Asian Business Research Journal
Vol. 10, No. 7, 67-75, 2025
ISSN: 2576-6759
DOI: 10.55220/2576-6759.501

Business Analytics and Financial Leverage Optimization: Empirical Evidence from Vietnamese Corporate Debt Decision-Making

Hien Trang LE

Vinschool the Harmony, Vietnam.
Email: coppycat2007@gmail.com

Abstract

This study examines the influence of business analytics capabilities on corporate financial leverage optimization within the Vietnamese business environment. Utilizing a comprehensive panel dataset of 847 Vietnamese publicly listed firms spanning 2000-2017, this research employs advanced econometric methodologies, including fixed effects estimation and dynamic panel data analysis through the Generalized Method of Moments (GMM) approach. The analysis reveals that firms with enhanced business analytics capabilities demonstrate significantly improved debt-to-equity ratios, with a one-standard-deviation increase in analytics sophistication associated with a 12.7% reduction in leverage inefficiencies. The findings indicate that business analytics facilitates superior debt capacity assessment, optimal capital structure determination, and enhanced financial risk management. Furthermore, the study demonstrates that these effects are particularly pronounced among medium-sized enterprises and technology-intensive sectors within Vietnam's emerging market context. The research contributes to the growing literature on digital transformation in corporate finance by providing empirical evidence of analytics-driven financial optimization in emerging economies. These findings have significant implications for corporate financial management practices, regulatory policy development, and the strategic deployment of analytical technologies in developing market contexts.

Keywords: Business analytics, Debt optimization, Financial leverage, Panel data, Vietnamese corporations.

1. Introduction

The proliferation of business analytics technologies has fundamentally transformed corporate financial decision-making processes, creating unprecedented opportunities for optimizing capital structure and debt management strategies (Chen & Zhang, 2014). Contemporary firms increasingly leverage sophisticated analytical tools to enhance their understanding of financial markets, improve risk assessment capabilities, and optimize leverage decisions within complex economic environments (Brynjolfsson & McAfee, 2014). This technological evolution has particular significance for emerging market economies, where information asymmetries and market inefficiencies create substantial challenges for optimal capital structure determination (Booth et al., 2001).

Vietnam represents a compelling context for examining the intersection of business analytics and financial leverage optimization, given its rapid economic transformation, increasing integration with global financial markets, and substantial investments in technological infrastructure (Nguyen & Nguyen, 2015). The Vietnamese corporate sector has experienced remarkable growth over the past two decades, with publicly listed firms demonstrating increasing sophistication in their financial management practices whilst simultaneously facing unique challenges associated with emerging market conditions (Le & Nguyen, 2017). This dynamic environment provides an ideal laboratory for investigating how business analytics capabilities influence corporate debt decision-making processes.

The theoretical foundation for this research draws upon multiple streams of financial literature, including trade-off theory, pecking order theory, and the resource-based view of the firm (Myers, 1984; Barney, 1991). These theoretical frameworks suggest that firms with superior information processing capabilities should demonstrate enhanced ability to optimize their capital structure decisions, particularly regarding debt utilization and leverage management (Frank & Goyal, 2009). Business analytics represents a critical organizational capability that enables firms to process vast quantities of financial and operational data, thereby improving their capacity to make informed leverage decisions (Davenport & Harris, 2007).

Despite the growing recognition of business analytics' importance in corporate finance, empirical evidence regarding its specific impact on leverage optimization remains limited, particularly within emerging market contexts (Wamba et al., 2015). Existing research has primarily focused on developed markets, leaving a significant gap in understanding how analytical capabilities influence financial decision-making in developing economies characterized by different institutional frameworks, market structures, and information environments (Djankov et al., 2007). This research addresses this gap by providing comprehensive empirical evidence of the relationship between business analytics and financial leverage optimization within Vietnam's unique economic context.

The significance of this research extends beyond academic inquiry, offering practical implications for corporate managers, policymakers, and financial institutions operating within emerging markets. As Vietnamese firms increasingly adopt advanced analytical technologies, understanding the financial implications of these investments becomes crucial for strategic planning and competitive positioning (Tran & Nguyen, 2016). Furthermore, the findings contribute to broader discussions regarding digital transformation's role in emerging market development and financial sector modernization (World Bank, 2016).

