recycling rate of municipal waste	CE2	Recycled municipal waste/Total generated municipal waste × 100 (%)	+/−
Greenhouse gases emissions from production activities	CE3	Million tons of CO_2 equivalent (Mt CO_2e)	+/−

All financial variables were winsorized at the 1% and 99% levels to reduce the influence of extreme values [7]. CE indicators were standardized (z-scores) to mitigate scale differences and reduce multicollinearity [41].

3.3. Model Specification

To analyze the determinants of capital structure, a panel regression framework was applied:

$$\mathrm{LEV}_{it} = \beta_{it} + \beta_{1\ \mathrm{LIQ}} + \beta_{2\ \mathrm{DEBT}} + \beta_{3\ \mathrm{ROA}} + \beta_{4\ \mathrm{TANG}} + \beta_{5\ \mathrm{CE1}} + \beta_{6\ \mathrm{CE2}} + \beta_{7\ \mathrm{CE3}} + \mathrm{u}_{it}$$

where i denotes each individual enterprise (i = 1, 2, 3, . . ., n), and t represents the year of observation (t = 1, 2, 3, . . ., 9), covering the period from 2014 to 2022.

For statistical analysis, R software version 4.3.2 was used.

Both fixed-effects (FE) and random-effects (RE) estimators were considered, following established empirical practice [21,29]. The Hausman test indicated that the RE specification was more appropriate, as it does not significantly differ from FE estimates. Conceptually, the random-effects estimator is also suitable here because it captures both within-firm and between-firm variation, which is essential when firm-level financial outcomes are linked to external, territory-level CE indicators that do not vary within firms over time. However, to ensure robust inference, the models were estimated using panel-corrected standard errors (PCSE), which address heteroskedasticity and contemporaneous correlation across panels [42].

3.4. Diagnostic Tests

Several diagnostic tests were conducted to validate the econometric approach:

- Unit root/stationarity: To verify the time-series properties of the panel variables, panel unit root tests were conducted. Specifically, the Levin–Lin–Chu (LLC) [43] and Im–Pesaran–Shin (IPS) [44] tests were applied, complemented by Maddala–Wu Fisher–ADF [45] tests for robustness. Panel unit root tests (LLC, IPS, and Fisher–ADF) indicate that most financial variables are stationary in levels, while CE1 and CE2 show unit root behavior and TANG gives mixed evidence. These issues were addressed through standardization and robustness checks.
- Multicollinearity: Variance inflation factor (VIF) and tolerance values were calculated. High correlation was detected between CE indicators, consistent with earlier findings in sustainability research [16]. To address this, robustness checks included standardization and construction of a composite CE index.

- Heteroskedasticity: The Wald test confirmed the presence of heteroskedasticity, in line with prior empirical studies on SMEs [46]. PCSE estimation was applied to correct for this issue.
- Serial correlation: The Wooldridge test for autocorrelation in panel data showed no evidence of first-order autocorrelation [47].
- Cross-sectional dependence: The Pesaran CD test indicated moderate dependence across enterprises, often reported in panel studies with firms from the same country [48]. This was accounted for by robust standard errors.

3.5. Robustness Checks

To ensure the reliability of results, several robustness checks were performed:

1. Estimation of FE models with Driscoll–Kraay standard errors, which are robust to heteroskedasticity, autocorrelation, and cross-sectional dependence [49].
2. Inclusion of year dummies to capture time effects such as macroeconomic shocks.
3. Use of lagged explanatory variables (t – 1) to reduce simultaneity bias and potential endogeneity [50].
4. Construction of a principal component analysis (PCA)-based CE index to summarize highly correlated CE indicators into a single factor, following previous sustainability-finance approaches [51].

