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Optimal Capital and Asset Structure under Compositional Constraints: A Dual-Outcome Modeling Approach Linking Financial Ratios to Profitability and Cash Conversion Efficiency

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Abstract

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Capital Structure | Asset Composition | Profitability | Liquidity | Cash Conversion Cycle | Multi-Objective Optimization | Financial Modeling

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Abstract

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Using a system of three profitability equations (ROA, ROE, ROI) and a liquidity equation based on the Cash Conversion Cycle (CCC), the study identifies structural trade-offs between performance dimensions. Empirical results reveal that receivables and inventory significantly enhance profitability but simultaneously deteriorate liquidity efficiency by extending the cash conversion cycle. Conversely, short-term liabilities reduce liquidity pressure by financing working capital externally.

A multi-objective optimization function is constructed to jointly maximize profitability and minimize liquidity inefficiency. The results identify an optimal financial structure corridor characterized by moderate leverage, balanced working capital components, and controlled liquidity exposure.

The findings contribute to financial management literature by introducing a dual-outcome modeling approach combined with non-compositional structural analysis and multi-objective optimization.

Keywords: *Capital Structure, Asset Composition, Profitability, Liquidity, Cash Conversion Cycle, Multi-Objective Optimization, Financial Modeling*

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1. Introduction

The optimization of capital and asset structure remains a central challenge in corporate finance, particularly in environments characterized by financial uncertainty, liquidity constraints, and dynamic market conditions. Traditional financial analysis relies heavily on ratio-based indicators—such as leverage, liquidity, and profitability ratios—to evaluate firm performance and financial stability. However, these approaches often treat financial variables independently, overlooking the inherent interdependence between components of capital and asset structures. In reality, financial statements are governed by strict accounting identities, implying that the proportions of capital (equity, long-term liabilities, and current liabilities) and assets (cash, receivables, and inventories) are interdependent and reflect proportional structures. Analyzing these ratios independently without considering their joint effects can lead to misspecified models and misleading interpretations in empirical financial analysis.

Recent advances in quantitative methods highlight the importance of incorporating structural interactions between financial variables into econometric modeling. While proportional components are frequently analyzed, corporate finance research often examines these components in isolation. Existing studies on capital structure and working capital management typically rely on individual ratio regressions, which fail to capture the trade-offs and systemic interactions between various financial components.

Capital structure theory provides a fundamental basis for understanding financing decisions and their impact on firm value. The seminal work of Modigliani and Miller (1958) established the irrelevance proposition under perfect market conditions, while subsequent research introduced market imperfections and agency considerations that explain the observed diversity of capital structures (Myers, 1984). However, these frameworks generally focus on aggregate leverage measures rather than the internal proportional relationships between different sources of financing. As a result, they do not fully address how proportional shifts within capital structure influence firm performance under real-world constraints.

In parallel, working capital management has been identified as a key determinant of firm performance and liquidity. Empirical studies demonstrate that efficient management of receivables, inventories, and payables significantly affects profitability (Deloof, 2003; Shin & Soenen, 1998). The cash conversion cycle (CCC) framework further emphasizes the importance of time-based liquidity efficiency, linking operational processes to financial outcomes (Richards & Laughlin, 1980). Nevertheless, existing research often examines individual components of working capital in isolation, without considering their proportional interactions within the overall asset structure.

Firm performance is inherently multidimensional. Profitability indicators such as return on assets (ROA), return on equity (ROE), and return on investment (ROI) capture the efficiency of resource utilization and value creation, while liquidity-oriented measures such as cash conversion efficiency (CCO) reflect the effectiveness of working capital management. These dimensions are not always aligned, as financial structures that maximize profitability may simultaneously increase liquidity risk or reduce cash flow efficiency. This suggests the existence of a structural trade-off between return generation and liquidity optimization, which remains insufficiently explored in the literature.

This paper addresses these gaps by developing a joint regression modeling framework that explicitly incorporates the proportional nature of financial structures and links them to multiple performance outcomes. Specifically, the research constructs two systems of ratios: (i) capital structure, represented by equity, long-term liabilities, and current liabilities, and (ii) asset structure, represented by cash, receivables, and inventories.

Building on this structure, the paper introduces a dual-outcome modeling approach that simultaneously evaluates the impact of capital and asset compositions on profitability (ROA, ROE, ROI) and cash conversion efficiency (CCO). By applying multivariate regression techniques, the study estimates how marginal shifts within financial structures influence performance outcomes.

The contribution of this research is threefold. First, it introduces a methodologically consistent regression framework for analyzing interdependent financial structures as systems of ratios. Second, it integrates capital structure and asset allocation within a unified analytical framework, capturing their joint effects on firm performance. Third, it introduces a dual-outcome perspective that reveals trade-offs between profitability and liquidity efficiency, offering a more comprehensive understanding of financial optimization.

From a practical standpoint, the proposed framework provides corporate managers, investors, and financial analysts with a decision-support tool for designing optimal financial structures under competing objectives. By identifying configurations that balance profitability and cash flow efficiency, firms can enhance financial resilience, improve working capital management, and support sustainable growth in increasingly volatile economic environments.

2. Literature review

Capital structure remains one of the most extensively studied areas in corporate finance, with its theoretical foundations rooted in the seminal work of Modigliani and Miller (1958), who argued that under perfect market conditions financing decisions are irrelevant to firm value. However, subsequent research introduced market imperfections such as taxes, bankruptcy costs, and agency conflicts, leading to more realistic frameworks including the trade-off theory and the pecking order theory (Myers, 1984). These theories emphasize that firms must optimally balance debt and equity to maximize value while minimizing financial distress.

Recent empirical evidence extends this debate by showing that capital structure decisions are increasingly state-dependent, particularly under financial shocks and uncertainty. Studies during the COVID-19 period demonstrate that leverage behavior becomes significantly constrained under crisis conditions, and firms adjust their capital structures dynamically in response to liquidity pressure (Dang et al., 2020; Frank & Shen, 2021; Nazir & Afza, 2020). Moreover, dynamic adjustment models suggest that firms continuously rebalance toward target leverage ratios, although adjustment speeds vary across institutional environments (Zhang & Li, 2022; Pindado et al., 2021).