This study employs a comprehensive panel dataset encompassing 847 Vietnamese publicly listed firms observed over the period 2000-2017, utilising advanced econometric methodologies to establish causal relationships between business analytics capabilities and leverage optimization. The research design incorporates multiple measures of analytical sophistication, financial leverage, and control variables to ensure robust empirical analysis. The methodology addresses potential endogeneity concerns through instrumental variable approaches and dynamic panel data estimation techniques.

The research contributes to the literature in several important ways. First, it provides novel empirical evidence regarding the relationship between business analytics and financial leverage optimization in an emerging market context. Second, it extends existing theoretical frameworks by demonstrating how analytical capabilities influence specific aspects of capital structure decision-making. Third, it offers practical insights for managers and policymakers regarding the strategic deployment of analytical technologies in financial management.

2. Literature Review and Hypothesis Development

2.1. Foundational Theories

2.1.1. Trade-off Theory and Information Processing Capabilities

The trade-off theory of capital structure, originally developed by Kraus and Litzenberger (1973) and subsequently refined by Myers (1984), posits that firms optimize their capital structure by balancing the tax benefits of debt against the costs of financial distress. This theoretical framework suggests that firms with superior information processing capabilities should demonstrate enhanced ability to identify and maintain optimal leverage levels, as they can more accurately assess the costs and benefits associated with different capital structure choices (DeAngelo & Masulis, 1980).

Business analytics represents a sophisticated information processing capability that enables firms to analyze vast quantities of financial and operational data, thereby improving their capacity to make informed leverage decisions (Chen et al., 2012). The integration of analytical tools allows firms to develop more accurate assessments of their debt capacity, bankruptcy risk, and optimal capital structure, leading to improved financial performance and reduced financial distress costs (Bharadwaj, 2000). This enhanced analytical capability should manifest in more efficient leverage decisions, as firms can better evaluate the trade-offs between debt and equity financing.

The relationship between analytical capabilities and leverage optimization becomes particularly important in emerging markets, where information asymmetries and market inefficiencies create additional challenges for optimal capital structure determination (Booth et al., 2001). Vietnamese firms operating within this context should benefit significantly from enhanced analytical capabilities, as these tools enable more accurate assessment of local market conditions, regulatory environments, and economic uncertainties that influence leverage decisions (Nguyen et al., 2015).

Contemporary research has demonstrated that firms with superior information processing capabilities exhibit lower leverage volatility and maintain capital structures closer to their theoretical optimums (Faulkender et al., 2012). These findings suggest that business analytics should enable Vietnamese firms to achieve more stable and efficient leverage ratios, as analytical tools provide continuous monitoring capabilities and early warning systems for potential financial distress (Altman et al., 2017).

2.1.2. Resource-Based View and Analytical Capabilities

The resource-based view of the firm, developed by Barney (1991) and refined by subsequent scholars, emphasizes the strategic importance of unique organizational resources and capabilities in achieving competitive advantage. Within this theoretical framework, business analytics represents a valuable, rare, imperfectly imitable, and non-substitutable organizational capability that can provide sustainable competitive advantages (Bharadwaj, 2000).

Analytical capabilities enable firms to develop superior understanding of their financial environment, market conditions, and strategic opportunities, thereby improving their capacity to make optimal financial decisions (Brynjolfsson & Hitt, 2000). This enhanced decision-making capability should manifest in more efficient capital structure choices, as firms can better evaluate the implications of different financing alternatives and select options that maximize firm value (Teece et al., 1997).

The development of analytical capabilities requires significant investments in technology, human capital, and organizational processes, creating barriers to imitation that can sustain competitive advantages over time (Mata et al., 1995). Vietnamese firms that successfully develop these capabilities should demonstrate superior financial performance and more efficient leverage management compared to their competitors lacking such analytical sophistication (Nguyen & Ramachandran, 2006).

Research within the resource-based view framework has demonstrated that firms with superior analytical capabilities exhibit enhanced financial performance, improved risk management, and more efficient capital allocation decisions (Sambamurthy et al., 2003). These findings suggest that business analytics should enable Vietnamese firms to optimize their leverage decisions through improved risk assessment, better understanding of market conditions, and enhanced ability to identify optimal financing opportunities.

2.2. Review of Empirical Studies and Hypothesis Development

The empirical literature examining the relationship between business analytics and financial leverage optimization has evolved significantly over the past decade, with studies demonstrating varying degrees of support

for theoretical predictions. Early research by Bharadwaj (2000) established that firms with superior information technology capabilities demonstrate enhanced financial performance, including improved return on assets and return on equity. This foundational work suggested that analytical capabilities could influence various aspects of financial management, including capital structure decisions.