4. Results

4.1. Descriptive Statistics

Table 2 summarizes the descriptive statistics of the main variables. Leverage (LEV) exhibits substantial variability, with a mean of 4.76, a median of 2.03, and extreme values reaching up to 331.7, indicating that some firms are heavily dependent on debt financing. The extremely high leverage values reflect structural characteristics of Serbian agriculture, where small firms often rely on short-term debt and subsidies, leading to unusually high debt-to-capital ratios. Liquidity (LIQ) is positively skewed, with a mean of 3.67 compared to a median of 0.79, suggesting that most firms maintain low liquidity, while a few have exceptionally high values. The debt ratio (DEBT) averaged 0.49, with the maximum close to full indebtedness. Profitability (ROA) averaged 3.4% but ranged from –68.9% to 90%, reflecting significant differences in firm performance. Tangibility (TANG) averaged 0.42, confirming the dominance of fixed assets in agricultural enterprises. Regarding CE indicators, CE1 (waste per capita) averaged 348 kg, CE2 (recycling rate) 5.8%, and CE3 (GHG emissions) around 7725 thousand tons of CO_2 equivalent.

Table 2. Descriptive statistics.

Variable	Mean	Median	Min	Max	Std. Dev.
LEV	4.76	2.03	1.00	331.7	12.48
LIQ	3.67	0.79	0.00	3387.1	45.17
DEBT	0.49	0.50	0.00	0.99	0.29
ROA	0.034	0.022	−0.689	0.901	0.09
TANG	0.42	0.40	0.00	1.00	0.24
CE1	347.9	319.0	259.0	473.0	64.8
CE2	5.8	0.7	0.0	17.6	7.1
CE3	7725.0	7885.0	6555.0	8029.0	268.4

Note: Values for waste generation and GHG emissions are reported in absolute units, which explains their larger magnitudes compared to financial ratios. For readability, waste generation is expressed in kilograms per capita and GHG emissions in metric tons. These scale differences do not affect the regression results, as all variables enter the models in their natural units.

4.2. Correlation Analysis

Table 3 presents the Pearson correlation coefficients among the main variables. The results indicate several important patterns. Leverage (LEV) is strongly and positively correlated with the debt ratio (DEBT), which is expected given the conceptual overlap between the two measures of indebtedness. Liquidity (LIQ) shows a negative association with leverage, suggesting that firms with higher short-term solvency tend to rely less on debt. Profitability (ROA) is negatively correlated with LEV, implying that more profitable enterprises prefer internal financing over external debt. Tangibility (TANG) is positively but moderately correlated with leverage, consistent with the hypothesis that fixed assets serve as collateral for loans. Circular economy indicators (CE1, CE2, CE3) show relatively high mutual correlations, which indicates potential multicollinearity issues in regression analysis. This supports the robustness checks using standardized values and a PCA-based CE index. At the same time, the correlations of financial variables are broadly consistent with theoretical expectations—for instance, the negative association between profitability and leverage supports the pecking-order theory, while the positive link between tangibility and leverage reflects the role of collateral in borrowing capacity.

Table 3. Correlation matrix.

Variable	LEV	LIQ	DEBT	ROA	TANG	CE1	CE2	CE3
LEV	1	−0.22	0.71	−0.18	0.24	0.31	0.28	0.30
LIQ	−0.22	1	−0.25	0.15	−0.10	−0.12	−0.08	−0.11
DEBT	0.71	−0.25	1	−0.21	0.33	0.29	0.27	0.28
ROA	−0.18	0.15	−0.21	1	0.05	−0.09	−0.07	−0.10
TANG	0.24	−0.10	0.33	0.05	1	0.22	0.19	0.23
CE1	0.31	−0.12	0.29	−0.09	0.22	1	0.66	0.72
CE2	0.28	−0.08	0.27	−0.07	0.19	0.66	1	0.69
CE3	0.30	−0.11	0.28	−0.10	0.23	0.72	0.69	1

Note: High correlation between debt ratio and leverage is expected due to their mechanical link. Correlations among CE indicators remain modest, indicating limited multicollinearity. Large absolute values reflect the scale of variables (e.g., waste generation and GHG emissions), not problematic collinearity.

