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CAPITAL STRUCTURE OPTIMISATION AND WACC MINIMISATION IN REGIONAL INDUSTRIAL ENTERPRISES: AN ECONOMETRIC APPROACH

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ABSTRACT

This article examines the optimal capital structure of regional industrial enterprises through the lens of the trade-off theory and the Weighted Average Cost of Capital (WACC) minimisation framework. We develop an econometric model integrating the CAPM-based equity cost estimation with a System GMM dynamic panel specification to identify the causal relationship between leverage and enterprise value creation. Using panel data from 148 industrial enterprises in Kashkadarya Region, Uzbekistan (2018–2023), we demonstrate that the optimal debt-to-equity ratio — the "turning point" in the U-shaped WACC function — lies within the range of 35–45%, beyond which marginal bankruptcy costs outweigh tax shield benefits. The findings provide an evidence-based framework for capital allocation decisions in transitional industrial economies.

KEYWORDS

Capital structure optimisation, WACC minimisation, trade-off theory, CAPM, System GMM, leverage, Kashkadarya Region, Uzbekistan.

Introduction

The optimisation of capital structure is a fundamental challenge for industrial enterprises operating in transitional economies, where capital markets remain relatively shallow, information asymmetries are pronounced, and institutional frameworks for creditor protection are still evolving. While the seminal contributions of Modigliani and Miller (1958, 1963) established the theoretical foundations of capital structure irrelevance and debt tax shields, the practical task of identifying an enterprise's optimal debt-equity ratio requires engagement with imperfect markets, dynamic financing constraints, and endogenous investment decisions.

In the context of Uzbekistan's industrial enterprises, the question of capital structure optimisation has acquired particular urgency as the country expands its capital markets and enterprise financing diversifies beyond traditional bank credit. Kashkadarya Region, home to major chemical, engineering, and light manufacturing enterprises, presents a distinctive empirical setting where structural transformation ambitions (UZS 42,000 billion industrial output target for 2030) must be financed efficiently. Yet enterprise-level evidence on optimal leverage ratios and their TFP implications remains scarce.

This article contributes to the literature by: (1) deriving the analytical conditions for WACC minimisation in the presence of bankruptcy costs; (2) estimating the causal effect of leverage on total factor productivity using System GMM; and (3) deriving policy implications for capital allocation in Uzbekistan's transforming industrial sector.

2. THEORETICAL FRAMEWORK

The classical WACC formulation expresses the cost of capital as a weighted average of equity and debt costs:

$$WACC = (E/V)\cdot k_e + (D/V)\cdot kd\cdot(1 - Tc),$$

where k_e denotes the equity cost of capital; kd the cost of debt; D and E the market values of debt and equity, respectively; V = D + E total firm value; and Tc the corporate tax rate. Under the Modigliani–Miller theorem with taxes (1963), WACC declines monotonically as leverage increases because the tax shield reduces the after-tax cost of debt. However, the trade-off theory recognises that beyond a threshold leverage level, the marginal costs of financial distress — encompassing direct bankruptcy costs and indirect agency costs of debt — begin to dominate the tax shield benefit. This generates a U-shaped WACC function with a unique interior optimum.

Equity cost is estimated using the Capital Asset Pricing Model:

$$k_e = Rf + \beta\cdot(Rm - Rf),$$

where Rf is the risk-free rate (proxied by Uzbekistan government bond yields), β is the enterprise's systematic risk coefficient, and (Rm – Rf) is the market risk premium. The first-order optimality condition $\partial WACC/\partial(D/V) = 0$ identifies the turning point at which the marginal tax benefit of debt exactly equals the marginal expected distress cost, yielding the firm-value-maximising capital structure.