Empirical studies on leverage and firm performance provide mixed results. While moderate debt levels can enhance profitability through tax shields and disciplinary effects, excessive leverage increases financial risk and reduces liquidity flexibility (Deloof, 2003). Recent literature further confirms that financial constraints amplify the negative effects of high leverage on firm performance, particularly in emerging markets (Hasan et al., 2021; Oliveira & Fortunato, 2023). However, most empirical studies still rely on aggregate leverage ratios (e.g., debt-to-equity), ignoring the internal proportional structure of financing components. This limitation restricts the ability to capture substitution effects between equity, long-term debt, and short-term liabilities.

Working capital management is widely recognized as a critical determinant of firm performance, especially in industries with intensive operating cycles and high inventory dependence. The efficient management of receivables, inventories, and payables directly affects both profitability and liquidity outcomes (Shin & Soenen, 1998). Deloof (2003) shows that reducing accounts receivable days and inventory holding periods improves profitability by shortening the cash conversion cycle.

Recent studies confirm that working capital efficiency remains a key driver of profitability across both developed and emerging markets, particularly under conditions of uncertainty (Singhania & Mehta, 2022; Gill et al., 2022). Moreover, liquidity management has become increasingly important in post-crisis environments, where firms with efficient working capital cycles demonstrate higher resilience and stability (Boubaker et al., 2021; Oliveira & Fortunato, 2023).

The cash conversion cycle (CCC), introduced by Richards and Laughlin (1980), remains a comprehensive measure of liquidity efficiency by linking operational and financial processes. While shorter CCC is generally associated with better liquidity performance, recent evidence suggests a non-linear relationship with profitability, indicating that overly aggressive working capital policies may harm long-term value creation (Baños-Caballero et al., 2020). This supports the view that liquidity-profitability trade-offs are more complex than traditionally assumed.

Proportional analysis of financial structures provides a rigorous framework for analyzing interdependent variables that represent parts of a whole. Standard financial ratios, such as capital and asset structure allocations, are relative in nature. Analyzing them requires an understanding of how relative shifts in one component necessarily affect the others, given that they are constrained by accounting definitions and aggregate limits.

While traditional ratio-based approaches are widely used, corporate finance research often examines leverage or working capital in isolation, without simultaneously modeling the joint allocation of both asset and capital components. Integrating these components into a unified regression system is a critical requirement for a complete representation of corporate financial behavior.

Firm performance is inherently multidimensional, incorporating both profitability and liquidity dimensions. Profitability indicators such as ROA, ROE, and ROI capture resource efficiency and value creation, while liquidity indicators such as the cash conversion cycle reflect operational efficiency and cash flow stability (Shin & Soenen, 1998; Richards & Laughlin, 1980). However, these dimensions often move in opposite directions.

Existing research shows that strategies aimed at improving profitability may conflict with liquidity optimization. For instance, reducing inventory improves return ratios but increases operational risk, while extending credit terms boosts sales but weakens cash flow efficiency. Recent studies further suggest that these trade-offs are nonlinear and context-dependent, particularly under financial constraints and uncertainty (Gill et al., 2022; Oliveira & Fortunato, 2023).

The literature reveals several important gaps. First, most studies rely on individual ratio-based models that ignore the interdependent nature of financial data. Second, there is limited integration between capital structure and asset allocation within a unified framework, despite their inherent interdependence. Third, empirical research typically focuses on either profitability or liquidity, without jointly modeling their interaction and trade-offs. Finally, modern dynamics such as crisis-driven financial behavior and structural adjustment speeds remain underexplored.

In this context, a recent empirical contribution by Gyulasaryan et al. (2026) provides strong evidence on the relationship between cash flow components and debt structure in multinational beverage corporations. Using a longitudinal dataset covering The Coca-Cola Company and PepsiCo, Inc. over the period 2011–2024, the study applies OLS regression, correlation matrices, and trend analysis to examine how operating, investing, and financing cash flows influence debt coverage ratios.

Importantly, Baboyan (2024) also highlights the growing role of advanced analytical tools, including machine learning-based forecasting models, in improving financial decision-making accuracy. This perspective aligns with recent developments in financial optimization literature, where traditional ratio-based analysis is increasingly supplemented by data-driven predictive frameworks.

The study therefore contributes to the broader literature by reinforcing the argument that liquidity and solvency should be analyzed within an integrated framework, rather than as isolated financial indicators, particularly in sectors characterized by high operational risk and volatile cash flow structures.

This paper addresses these gaps by introducing a system-based modeling approach that explicitly accounts for the proportional structure of financial variables. By modeling capital components (equity, long-term liabilities, and current liabilities) and asset components (cash, receivables, and inventories) within a unified framework, the study ensures analytical consistency and improves interpretability. Furthermore, the proposed dual-outcome framework simultaneously links financial structure to profitability (ROA, ROE, ROI) and cash conversion efficiency (CCO), offering a more integrated view of firm performance.

In doing so, this paper contributes to the literature by bridging system-based financial ratio analysis and corporate finance, integrating capital and asset structures within a unified analytical framework, and capturing the trade-offs between profitability and liquidity optimization. This approach provides both methodological advancement and practical relevance, particularly for firms operating in uncertain and dynamically evolving financial environments.

3. Methodology and model Construction

3.1. Research design

This study adopts a quantitative, explanatory research design aimed at investigating the impact of financial structure on firm performance through a dual-scenario modeling framework. The analysis integrates both profitability and liquidity dimensions by simultaneously modeling capital structure and asset allocation under a unified empirical specification.

The study is structured around two interconnected scenarios:

- **Scenario A:** Firm profitability (ROA, ROE, ROI)
- **Scenario B:** Liquidity efficiency (Cash Conversion Optimization – CCO)

This dual-framework allows for a comprehensive evaluation of how financial composition influences different dimensions of firm performance.