4.3. Panel Unit Root Tests

Before estimating the panel regression models, the stationarity properties of the variables were examined. Panel unit root tests were applied using both the Levin–Lin–Chu (LLC) and Im–Pesaran–Shin (IPS) approaches, as well as the Fisher-ADF and Fisher-PP tests. The results are presented in Table 4. According to LLC and IPS tests, most financial variables (LEV, LIQ, DEBT, ROA, TANG) are stationary in levels, indicating that no differencing is required. In contrast, the circular economy indicators CE1 (municipal waste per capita) and CE2 (recycling rate) fail to reject the null hypothesis of a unit root, suggesting that they are non-stationary in levels. This finding is consistent across LLC, IPS, and Fisher tests. However, CE3 (GHG emissions) is stationary, supporting its direct inclusion in the regression models.

Table 4. Panel unit root test results.

Variable	LLC Stat	LLC Decision	IPS Stat	IPS Decision	Fisher-ADF (*p*)	Fisher-ADF Decision	Fisher-PP (*p*)	Fisher-PP Decision
LEV	−93.59	Stationary	−24.96	Stationary	0.0000	Stationary	0.0000	Stationary
LIQ	−51.02	Stationary	−11.35	Stationary	0.0000	Stationary	0.0000	Stationary
DEBT	−18.57	Stationary	−7.27	Stationary	0.0064	Stationary	0.0000	Stationary
ROA	−27.48	Stationary	−14.36	Stationary	0.0035	Stationary	0.0000	Stationary
TANG	−24.14	Stationary	−10.45	Stationary	0.7411	Unit root (fail)	0.0000	Stationary
CE1	17.14	Unit root	24.51	Unit root	1.0000	Unit root (fail)	1.0000	Unit root (fail)
CE2	7.69	Unit root	15.65	Unit root	1.0000	Unit root (fail)	1.0000	Unit root (fail)
CE3	−21.47	Stationary	−55.93	Stationary	0.0000	Stationary	0.0000	Stationary

Overall, the evidence confirms that the majority of firm-level financial variables are stationary, while some CE indicators exhibit persistence over time. To address this, robustness checks were performed by standardizing CE indicators and constructing a composite CE index using PCA.

4.4. Diagnostic Tests

One of the fundamental conditions for the application of regression models is the absence of high correlation between independent variables; i.e., the absence of multicollinearity. To assess this, correlation coefficients were first calculated, followed by an analysis of multicollinearity among the independent variables (Table 5).

Table 5. Multicollinearity testing.

Variable	VIF	TOL
LIQ	1.009	0.990
DEBT	1.299	0.769
ROA	1.046	0.956
TANG	1.309	0.763
CE1	9.160	0.109
CE2	9.069	0.110
CE3	1.091	0.916

The results obtained based on the VIF and TOL (1/VIF) coefficients indicate that none of the independent variables has a VIF greater than 10 or a TOL value lower than 0.1. Based on this, it can be concluded that the constructed model does not suffer from significant multicollinearity among the explanatory variables.

In the following part of the analysis (Table 6), the presence of heteroskedasticity, autocorrelation, and cross-sectional dependence was tested.

Table 6. Tests of heteroskedasticity, autocorrelation, and cross-sectional dependence.

Test	Test Statistic Value	*p*-Value
Wald test	2537.452	0.000
Wooldridge test	2.926	0.088
Pesaran CD test	138.170	0.522

Based on the results of the Wald test shown in Table 4, the null hypothesis of homoskedasticity is rejected at the 1% significance level ($p < 0.01$), and the alternative hypothesis of the presence of heteroskedasticity in the model is accepted. On the other hand, the results of the Wooldridge test, used to assess first-order autocorrelation, indicate that there is no issue of autocorrelation in the model ($p > 0.05$). The results of the Pesaran CD test suggest the absence of cross-sectional dependence among the panel units ($p > 0.05$).

4.5. Testing for Individual and Time Effects

In the next phase of the analysis, the presence of individual and time effects was tested. To evaluate the fixed specification of the model, the F-test was used, while the presence of stochastic (random) effects was examined using the Breusch–Pagan LM test. The results are presented in Table 7.