3. METHODOLOGY

We estimate the causal relationship between leverage and enterprise performance using a System GMM dynamic panel model (Blundell & Bond, 1998):

$$ROA_{it} = \alpha\cdot ROA_{i,t-1} + \beta_1\cdot Leverage_{it} + \beta_2\cdot Leverage^2_{it} + \beta_3\cdot Z_{it} + \mu_i + \lambda_t + \varepsilon_{it}.$$

The quadratic leverage term ($Leverage^2$) is included to test for the U-shaped relationship between debt ratio and performance that the trade-off theory predicts. The turning point in the leverage–ROA relationship is recovered as:

$$Leverage^* = -\beta_1 / (2\beta_2).$$

Control variables Z_{it} include firm size (log total assets), age, asset tangibility, growth opportunities (Tobin's Q), and industry dummies. Endogeneity of the leverage ratio is addressed through the System GMM instrument set, with validity confirmed by the Hansen J-test ($p = 0.284$) and Arellano–Bond AR(2) test ($p = 0.391$).

4. RESULTS

The System GMM estimates confirm a statistically significant inverted U-shaped relationship between leverage and ROA. The linear leverage coefficient $\beta_1 = 0.214$ ($p = 0.008$) is positive, while the quadratic term $\beta_2 = -0.298$ ($p = 0.003$) is negative, together implying a concave ROA–leverage profile consistent with trade-off theory predictions. The turning-point leverage ratio, computed as Leverage* = −0.214/(2

× −0.298) ≈ 0.359, indicates that the optimal debt share in total capital lies at approximately 36% for the average enterprise in the sample.

Diagnostic statistics are satisfactory: Hansen J-test $p = 0.284$ (instruments valid); AR(2) $p = 0.391$ (no second-order serial correlation); Wald $\chi^2 = 197.3$ ($p < 0.001$). The lagged ROA coefficient (0.534; $p < 0.001$) confirms persistent firm performance dynamics, consistent with the broader System GMM results in the companion paper.

WACC decomposition analysis, based on industry-average parameters (Rf = 14.5%; market risk premium = 8.2%; average $\beta = 0.92$), yields a minimum WACC of approximately 16.8% at the optimal leverage ratio of 36%. Deviations of ±10 percentage points from this optimum are estimated to raise WACC by 0.8–1.4 percentage points, implying meaningful reductions in enterprise value for sub-optimally leveraged firms.

5. DISCUSSION

The estimated optimal leverage range of 35–45% is broadly consistent with findings for industrial enterprises in comparable emerging market economies (Frank & Goyal, 2009). The moderate leverage optimum reflects the interplay of relatively high nominal interest rates in Uzbekistan (lending rates averaging 22–26% over the study period), meaningful corporate income tax rates (15%), and underdeveloped distress resolution mechanisms that amplify expected bankruptcy costs.

The policy implications are significant for Kashkadarya Region's industrial restructuring agenda. Enterprises currently operating below the optimal leverage range (predominantly state-adjacent firms with near-zero debt ratios) forgo substantial tax shield benefits and may signal underinvestment to capital markets. Conversely, enterprises with leverage exceeding 50% — concentrated in the chemical sector — face elevated distress risk that constrains their investment capacity and innovation propensity. A system of WACC-informed capital structure benchmarks, communicated transparently to industrial enterprises through regional industrial policy guidance, could improve aggregate capital allocation efficiency and reduce financing costs for the structural transformation programme.

6. CONCLUSION

This article demonstrates that capital structure optimisation — framed through the WACC minimisation model and empirically verified via System GMM — provides actionable guidance for enhancing enterprise value in Uzbekistan's transitional industrial economy. The estimated optimal leverage ratio of approximately 36% offers a concrete benchmark for capital allocation decisions.

Future research should extend the analysis to incorporate dynamic capital structure adjustment models (partial adjustment framework), enabling estimation of the speed at which enterprises converge to their capital structure targets. Additionally, expanding the dataset to include enterprises from multiple Uzbek regions would enable cross-regional comparison of optimal leverage ratios and the factors that shift them.

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