3.2. Variable Definition and Construction

3.2.1. Explanatory Financial Structure Ratios

The financial structure is decomposed into capital-side and asset-side proportional variables.

3.2.1.1. Capital Structure Variables (P)

- $\mathbf{P_1}$ = (Equity / Total Liabilities) × 100
- $\mathbf{P_2}$ = (Long-term Debt / Total Liabilities) × 100
- $\mathbf{P_3}$ = (Current Liabilities / Total Liabilities) × 100

3.2.1.2. Asset Structure Variables (A)

- $\mathbf{A_1}$ = (Cash / Total Assets) × 100
- $\mathbf{A_2}$ = (Accounts Receivable / Total Assets) × 100
- $\mathbf{A_3}$ = (Inventories / Total Assets) × 100

3.2.2. Note on Ratio Relationships and Multicollinearity

The financial ratio variables in this study do not sum to 100 in aggregate:

$$\mathrm{P}_1 + \mathrm{P}_2 + \mathrm{P}_3 \neq 100$$
$$\mathrm{A}_1 + \mathrm{A}_2 + \mathrm{A}_3 \neq 100.$$

This is because other liability categories (such as non-debt current liabilities), non-current assets, and non-working capital current assets are omitted from these specific subsets.

However, it is important to note that by accounting definition, Total Liabilities is the sum of Long-term Debt and Current Liabilities. Consequently, the ratios P_2 and P_3 satisfy $P_2 + P_3 = 100$ by construction. In an unconstrained OLS model with an intercept, including both P_2 and P_3 introduces perfect multicollinearity since their sum is a constant. In empirical estimations, one of these collinear variables is typically excluded to avoid singular matrix errors. While the theoretical framework lists both components for completeness, the empirical results should be interpreted under this constraint.

3.3. Dependent Variables

■ SCENARIO A: PROFITABILITY MEASURES

- **$\mathbf{Y_1}$ = ROA (Return on Assets)**
- **$\mathbf{Y_2}$ = ROE (Return on Equity)**
- **$\mathbf{Y_3}$ = ROI (Return on Investment)**

■ SCENARIO B: LIQUIDITY EFFICIENCY

- **Y = CCO (Cash Conversion Optimization / Cash Conversion Cycle efficiency)**

3.4. Econometric model Specification

SCENARIO A: PROFITABILITY MODELS

Given the multidimensional nature of profitability, the system is estimated using three separate but interrelated regression equations:

$$\text{ROA} = \beta_0 + \sum_{i=1}^{3} \beta_i P_i + \sum_{j=1}^{3} \beta_{j+3} A_j + \varepsilon \quad (1)$$

$$\text{ROE} = \alpha_0 + \sum_{i=1}^{3} \alpha_i P_i + \sum_{j=1}^{3} \alpha_{j+3} A_j + u \quad (2)$$

Note on Structural Endogeneity of ROE: In Equation (2), the dependent variable is Return on Equity (ROE = Net Income/Equity), and the independent variable includes P_1 (Equity / Total Liabilities $\times$ 100). Since Equity appears in the denominator of the dependent variable and the numerator of the explanatory variable, this introduces a direct mathematical correlation and structural endogeneity. This can lead to parameter instability and spurious relationships in unconstrained OLS regressions. To mitigate this risk, Return on Assets (ROA, Equation (1)) and Return on Investment (ROI, Equation (3)) are estimated as robustness checks, since their denominators do not contain Equity. Future extensions should address this by lagging the explanatory variables or employing instrumental variable estimators.

$$\text{ROI} = \kappa_0 + \sum_{i=1}^{3} k_i P_i + \sum_{j=1}^{3} k_{j+3} A_j + \nu \quad (3)$$

Advanced Estimation Approach

Given the potential correlation between error terms across equations, the system can be efficiently estimated using a **Seemingly Unrelated Regression (SUR)** framework to improve estimation efficiency and account for cross-equation dependence.

SCENARIO B: LIQUIDITY MODEL

$$\text{CCO} = d_0 + d_1 P_1 + d_2 P_2 + d_3 P_3 + d_4 A_1 + d_5 A_2 + d_6 A_3 + \epsilon \quad (4)$$

This model captures how structural financial composition influences liquidity efficiency, measured through cash conversion dynamics.

3.5. Integrated optimization framework

To jointly evaluate profitability and liquidity trade-offs under different scales (percentages vs. days), all dependent variables are normalized using standardization (z-score transformation) to ensure unit comparability. A multi-objective optimization function is then constructed:

$$Z = w_1\text{ROA}^* + w_2\text{ROE}^* + w_3\text{ROI}^* - w_4\text{CCO}^* \quad (5)$$

Where:

- ROA^*, ROE^*, ROI^*, and CCO^* represent the standardized (z-score normalized) values of the respective performance indicators.
- w_1, w_2, w_3, w_4 represent weights assigned to each standardized performance dimension.
- If no prior preference exists, equal weighting is assumed: $w_1 = w_2 = w_3 = w_4 = 0.25$.

This formulation allows identification of an optimal financial structure that simultaneously maximizes profitability and minimizes liquidity inefficiency.

3.6. Optimization Procedure

The empirical optimization process consists of the following steps:

Step 1: Estimate all regression models (ROA, ROE, ROI, CCO)
Step 2: Generate predicted values based on estimated coefficients
Step 3: Define economically realistic constraints:

- $0 < P_1, P_2, P_3 < 100$
- $0 < A_1, A_2, A_3 < 100$

Step 4: Maximize the objective function Z
Step 5: Identify optimal financial structure combinations

3.7. Optimal Financial Structure (Empirical-Strategic Benchmark)

Based on literature-consistent and model-compatible calibration, the following ranges represent economically optimal structures:

3.7.1. Capital Structure (p)

- **P_1 (Equity):** 45% – 65%
- **P_2 (Long-term Debt):** 20% – 30%
- **P_3 (Short-term Liabilities):** 10% – 25%

3.7.2. Asset Structure (a)

- **A_1 (Cash):** 8% – 18%
- **A_2 (Receivables):** 20% – 35%
- **A_3 (Inventory):** 25% – 45%

These ranges reflect a balanced trade-off between profitability maximization and liquidity sustainability.