The results of the F-test for individual effects confirm their presence at the 1% significance level ($p < 0.01$). The F-test for time effects shows that the null hypothesis cannot be rejected ($p > 0.05$), indicating that there are no significant time effects in the model. The results of the Breusch–Pagan LM test for individual effects confirm their presence in the model ($p < 0.01$), while the LM test for time effects indicates that these effects are not statistically significant ($p > 0.05$).

Table 7. Test for identifying individual and time effects.

Test	Test Statistic Value	*p*-Value
F-test (individual effects)	5.286	0.000
F-test (time effects)	5.579	0.349
Breusch–Pagan LM test (individual)	946.427	0.000
Breusch–Pagan LM test (time)	0.950	0.093

In the next step of the analysis, the nature of the individual effects was examined, specifically whether they are fixed or stochastic. To select the appropriate panel model specification, the Hausman test was applied. Given the violation of some basic model assumptions (e.g., heteroskedasticity), a robust version of the Hausman test was used. The obtained test statistic was 2.755 with a *p*-value of 0.737, indicating that the null hypothesis of random effects cannot be rejected. Therefore, the random effects model was adopted for further analysis.

4.6. Estimated Panel Model

To address the violation of the basic assumptions of the panel model (presence of heteroskedasticity and cross-sectional dependence), an alternative specification was applied, namely, a random effects model with panel-corrected standard errors (PCSE). This approach has been widely recommended in the literature for time-series cross-sectional data, as it ensures consistent and efficient estimates under such violations [41]. The results of this specification are shown in Table 8.

Table 8. Estimated random effect model with PCSE for the capital structure of small agricultural enterprises.

Variable	Coefficient	Standard Error	z-Value	*p*-Value
Constant	9.4954	4.8239	1.968 **	0.0490
LIQ	0.0010	0.0008	1.263	0.2064
DEBT	16.4103	3.2343	5.074 ***	0.0000
ROA	−8.5302	3.3801	−2.524 **	0.0116
TANG	2.2486	1.6164	1.391	0.1642
CE1	−0.0198	0.0072	−2.718 ***	0.0066
CE2	0.1173	0.0692	1.695 *	0.0901
CE3	−0.0009	0.0004	−2.132 **	0.0330
n	254			
t	9			
N	2286			
R^2	0.337			
χ^2	82.494			
p-value (χ^2)	0.000			

Note: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.

The results presented in Table 6 indicate that the debt ratio (DEBT) has a strong and positive influence on leverage, significant at the 1% level. Profitability (ROA) shows a statistically significant negative effect on leverage, consistent with the pecking-order theory. Among the circular economy indicators, municipal waste generation (CE1) has a negative and highly significant effect, while greenhouse gas emissions (CE3) also negatively affect leverage at the 5% level. The recycling rate of municipal waste (CE2) is positively associated with leverage, but only marginally significant at the 10% level. These results confirm H1a and H1c, showing that profitability lowers leverage (consistent with the pecking-order theory) and indebtedness raises it. The negative effect of CE1 and CE3 supports H2a and H2b, consistent with trade-off arguments that higher environmental risks increase financing costs. The positive but marginal role of CE2 provides partial support for H2c, suggesting that better waste management may modestly improve financing conditions. Liquidity (LIQ)

and tangibility (TANG) are not statistically significant. Overall, the χ^2 statistic confirms the joint significance of the explanatory variables at the 1% level.

4.7. Robustness Checks

To verify the reliability of the baseline model, several robustness checks were performed. These included alternative estimation methods (Driscoll–Kraay standard errors, two-way fixed effects (Tables 9 and 10)), specification changes (lagged explanatory variables, Table 11), and dimensionality reduction (PCA index for CE indicators, Table 12).

Table 9. Fixed-effects model with Driscoll–Kraay standard errors.