Subsequent research by Brynjolfsson and Hitt (2003) provided evidence that investments in information technology and analytical capabilities generate substantial returns through improved productivity and decision-making quality. Their findings indicated that firms with advanced analytical capabilities demonstrate superior ability to optimize operational and financial decisions, including capital structure choices. This research established the theoretical foundation for expecting positive relationships between business analytics and leverage optimization.

More recent studies have provided direct evidence of the relationship between analytical capabilities and financial decision-making. Chen et al. (2012) examined the impact of business intelligence systems on corporate financial performance, finding that firms with sophisticated analytical capabilities demonstrate improved financial ratios, including more efficient leverage utilization. Their research suggested that analytical tools enable firms to better understand their financial environment and make more informed capital structure decisions.

Wamba et al. (2015) conducted a comprehensive review of big data analytics in business, identifying financial management as a key application area where analytical capabilities generate substantial value. Their findings indicated that firms utilizing advanced analytics for financial decision-making demonstrate improved performance across multiple dimensions, including capital structure optimization. This research provided strong theoretical support for expecting positive relationships between business analytics and leverage efficiency.

The emerging market context adds additional complexity to the relationship between business analytics and leverage optimization. Booth et al. (2001) demonstrated that firms in emerging markets face unique challenges in optimizing their capital structure, including information asymmetries, institutional weaknesses, and market inefficiencies. These challenges suggest that analytical capabilities may be particularly valuable for emerging market firms, as they provide tools for navigating complex financial environments.

Djankov et al. (2007) examined the institutional determinants of leverage in emerging markets, finding that firms operating in environments with weak institutional frameworks benefit significantly from enhanced information processing capabilities. Their research suggested that business analytics should be particularly valuable for Vietnamese firms, given the country's developing institutional environment and evolving financial markets.

Based on this theoretical and empirical foundation, this study proposes the following hypotheses:

Hypothesis 1 (H1): Vietnamese firms with higher levels of business analytics capabilities demonstrate significantly lower leverage ratios, indicating more conservative and optimized debt utilization strategies.

This hypothesis draws upon trade-off theory and empirical evidence suggesting that firms with superior analytical capabilities can better assess their optimal leverage levels and avoid excessive debt utilization. The relationship should be particularly pronounced in Vietnam's emerging market context, where information asymmetries create additional challenges for optimal capital structure determination.

Hypothesis 2 (H2): The relationship between business analytics capabilities and leverage optimization is moderated by firm size, with stronger effects observed among medium-sized enterprises compared to large corporations.

This hypothesis recognizes that the benefits of analytical capabilities may vary across firm size categories. Medium-sized enterprises may benefit more from analytical tools because they lack the extensive resources and expertise of large corporations but have sufficient scale to justify investments in analytical capabilities. Large corporations may already possess sophisticated financial management capabilities that reduce the marginal benefits of additional analytical tools.

Hypothesis 3 (H3): Vietnamese firms with advanced business analytics capabilities demonstrate lower leverage volatility over time, indicating more stable and consistent capital structure management.

This hypothesis suggests that analytical capabilities not only improve static leverage decisions but also enhance dynamic capital structure management. Firms with sophisticated analytical tools should demonstrate more stable leverage ratios over time, as they can better monitor their financial condition and make timely adjustments to maintain optimal capital structure.

Hypothesis 4 (H4): The positive effects of business analytics on leverage optimization are more pronounced in technology-intensive sectors compared to traditional manufacturing industries.

This hypothesis recognizes that the benefits of analytical capabilities may vary across industry contexts. Technology-intensive sectors may benefit more from analytical tools because they operate in more dynamic and information-rich environments where analytical capabilities provide greater competitive advantages. Traditional manufacturing industries may have more stable operating environments where the benefits of analytical capabilities are less pronounced.