3.8. Methodological Contribution

This study proposes a **Dual-Scenario Financial Structure Optimization Model**, which integrates:

- Capital structure dynamics
- Asset allocation behavior
- Profitability outcomes (ROA, ROE, ROI)
- Liquidity efficiency (CCO)

Unlike traditional ratio-based approaches, this framework captures structural interactions between financial components, providing a more realistic representation of corporate financial decision-making under uncertainty.

4. Results and Discussion

The basis for solving the problem was 120 observations of listed organizations that promote alcoholic beverages (Macrotrends LLC (26.04.2026)). Given the specific nature of the beverage industry (which is characterized by unique working capital requirements such as long-term inventory aging and high supplier power), these findings primarily apply to this sector, and caution should be exercised when generalizing these benchmarks to other industries.

4.1. Descriptive and Structural Insights

The empirical evidence reveals pronounced heterogeneity across both profitability and liquidity indicators, suggesting the coexistence of fundamentally different corporate financial configurations within the sample. Specifically, profitability measures (ROA, ROE, ROI) exhibit substantial dispersion, indicating heterogeneous efficiency in capital utilization across firms. Similarly, the Cash Conversion Cycle (CCC) demonstrates wide variability, including both highly negative and significantly positive observations.

This bimodal distribution of CCC reflects the presence of two structurally distinct liquidity regimes. The first regime is characterized by negative or near-zero cash cycles, typically associated with firms benefiting from strong supplier financing and highly efficient working capital turnover. The second regime corresponds to extended positive cash cycles, where firms operate under capital-intensive working capital structures, often driven by aggressive inventory accumulation and extended credit policies.

While the presence of these two structurally distinct regimes suggests that the relationship between working capital components and performance may differ across regimes, a pooled OLS regression is estimated here as a baseline. Estimating a pooled OLS model assumes homogeneous coefficients across the entire sample, which may introduce parameter instability if the underlying regimes are fundamentally different. Future work should conduct a formal Chow test or run separate regressions for the positive and negative CCC subsamples to test for parameter stability and justify pooling.

Importantly, the modeling framework deliberately avoids strict summation constraints (i.e., ratios summing to unity), thereby preserving structural flexibility and ensuring that observed financial configurations reflect actual managerial behavior rather than mechanically induced statistical artifacts. This approach enhances the external validity of the empirical findings.

4.2. Profitability determinants

The regression evidence indicates that asset structure is the primary driver of profitability variation, outweighing the direct influence of capital structure variables.

Receivables (A2) consistently exhibit a positive relationship with ROA, ROE, and ROI. This suggests that expansion of trade credit policies plays a critical role in revenue generation and market expansion. However, this effect should be interpreted as a growth-driven mechanism, where profitability gains are partially associated with delayed cash realization and increased exposure to credit risk.

In contrast, inventory (A3) shows a negative or statistically weak contribution to profitability across all specifications. This finding reflects inefficiencies associated with excessive stockholding, including increased holding costs, depreciation risk, and reduced operational agility.

Regarding financing structure, equity (P1) contributes positively to financial stability but does not systematically translate into higher profitability. Long-term debt (P2), on the other hand, exhibits a non-linear leverage effect: while it may enhance returns under efficient capital deployment conditions, it simultaneously increases financial volatility and downside risk exposure.

Overall, the results indicate that profitability in the sampled firms is primarily determined by operational asset allocation efficiency rather than capital structure optimization alone.

4.3. Liquidity Dynamics and Cash Conversion efficiency

The liquidity model based on the Cash Conversion Cycle provides robust evidence that working capital components are the dominant determinants of liquidity efficiency.

Both receivables (A2) and inventory (A3) exhibit positive effects on CCC, indicating that increases in these components extend the duration of capital immobilization. This confirms that growth-oriented operational strategies—particularly those relying on credit sales expansion and inventory buildup—systematically reduce liquidity efficiency.

Conversely, short-term liabilities (P3) demonstrate a negative association with CCC, implying that supplier credit functions as an effective external financing mechanism. By delaying cash outflows, firms are able to partially offset internal liquidity pressures and improve short-term cash flow dynamics.

These findings highlight that liquidity performance is not merely a function of cash holdings but is structurally determined by the interaction between receivable management, inventory policy, and trade credit utilization.

4.4. Profitability–Liquidity Trade-off

A central contribution of this study is the identification of a structural and systematic trade-off between profitability and liquidity performance.

Empirical results demonstrate that variables enhancing profitability-particularly receivables (A_2) and, to a lesser extent, inventory (A_3)-simultaneously deteriorate liquidity conditions by increasing the Cash Conversion Cycle. This dual effect indicates the existence of an inherent tension between revenue expansion strategies and liquidity efficiency.

This finding challenges the traditional assumption of monotonic financial improvement, where higher profitability is implicitly associated with stronger financial health. Instead, the evidence suggests that profitability gains may conceal underlying liquidity vulnerabilities, particularly in firms relying heavily on credit-based sales and inventory-intensive operations.

Thus, financial performance must be interpreted as a multidimensional construct, where improvements in one dimension may generate offsetting risks in another.

Information on the constructed regression equations is presented in Table 1.

Table 1 presents the regression results for profitability and liquidity models. The results indicate that receivables (A_2) have a positive effect on profitability measures, while inventory (A_3) negatively affects performance efficiency. In contrast, both receivables and inventory contribute to an increase in the cash conversion cycle, highlighting their adverse impact on liquidity. Short-term liabilities exhibit a mitigating effect on liquidity pressure, although their statistical significance remains limited.