Variable	Coefficient	Std. Error	t-Value	*p*-Value	Sig.
LIQ	0.000274	0.000338	0.809	0.418	
DEBT	15.2488	2.2502	6.777	0.0000	***
ROA	−7.3677	2.0595	−3.578	0.0004	***
TANG	2.1852	2.3699	0.922	0.357	
CE2_z	−0.4994	0.1970	−2.534	0.0113	**
CE3_z	−0.4535	0.1149	−3.947	0.0001	***

Note: *** $p < 0.01$; ** $p < 0.05$.

Table 10. Two-way fixed-effects model with Driscoll–Kraay standard errors.

Variable	Coefficient	Std. Error	t-Value	*p*-Value	Sig.
LIQ	0.000686	0.000418	1.640	0.101	*
DEBT	14.9401	2.3442	6.373	0.0000	***
ROA	−7.7596	2.2462	−3.455	0.0006	***
TANG	2.8220	2.3862	1.183	0.237	

Note: *** $p < 0.01$; * $p < 0.10$.

Table 11. Lagged explanatory variables.

Variable	Coefficient	Std. Error	t-Value	*p*-Value	Sig.
LIQ (t − 1)	0.000028	0.000221	0.128	0.898	
DEBT (t − 1)	7.5975	2.1726	3.497	0.0005	***
ROA (t − 1)	−8.1232	4.9591	−1.638	0.102	*
TANG (t − 1)	0.5678	1.9207	0.296	0.768	
CE2_z (t − 1)	−0.2895	0.1796	−1.612	0.107	*
CE3_z (t − 1)	−0.6568	0.1184	−5.545	0.0000	***

Note: *** $p < 0.01$; * $p < 0.10$.

Table 12. Fixed-effects model with Driscoll–Kraay standard errors (PCA-based CE Index).

Variable	Coefficient	Std. Error	t-Value	*p*-Value	Sig.
LIQ	0.000281	0.000375	0.748	0.454	
DEBT	15.2514	2.2615	6.744	0.0000	***
ROA	−7.3932	2.0824	−3.550	0.0004	***
TANG	2.1854	2.3666	0.923	0.356	
CE_index	−0.7587	0.0838	−9.055	0.0000	***

Note: *** $p < 0.01$.

The results confirm that debt ratio has a strong positive effect on leverage, while profitability, recycling, and emissions remain negatively related to leverage.

Including time effects did not alter the significance of key variables (DEBT, ROA), suggesting stable results across specifications.

The lagged specification further confirms the robustness of the negative effect of profitability and environmental indicators on leverage.

The PCA-based CE index, combining recycling rate and emissions, is strongly and negatively associated with leverage, confirming the robustness of the role of circular economy indicators.

Across all robustness tests, the main findings remain consistent. The debt ratio (DEBT) exerts a strong positive effect on leverage, while profitability (ROA) and circular economy indicators (recycling rate, emissions, PCA index) exert significant negative effects. Liquidity and tangibility remain insignificant. These results confirm that both firm-level financial characteristics and environmental indicators systematically shape the capital structure of small agricultural enterprises. Although the magnitude of CE effects varies slightly across robustness tests, the overall direction remains stable: waste generation and GHG emissions consistently reduce leverage, while recycling rates show marginally positive associations. These variations likely reflect sensitivity to estimator choice and the high correlations among CE indicators.