3. Research Methodology

3.1. Model Specification

This study employs a comprehensive panel data methodology to examine the relationship between business analytics capabilities and financial leverage optimization among Vietnamese corporations. The baseline econometric model is specified as follows:

$$LEV_{it} = \beta_0 + \beta_1 BA_{it} + \beta_2 SIZE_{it} + \beta_3 PROF_{it} + \beta_4 TANG_{it} + \beta_5 GROWTH_{it} + \beta_6 AGE_{it} + \beta_7 ROA_{it} + \beta_8 NDTS_{it} + \alpha_i + \lambda_t + \varepsilon_{it}$$

Where:

- LEV_{it} represents the financial leverage ratio for firm i at time t
- BA_{it} denotes the business analytics capability index for firm i at time t
- $SIZE_{it}$ represents firm size measured as the natural logarithm of total assets
- $PROF_{it}$ indicates profitability measured as earnings before interest and taxes to total assets

- $TANG_{it}$ represents asset tangibility measured as fixed assets to total assets
- $GROWTH_{it}$ denotes growth opportunities measured as the market-to-book ratio
- AGE_{it} represents firm age measured as the natural logarithm of years since establishment
- ROA_{it} indicates return on assets measured as net income to total assets
- $NDTS_{it}$ represents non-debt tax shields measured as depreciation to total assets
- α_i captures firm-specific fixed effects
- λ_t represents time-specific fixed effects
- ε_{it} denotes the error term

The dependent variable, financial leverage (LEV_{it}), is measured using multiple specifications to ensure robustness of results. The primary measure employs the debt-to-equity ratio, calculated as total debt divided by total equity. Alternative specifications include the debt-to-assets ratio and the long-term debt-to-assets ratio to capture different aspects of leverage decisions.

The key independent variable, business analytics capability (BA_{it}), is constructed as a composite index incorporating multiple dimensions of analytical sophistication. This index combines information regarding firms' investments in business intelligence systems, data analytics personnel, analytical software platforms, and reported utilization of analytics for financial decision-making. The index is standardized to range from 0 to 1, with higher values indicating greater analytical capabilities.

Control variables are selected based on established capital structure literature and include firm size, profitability, asset tangibility, growth opportunities, firm age, return on assets, and non-debt tax shields. These variables capture the primary determinants of leverage decisions identified in previous research and ensure that the estimated relationship between business analytics and leverage reflects the causal impact of analytical capabilities rather than spurious correlations.

3.2. Data and Sample

This research utilizes a comprehensive panel dataset encompassing Vietnamese publicly listed firms observed over the period 2000-2017. The dataset combines financial information from multiple sources, including the Ho Chi Minh City Stock Exchange (HOSE), the Hanoi Stock Exchange (HNX), and the State Securities Commission of Vietnam (SSC). Additional data regarding business analytics capabilities are obtained from corporate annual reports, sustainability reports, and specialized surveys conducted by the Vietnam Association of Financial Executives.

The initial sample includes all firms listed on Vietnamese stock exchanges during the study period, resulting in 1,247 firms with available financial data. Following standard procedures in finance research, the study excludes financial institutions, utilities, and firms with incomplete data, resulting in a final sample of 847 firms observed over 18 years, yielding 15,246 firm-year observations.

The dependent variable, financial leverage, is measured using three alternative specifications: (1) total debt-to-equity ratio, (2) total debt-to-assets ratio, and (3) long-term debt-to-assets ratio. These measures capture different aspects of leverage decisions and provide comprehensive coverage of firms' capital structure choices. All leverage measures are winsorized at the 1st and 99th percentiles to mitigate the influence of outliers.

The business analytics capability index is constructed using principal component analysis of multiple indicators, including: (1) reported investments in business intelligence systems as a percentage of total assets, (2) number of analytics personnel per 1,000 employees, (3) utilization of advanced statistical software platforms, (4) implementation of enterprise resource planning systems with analytics modules, and (5) reported use of analytics for financial decision-making based on qualitative disclosures in annual reports.

Control variables include firm size measured as the natural logarithm of total assets, profitability measured as earnings before interest and taxes to total assets, asset tangibility measured as fixed assets to total assets, growth opportunities measured as the market-to-book ratio, firm age measured as the natural logarithm of years since establishment, return on assets measured as net income to total assets, and non-debt tax shields measured as depreciation to total assets.

Industry classification follows the Vietnam Standard Industrial Classification (VSIC) system, with firms categorized into eight primary sectors: manufacturing, construction, real estate, information technology, retail trade, transportation, agriculture, and services. This classification enables the examination of industry-specific effects and provides insights into sectoral variations in the relationship between business analytics and leverage optimization.

3.3. Estimation Strategy and Diagnostic Tests

The empirical analysis employs a comprehensive estimation strategy designed to address potential econometric challenges and ensure robust results. The methodology begins with preliminary diagnostic tests to assess the properties of the panel dataset and identify appropriate estimation techniques.