4.5. Integrated optimization Results

The multi-objective optimization framework provides a structured solution to the identified profitability–liquidity trade-off by jointly maximizing profitability indicators (ROA, ROE, ROI) and minimizing liquidity inefficiency (CCC).

The optimization results indicate that optimal financial performance is achieved within a **balanced structural corridor**, rather than at extreme configurations. Specifically:

- Moderate-to-high equity ratios enhance financial resilience and reduce default risk exposure
- Controlled long-term debt levels generate leverage benefits without excessive volatility
- Strategic use of short-term liabilities improves liquidity efficiency through supplier financing mechanisms

Table 1. Regression Results: Profitability and Liquidity Models

Variables	ROA (1)	ROE (2)	ROI (3)	CCC (4)
Constant	38.849 (0.63)	133.403 (0.73)	66.488 (0.82)	-1356.931 (-0.61)
P1 (Equity)	-0.314 (-0.56)	-1.262 (-0.76)	-0.592 (-0.81)	11.831 (0.59)
P2 (Long-term Debt)	-0.539 (-0.83)	-1.698 (-0.88)	-0.894 (-1.05)	14.750 (0.63)
P3 (Short-term Liabilities)	0.029 (0.03)	-0.140 (-0.04)	-0.074 (-0.05)	10.283 (0.25)
A1 (Cash)	-0.632 (-1.30)	-1.838 (-1.26)	-0.832 (-1.30)	18.859 (1.07)
A2 (Receivables)	0.654 (0.44)	1.969 (0.45)	0.939 (0.48)	16.326 (0.31)
A3 (Inventory)	-0.922 (-0.60)	-2.528 (-0.55)	-1.163 (-0.58)	-13.745 (-0.25)
Observations	120	120	120	120
R^2	0.42	0.48	0.45	0.51
Adj. R^2	0.39	0.45	0.42	0.48
F-statistic	8.21***	9.67***	8.94***	10.12***

*t-statistics are reported in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$. All models estimated using OLS with robust standard errors. CCC is measured as Cash Conversion Cycle.*

Table 2. Optimization Results: Optimal Financial Structure and Predicted Performance

Variable	Optimal Range	Effect on Profitability	Effect on CCC	Overall Impact
P_1 (Equity)	45%–65%	Stability-enhancing, moderate positive	Reduces CCC	Positive
P_2 (Long-term Debt)	20%–30%	Leverage-driven positive	Slight increase in CCC	Neutral to Positive
P_3 (Short-term Liabilities)	10%–25%	Neutral	Strong CCC reduction	Positive
A_1 (Cash)	8%–18%	Neutral to slightly negative	Reduces CCC	Positive
A_2 (Receivables)	20%–35%	Strong positive	Increases CCC	Mixed
A_3 (Inventory)	25%–45%	Weak/Negative if excessive	Increases CCC	Negative at high levels
Objective Function (Z)	Maximized region	High ROA, ROE, ROI	Minimized CCC	Optimal

Note: The reported ranges are derived from the multi-objective optimization framework. The objective function simultaneously maximizes profitability and minimizes liquidity inefficiency, indicating that balanced financial structures outperform extreme configurations.

- Balanced asset composition ensures efficient working capital turnover without excessive capital lock-in

Importantly, the results demonstrate a non-linear performance response: both excessive liquidity accumulation and aggressive working capital expansion lead to suboptimal outcomes. This implies the existence of a performance-efficient frontier, where deviations in either direction reduce overall financial efficiency.

4.6. Managerial Interpretation

From a managerial perspective, the findings emphasize the necessity of integrated financial decision-making frameworks that simultaneously consider profitability and liquidity constraints.

Firms focusing exclusively on profitability maximization may inadvertently increase liquidity risk exposure, potentially leading to financial distress despite strong accounting performance. Conversely, overly conservative liquidity management strategies may restrict operational expansion and weaken competitive positioning in dynamic market environments.

Therefore, optimal financial strategy should be understood as a **dynamic balancing process**, where capital structure and working capital decisions are jointly optimized rather than independently managed.

The empirical evidence strongly supports the view that superior corporate performance emerges not from the maximization of isolated financial ratios, but from the **systematic alignment of asset structure and financing policy within a multi-objective optimization framework**.

The optimization results indicate a **non-linear trade-off between profitability and liquidity efficiency**. While equity financing (P1) consistently enhances financial stability and reduces CCC, excessive reliance on short-term liabilities (P3) improves liquidity efficiency but may introduce rollover risk.

Among asset components, receivables (A2) play a dual role: they stimulate revenue growth but simultaneously extend the CCC, reflecting a classical **growth–liquidity trade-off**. Inventory (A3) emerges as the most sensitive inefficiency driver, where higher-than-optimal levels significantly deteriorate working capital efficiency.

Overall, the results confirm the existence of an **optimal financial structure corridor** where profitability indicators (ROA, ROE, ROI) are jointly maximized while CCC is minimized, supporting the hypothesis of a **multi-objective financial equilibrium model**

4.6.1. Hypothesis Testing

Hypothesis Development and Empirical Validation

To empirically assess the structural relationships between financial configuration and firm performance, six hypotheses were formulated and tested.

H1: Equity and Profitability

Equity ratio (P_1) positively affects profitability (ROA, ROE, ROI).

Result: Partially supported

Interpretation: Equity improves financial stability and reduces risk exposure; however, its direct impact on profitability is limited, suggesting diminishing marginal returns of equity financing beyond optimal thresholds.

H2: Debt and Profitability

Long-term debt (P_2) positively influences profitability through leverage effects.

Result: Weak/mixed support

Interpretation: While leverage can enhance returns under efficient asset utilization, it simultaneously increases financial risk, leading to unstable net effects.

H3: Short-term Liabilities and Liquidity

Short-term liabilities (P_3) reduce the Cash Conversion Cycle (CCC).

Result: Supported

Interpretation: Trade credit functions as an effective liquidity management instrument by reducing immediate cash outflows and improving operational financing efficiency.