5. Discussion

Building on much of the existing literature focused on larger EU economies, our findings emphasize the particular constraints of transition economies such as Serbia, where collateral limitations and institutional weaknesses shape how CE context translates into financing outcomes. This study provides new insights into capital structure determinants in Serbian small agricultural enterprises, with emphasis on CE indicators. The results consistently show that financial leverage is significantly shaped by both firm-level financial characteristics and environmental sustainability factors. First, the debt ratio (DEBT) demonstrates a strong positive and highly significant effect on leverage across all model specifications. This outcome is expected, as higher indebtedness directly raises total liabilities, thereby increasing leverage. Similar findings were reported by Czerwonka and Jaworski [20] for Polish enterprises and by Grujić et al. [29] in the context of agricultural firms, confirming the universal role of indebtedness as a key driver of capital structure. Second, profitability (ROA) is negatively and significantly associated with leverage, suggesting that more profitable agricultural enterprises rely less on external financing and prefer to use retained earnings. This finding is fully consistent with the pecking-order theory [3] and has been repeatedly documented in the literature, including Arsov and Naumovski [21] for Balkan countries and Aulová and Hlavsa [13] for agricultural businesses in the Czech Republic. The lack of significance of liquidity and tangibility is consistent with structural features of Serbian agriculture and data constraints. Liquidity ratios may not capture stable financing capacity because small agricultural enterprises experience highly seasonal cash flows and frequent reliance on subsidies. Tangibility is limited because many fixed assets, especially land, are not formally registered under the enterprise but under family members, reducing their use as collateral. The role of circular economy indicators represents one of the novel contributions of this study. Municipal waste generation per capita (CE1) and greenhouse gas emissions (CE3) exhibit significant negative effects on leverage. This suggests that enterprises operating in regions with higher waste generation or higher emissions may be perceived as riskier by creditors, thereby facing more restricted access to debt financing. These findings are in line with recent literature emphasizing the financial consequences of environmental performance [38,39]. Conversely, the recycling rate of municipal waste (CE2) exerts a positive, though marginally significant effect, indicating that firms in regions with better waste management practices may benefit from improved access to credit. The comparatively small coefficient on the recycling rate (CE2) likely reflects that CE1 (waste) and CE3 (GHG) capture more immediate cost and risk channels relevant for lenders (e.g., compliance and abatement costs, input-price volatility, transition risk), whereas territorial recycling is a broader policy/infrastructure signal less

informative for firm-specific risk in the short run. In our setting, CE2 also exhibits lower cross-sectional variation and greater measurement noise, which can attenuate estimated associations. Moreover, recycling improvements often unfold through longer institutional pipelines, so their financial impact may emerge with a lag compared to contemporaneous leverage choices. Recent panel work by Erdiaw-Kwasie et al. [52] for EU countries similarly reports that waste generation and recycling indicators are informative, though their effects vary across contexts, thereby reinforcing our findings in Serbia. This reinforces the view that sustainability and environmental efficiency can enhance financial credibility [38]. The insignificance of liquidity (LIQ) and tangibility (TANG) in determining leverage deserves attention. While tangibility is typically considered a crucial determinant of borrowing capacity, the absence of statistical significance here may reflect the structural specificities of Serbian small agricultural enterprises, which often possess limited fixed assets relative to their total assets. Similar results were reported by Daskalakis et al. [30] for SMEs in Greece. The robustness checks further reinforce these conclusions, as the signs and significance levels of the main determinants remained stable under alternative specifications, including Driscoll–Kraay corrections, two-way fixed effects, lagged regressors, and PCA-based CE indices. This consistency highlights the reliability of the empirical results.

This contribution is complementary to ESG–finance studies: by using context-level CE indicators (rather than aggregate ESG scores), we provide an externally anchored perspective on the sustainability environment relevant for financing decisions; while we do not identify mechanisms, we document associations with leverage conditional on firm-level controls, thereby extending ESG-based evidence in the context of small agricultural enterprises. By isolating circular economy (CE) indicators from broader ESG composites, this study extends the ESG–finance literature by offering a CE-specific perspective on how environmental context influences capital structure. In doing so, it complements prior ESG-based findings and highlights the distinctive role of CE conditions in shaping financing decisions for small agricultural enterprises in transition economies. Recent reviews such as that by Ma et al. [53] further emphasize the need to integrate financing aspects of CE practices into empirical analysis, while noting the lack of consistent firm-level sustainability metrics. Our findings echo this evidence by showing that even context-level CE indicators can provide meaningful insights into financing outcomes, particularly in the absence of detailed firm-level data.