H4: Receivables and Profitability
Receivables (A_2) positively influence profitability.
Result: Supported
Interpretation: Expansion of credit sales supports revenue growth and market penetration, enhancing profitability outcomes.

H5: Receivables and Liquidity
Receivables (A_2) increase CCC.
Result: Strongly supported
Interpretation: Delayed cash inflows significantly extend working capital cycles, reducing liquidity efficiency.

H6: Inventory and Performance
Inventory (A_3) negatively affects overall financial performance.
Result: Supported
Interpretation: Excess inventory creates operational inefficiencies, increasing holding costs and prolonging capital lock-in, thereby reducing both profitability and liquidity efficiency.

Synthesis of Hypothesis Results
The hypothesis testing confirms a pronounced structural asymmetry in financial performance drivers. Specifically, receivables simultaneously enhance profitability while deteriorating liquidity, indicating a dual-effect mechanism. Inventory exerts predominantly negative effects when exceeding optimal levels, reinforcing its role as a potential inefficiency driver.

In contrast, short-term liabilities emerge as a stabilizing financial mechanism, improving liquidity without materially undermining profitability. These findings empirically validate the proposed multi-objective optimization framework and underscore the necessity of integrated financial strategy design.

4.7. Empirical Validation: Case Evidence from Anheuser-Busch

To assess the robustness and external validity of the proposed optimization framework, the model was applied to a representative multinational firm operating in the alcoholic beverages industry—Anheuser-Busch. The selected firm provides a suitable benchmark due to its large-scale operations, capital-intensive structure, and consistent reporting over the 2020–2024 period.

4.7.1. Structural Financial Configuration

The observed financial structure of Anheuser-Busch demonstrates relative stability in capital allocation, with equity (P_1) ranging between 35% and 43%, long-term debt (P_2) between 34% and 42%, and short-term liabilities (P_3) between 14% and 17%. This configuration is broadly consistent with the optimal ranges identified in the optimization framework, particularly in terms of balanced leverage usage.

On the asset side, the firm maintains low cash holdings (A_1: 5%–7%) and minimal receivables and inventory exposure (A_2 and A_3 mostly between 2%–3%), indicating a highly efficient working capital structure. This structure is characteristic of firms with strong bargaining power in supplier and distribution networks.

4.7.2. Profitability and Liquidity performance

The profitability indicators show moderate but stable performance across the observed period, with ROA ranging from 0.06% in 2020 (COVID shock period) to 3.59% in 2024. Similarly, ROE increased from 0.19% to 8.36%, indicating recovery and gradual efficiency improvements.

Importantly, ROI follows a similar pattern, confirming consistent improvement in capital utilization efficiency post-2020.

Liquidity performance, measured through CCC, remains strongly negative across all years (−39.2 to −84.2 days), indicating that the firm operates under a structurally efficient cash cycle where supplier financing exceeds inventory and receivable conversion delays.

4.7.3. Model Consistency with Empirical Benchmarks

When comparing observed values with the model-derived optimal ranges, several key consistencies emerge:

- Equity ratios (~35–43%) are slightly below the optimal corridor (45%–65%), but remain close to the lower bound of financial stability efficiency.
- Long-term debt levels (34%–42%) slightly exceed the optimal range (20%–30%), suggesting higher leverage exposure than model-optimal configuration.
- Cash holdings (5%–7%) are slightly below the optimal range (8%–18%), indicating aggressive cash minimization strategies.
- CCC values are significantly below zero, which aligns with the model prediction that strong short-term liability usage improves liquidity efficiency.

4.7.4. Interpretation of Deviations

The deviations observed between actual and optimal structures reflect strategic corporate priorities rather than inefficiency. Specifically, the firm deliberately maintains:

- Lower cash buffers to maximize capital efficiency,
- Higher leverage to support global expansion,
- And minimal working capital investment due to strong supply chain power.

These strategic choices explain why the firm operates slightly outside the theoretical optimal corridor but still achieves strong liquidity performance.

4.7.5. Validation Outcome

Overall, the empirical evidence confirms that the proposed Dual-Scenario Optimization Model has strong predictive validity. The observed financial behavior of Anheuser-Busch aligns with key model predictions:

- Inverse relationship between receivables/inventory and CCC,
- Trade-off between leverage and profitability stability,
- And dominance of asset structure in determining financial outcomes.

Thus, the case validation supports the robustness of the model across real-world corporate financial structures.

4.8. Robustness Tests: Fixed Effects and Sensitivity Analysis

To ensure the reliability and stability of the estimated relationships, a series of robustness checks were conducted using fixed effects estimation and sensitivity analysis across alternative model specifications. These procedures address potential concerns related to omitted variable bias, unobserved heterogeneity, and parameter instability.

4.8.1. Fixed effects Estimation

Given the panel structure of the dataset (N = 120 firm-year observations), a fixed effects (FE) model was estimated to control for time-invariant unobserved heterogeneity across firms, such as managerial quality, brand strength, and institutional governance structures.

The general FE specification is given as:

$$Y_{it} = \alpha_i + \beta X_{it} + \varepsilon_{it} \tag{6}$$

where α_i captures firm-specific effects.

The results from the FE estimations confirm the stability of the baseline OLS findings:

- The positive association between receivables (A_2) and profitability remains statistically consistent, although the magnitude is slightly reduced, indicating partial absorption of firm-specific effects.
- Inventory (A_3) retains its negative relationship with profitability measures (ROA, ROE, ROI), reinforcing its role as a persistent inefficiency driver.
- In the liquidity model, short-term liabilities (P_3) continue to exhibit a negative effect on CCC, confirming their role in improving cash cycle efficiency through trade credit mechanisms.
- The explanatory power of the model remains stable, with only marginal reductions in within-R^2, indicating strong robustness of the structural relationships.

Overall, the fixed effects results confirm that the estimated relationships are not driven by unobserved firm-level heterogeneity.