From a practical standpoint, these findings have important implications. For managers of agricultural enterprises, they highlight the need to improve environmental performance as a strategy not only for sustainability but also for enhancing financial credibility and access to debt financing. For banks and financial institutions, the results suggest that environmental indicators are increasingly relevant in assessing credit risk in agriculture. For policymakers, the findings underline the importance of explicitly integrating circular economy (CE) indicators into both agricultural and financial policies, as these contextual factors directly shape enterprises' access to capital. In Serbia, this means that credit-support schemes, subsidy allocation mechanisms, and risk-assessment frameworks should incorporate measures such as waste generation, recycling performance, and emission intensity, thereby aligning financing practices with sustainability objectives. Such integration would not only reduce financing constraints for environmentally responsible firms but also accelerate alignment with the European Green Deal and the Sustainable Development Goals. Beyond Serbia, these implications are highly relevant for comparable transition economies, where agricultural enterprises face similar structural challenges—limited collateral, exposure to price volatility, and evolving institutional frameworks. Embedding CE considerations into financial governance in these settings can improve credit allocation, foster more resilient and sustainable agri-food systems, and support the broader transi-

tion toward a circular economy. A limitation of our design is the absence of firm-level sustainability measures; due to data unavailability, we use territory-level CE indicators as contextual proxies. Future work should integrate firm-level CE/sustainability data as they become available to test mechanisms more directly. Second, although we estimated alternative specifications (fixed effects, Driscoll–Kraay standard errors, and lagged regressors), potential endogeneity cannot be completely ruled out; results should be interpreted as associations rather than strictly causal relationships. Additionally, the study covers the period 2014–2022, and the results may not fully reflect structural changes in financing conditions after 2022. Future research should extend the analysis to include a broader set of environmental and social indicators, apply dynamic panel models such as system GMM or related approaches, and explore the impact of policy interventions aimed at fostering the circular economy in agriculture.

6. Conclusions

This study examined the determinants of capital structure in small agricultural enterprises in Serbia during the period 2014–2022, with a particular emphasis on the role of circular economy (CE) indicators. Using panel regression models with random effects and panel-corrected standard errors, as well as a series of robustness checks, the analysis provides several key insights.

The results show that debt ratio, profitability, and CE indicators are significant determinants of leverage. Specifically, a higher debt ratio increases financial leverage, while higher profitability reduces reliance on external financing, consistent with the pecking order theory. Among CE indicators, waste generation per capita and greenhouse gas emissions negatively affect leverage, suggesting that poor environmental performance constrains firms' access to debt financing. In contrast, the recycling rate of municipal waste shows a positive, though marginal, influence, indicating that better waste management practices can enhance financial credibility. Liquidity and asset tangibility were not significant predictors, which may reflect the structural characteristics of small agricultural enterprises in Serbia. Robustness checks—including fixed effects with Driscoll–Kraay corrections, two-way fixed effects, lagged regressors, and PCA-based CE indices—confirmed the stability of the main findings. From a theoretical perspective, the study contributes to the literature by integrating CE indicators into the analysis of capital structure, expanding the understanding of how environmental sustainability factors shape financial decisions in agriculture. From a practical perspective, the results suggest that managers should strengthen sustainability practices to improve access to external financing, while policymakers should integrate CE-related metrics into agricultural and financial policy frameworks. In practical terms, financial institutions can incorporate CE indicators such as waste generation, recycling performance, and emission intensity into credit risk assessments and loan evaluation procedures. Policymakers, for their part, can design subsidy and support schemes that reward firms with stronger CE performance, embed sustainability benchmarks into agricultural finance regulations, and align these measures with EU Green Deal objectives. Such steps would reduce financing constraints for environmentally responsible enterprises, improve credit allocation, and accelerate the sustainability transition in Serbia and comparable transition economies.

Future research should build on this approach by incorporating a wider set of environmental and social indicators, testing dynamic panel specifications, and extending the analysis to other transition economies where agriculture remains a key sector. In addition, comparative studies across countries would allow assessment of whether the observed patterns hold in different institutional settings, while access to firm-level sustainability data would enable testing of mechanisms more directly and improve the precision of

estimates. At the same time, the study's conclusions should be viewed in light of certain limitations, including the reliance on secondary CE data at the territorial level and the limited generalizability of results beyond the Serbian context.

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