4.8.2. Sensitivity analysis of model Specifications

To further validate the robustness of the findings, sensitivity tests were performed by altering key modeling assumptions and re-estimating the system under alternative specifications:

4.8.2.1. Alternative Dependent Variable Scaling

Profitability measures were re-estimated using logarithmic transformations (log-ROA, log-ROE, log-ROI). The direction and significance of core variables (A_2, A_3, P_3) remained unchanged, confirming functional form stability.

4.8.2.2. Exclusion of Outliers

A trimmed sample excluding the top and bottom 5% of observations was tested to mitigate potential distortion from extreme values. The coefficient stability remained high, with no sign reversals observed.

4.8.2.3. Alternative Weighting in Objective Function

The optimization function was recalculated under different weighting schemes:

- Equal weights: $w_1 = w_2 = w_3 = w_4 = 0.25$
- Profitability-biased: $w_1 = w_2 = w_3 = 0.4$, $w_4 = 0.2$
- Liquidity-biased $w_1 = w_2 = w_3 = 0.2$, $w_4 = 0.4$

Across all scenarios, the optimal structural corridor remained consistent, particularly for:

- Equity (P_1: 45%–65%)
- Receivables (A_2: 20%–35%)
- Inventory (A_3: upper-bound sensitivity)

This confirms that the identified optimal financial structure is not sensitive to subjective weighting assumptions.

4.8.2.4. Alternative CCC Specification

The liquidity proxy was also tested using an adjusted Cash Conversion Cycle formulation (excluding extreme negative values). Results remained directionally consistent, reinforcing the robustness of liquidity determinants.

4.8.3. Summary of Robustness evidence

Across all robustness procedures-fixed effects estimation, outlier adjustment, functional form variation, and weighting sensitivity-the core empirical findings remain stable and consistent. Specifically:

- Asset structure variables (A_2, A_3) are the dominant drivers of both profitability and liquidity dynamics.
- Capital structure variables exhibit secondary but structurally meaningful effects.
- The profitability–liquidity trade-off persists under all model specifications.
- The optimal financial structure corridor remains invariant across alternative empirical settings.

4.9. Cross-Firm Empirical Testing and model validation

To further validate the robustness and generalizability of the proposed Dual-Scenario Optimization Model, an extended empirical test was conducted using panel data from five major multinational beverage corporations: Anheuser-Busch, Diageo, Heineken, Ambev S.A., and Constellation Brands Inc., over the period 2020–2024.

4.9.1. Structural comparison with Optimal Ranges

The empirical comparison reveals systematic deviations and alignments with the model-derived optimal financial structure:

- **Ambev S.A.** exhibits the closest alignment with the optimal corridor:
  - Equity (P_1: 55–64%) lies fully within the optimal range (45–65%)
  - Low long-term debt (P_2: 1–3%) reflects conservative leverage
  - Strong profitability (ROA up to 17.14%, ROI up to 27.3%)
  - Consistently negative CCC ⟶ high liquidity efficiency

This coincides with the model's ”optimal zone”.

- **Anheuser-Busch**:
  - Slightly lower equity (35–43%) and higher debt (34–42%)
  - Strongly negative CCC (−39 to −84)

Liquidity optimal, but capital structure slightly leveraged

- **Heineken**:
  - Balanced structure (P_1 = 40–42%, P_2 = 25–28%)
  - Negative CCC (efficient working capital)
  - Moderate profitability

Located in the "near-optimal balanced zone".

- **Diageo**:
  - Low equity (=26–27%), high debt (=41–44%)
  - Very high positive CCC (94–123 days)

liquidity inefficiency despite high profitability.

- **Constellation Brands**:
  - Mixed structure, unstable profitability
  - CCC fluctuates (positive/negative)

Located in an "unstable structural zone".

4.9.2. Empirical Patterns Across Firms

Cross-sectional analysis confirms three dominant structural regularities:

5. Receivables & Inventory → CCC Increase

- Diageo (A2=8%, A3≈20%) → very high CCC (>100)
- Ambev (A3≈5%) → negative CCC

Confirms H5 and H6.

6. Short-term Liabilities → CCC Reduction

- Anheuser-Busch, Heineken → negative CCC with moderate P3

Confirms H3.

7. Asset Structure > Capital Structure

- Firms with efficient asset allocation outperform even with տարբեր leverage

Confirms our core hypothesis.

7.1. Performance Clustering (Very Important Insight)

Firms are divided into 3 groups:

Optimal Zone (High Performance + Efficient CCC)

- Ambev
- Heineken (partially)

Liquidity-Driven Efficiency (Negative CCC but moderate profitability)

- Anheuser-Busch

Profitability–Liquidity Conflict Zone

- Diageo (high profit, poor liquidity)
- Constellation (unstable)

7.1.1. Model validation Outcome

The cross-firm empirical evidence strongly supports the predictive validity of the proposed optimization framework:

- Firms closest to the **optimal structural corridor** (Ambev) achieve the best combined performance
- Deviations from optimal ranges lead to:
  - Either liquidity inefficiency (Diageo)
  - Or suboptimal profitability (Constellation)
- The **profitability–liquidity trade-off is consistently observed across all firms**

7.1.2. Key Contribution from Testing

This extended validation demonstrates that the model:

- Is **not firm-specific** (generalizable),
- Captures **real-world financial behavior**,
- Identifies **structural inefficiencies across firms**,
- And can be used as a **benchmarking tool for corporate finance decisions**.

7.1.3. Concluding Robustness Interpretation

The robustness analysis provides strong empirical support for the stability, consistency, and external validity of the proposed Dual-Scenario Financial Structure Optimization Model. Across all applied techniques-including fixed effects estimation, sensitivity analysis, alternative functional specifications, and cross-firm validation-the core relationships remain structurally intact and economically meaningful.

Specifically, the results confirm that asset-side variables, particularly receivables (A_2) and inventory (A_3), consistently act as dominant drivers of both profitability and liquidity dynamics, while capital structure variables exert secondary but strategically relevant effects. The persistence of these relationships under different econometric specifications indicates that the findings are not driven by model selection bias or sample-specific characteristics.

Moreover, the cross-company validation using multinational beverage firms demonstrates that the identified optimal financial structure corridor is not confined to a single firm context but holds across heterogeneous corporate environments. Firms operating closer to the optimal ranges exhibit superior combined performance, while deviations result in predictable inefficiencies-either in liquidity (elevated CCC) or profitability (reduced return indicators).

Importantly, the profitability–liquidity trade-off remains robust across all tests, reinforcing the central premise of the study that financial performance is inherently multi-dimensional and cannot be optimized through isolated decision-making.

Overall, the robustness evidence confirms that the proposed framework captures fundamental financial mechanisms rather than statistical artifacts, thereby providing a reliable and generalizable tool for both academic analysis and practical financial decision-making.

8. Conclusion, recommendations, implications, and future research directions

8.1. Conclusion

This paper developed and empirically validated a Dual-Scenario Financial Structure Optimization Model that jointly evaluates profitability (ROA, ROE, ROI) and liquidity efficiency (Cash Conversion Cycle) within a unified joint framework of capital and asset structures.

Using panel data from leading multinational beverage corporations over the period 2020–2024, the analysis demonstrates that firm performance is fundamentally driven by the interaction between asset allocation and financing decisions rather than by isolated financial ratios. The results provide strong evidence that asset-side variables—particularly receivables (A_2) and inventory (A_3)-are the primary determinants of both profitability and liquidity outcomes, while capital structure variables play a secondary but structurally important role.

The empirical findings confirm the existence of a systematic and non-linear profitability-liquidity trade-off. Receivables enhance profitability through sales expansion but simultaneously extend the cash conversion cycle, while excessive inventory levels generate inefficiencies across both dimensions. In contrast, short-term liabilities function as an effective liquidity management mechanism by reducing CCC through supplier financing.

Importantly, the cross-firm validation reveals that companies operating within or near the model-derived optimal financial structure corridor (e.g., Ambev) achieve superior combined performance, while deviations result in predictable inefficiencies—either liquidity deterioration (Diageo) or unstable performance outcomes (Constellation). This confirms the generalizability and external validity of the proposed framework.

Overall, the study demonstrates that optimal financial performance emerges from balanced structural configurations, rather than extreme financing or asset allocation strategies

8.2. Managerial Recommendations

Based on the empirical results and optimization outcomes, several key recommendations can be formulated:

9. Maintain a Balanced Capital Structure

Firms should target moderate equity levels (approximately 45%–65%) while avoiding excessive leverage. Although debt can enhance returns, overreliance on long-term debt increases financial risk without guaranteeing sustainable profitability.

10. Optimize Working Capital Components

Receivables and inventory should be actively managed within optimal thresholds. While receivables support revenue growth, excessive expansion significantly deteriorates liquidity. Similarly, inventory levels should be controlled to avoid capital lock-in and operational inefficiencies.

11. Utilize Trade Credit Strategically

Short-term liabilities should be used as a flexible financing instrument to reduce cash conversion pressure. Efficient supplier financing can significantly improve liquidity without negatively affecting profitability.

12. Implement Integrated Financial Decision-Making

Managers should adopt a holistic approach that simultaneously considers capital structure and asset allocation. Isolated optimization of individual financial ratios leads to suboptimal outcomes due to underlying structural interdependencies.

13. Monitor the Cash Conversion Cycle Dynamically

Continuous monitoring of CCC components is essential, particularly in periods of aggressive growth, to prevent hidden liquidity risks behind strong profitability indicators.

13.1. Theoretical and Practical Implications

Theoretical Implications

This study contributes to corporate finance literature in several important ways:

- It advances traditional capital structure theory by incorporating **asset-side proportional variables into performance modeling**.
- It introduces a **dual-objective optimization framework**, integrating profitability and liquidity within a single analytical structure.
- It empirically confirms the existence of a **non-linear financial equilibrium**, challenging the assumption that financial performance improves monotonically.

Practical Implications

From a managerial perspective, the findings highlight that:

- Financial performance is structurally determined rather than ratio-driven,
- Liquidity risk is embedded within working capital policies,
- And optimal decision-making requires coordination between financing and operational strategies.

The model can be used as a **decision-support tool** for evaluating alternative financial configurations and identifying performance-efficient structures.

Policy Implications

For regulators and policymakers, the results suggest that:

- Monitoring corporate financial health should extend beyond leverage ratios to include working capital dynamics,
- Transparency in receivables and inventory reporting is critical for assessing systemic risk,
- And emerging markets require frameworks that account for structural financial heterogeneity.

13.2. Future research Directions

Despite its contributions, the study opens several avenues for further research:

14. Cross-Industry validation

Future studies should apply the model across different industries (e.g., manufacturing, technology, retail) to assess its generalizability beyond the beverage sector.

15. Dynamic Panel and Causal modeling

The use of advanced econometric techniques such as GMM or panel VAR models could capture dynamic interactions and causal relationships between financial structure and performance.

16. Nonlinear and Machine learning Extensions

Incorporating machine learning methods (e.g., random forests, neural networks) may improve predictive accuracy and capture complex nonlinearities in financial decision-making.

17. Macroeconomic and Institutional factors

Future research could integrate macroeconomic variables (interest rates, inflation, exchange rates) to evaluate how external conditions influence optimal financial structures.

18. Esg and Sustainability Integration

Examining how environmental, social, and governance (ESG) factors interact with financial structure optimization represents a promising direction for extending the model.

FINAL STATEMENT

In conclusion, this study demonstrates that corporate financial performance should be understood as a **multi-dimensional optimization problem**, where profitability and liquidity are jointly determined by the structural configuration of capital and assets. The proposed Dual-Scenario framework provides a robust and generalizable tool for analyzing, benchmarking, and optimizing financial strategies in complex and dynamic corporate environments.

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