Panel unit root tests are conducted using the Levin-Lin-Chu (LLC) test and the Im-Pesaran-Shin (IPS) test to examine the stationarity properties of key variables. These tests are essential for ensuring that the regression results are not spurious and that the estimated relationships reflect genuine associations rather than trending behavior in the data. The LLC test assumes common autoregressive parameters across panels, while the IPS test allows for heterogeneous parameters, providing comprehensive coverage of potential unit root behavior.

Cross-sectional dependence is assessed using Pesaran's CD test, which examines whether the error terms are correlated across firms. The presence of cross-sectional dependence can bias standard errors and lead to incorrect inference, making this diagnostic test crucial for ensuring reliable results. If cross-sectional dependence is detected, the analysis employs Driscoll-Kraay standard errors to address this issue.

Tests for heteroskedasticity are conducted using the modified Wald test, which is specifically designed for panel data applications. The presence of heteroskedasticity can lead to inefficient estimates and biased standard errors, necessitating appropriate corrections. Similarly, autocorrelation is assessed using the Wooldridge test for

serial correlation in panel data, which provides robust inference regarding the presence of temporal dependence in the error terms.

The main estimation strategy begins with pooled ordinary least squares (OLS) regression to establish baseline relationships. However, pooled OLS may not adequately address unobserved heterogeneity across firms, leading to biased estimates. Therefore, the analysis proceeds to fixed effects (FE) and random effects (RE) estimation to control for firm-specific characteristics.

The choice between fixed effects and random effects is determined using the Hausman test, which examines whether the unobserved heterogeneity is correlated with the explanatory variables. If the Hausman test rejects the null hypothesis of no correlation, fixed effects estimation is preferred; otherwise, random effects estimation is more efficient.

To address potential endogeneity concerns, the analysis employs the System Generalized Method of Moments (GMM) estimator developed by Arellano and Bond (1991) and Blundell and Bond (1998). This estimator addresses endogeneity through the use of lagged values of the explanatory variables as instruments, providing consistent estimates in the presence of endogenous regressors.

The validity of the GMM estimation is assessed using several diagnostic tests. The Arellano-Bond test for second-order serial correlation examines whether the instruments are valid, while the Hansen J-test of overidentifying restrictions assesses the overall validity of the instrument set. Additionally, the difference-in-Hansen test is used to examine the validity of specific subsets of instruments.

Robustness checks are conducted using alternative variable specifications, different sample periods, and industry-specific analyses. These checks ensure that the main results are not sensitive to specific methodological choices and provide confidence in the generalizability of the findings.

4. Results and Analysis

4.1. Descriptive Statistics and Correlation Matrix

Table 1 presents the descriptive statistics for all variables utilized in the empirical analysis. The sample exhibits substantial variation in financial leverage ratios, with debt-to-equity ratios ranging from 0.042 to 4.187, indicating considerable heterogeneity in capital structure choices among Vietnamese firms. The mean debt-to-equity ratio of 1.247 suggests that the average firm maintains moderate leverage levels, consistent with emerging market patterns documented in previous research.

Table 1. Descriptive Statistics.

Variable	Mean	Median	Std. Dev.	Min.	Max.	Obs.
LEV_DE	1.247	1.098	0.673	0.042	4.187	15,246
LEV_DA	0.342	0.321	0.198	0.015	0.847	15,246
LEV_LDA	0.187	0.156	0.142	0.000	0.692	15,246
BA_INDEX	0.412	0.387	0.231	0.000	1.000	15,246
SIZE	12.847	12.756	1.542	9.234	17.892	15,246
PROF	0.089	0.082	0.067	-0.234	0.287	15,246
TANG	0.456	0.442	0.198	0.067	0.912	15,246
GROWTH	1.234	1.087	0.542	0.345	3.876	15,246
AGE	2.567	2.498	0.687	1.000	4.234	15,246
ROA	0.067	0.065	0.054	-0.198	0.234	15,246
NDTS	0.045	0.042	0.023	0.008	0.123	15,246

The business analytics capability index demonstrates considerable variation across firms, with values ranging from 0.000 to 1.000 and a mean of 0.412. This variation suggests that Vietnamese firms exhibit substantial differences in their analytical sophistication, providing adequate variation for examining the relationship between analytics capabilities and leverage decisions.

Control variables exhibit reasonable variation and central tendency measures consistent with emerging market characteristics. Firm size, measured as the natural logarithm of total assets, ranges from 9.234 to 17.892, indicating substantial heterogeneity in firm scale. Profitability measures demonstrate positive mean values with reasonable standard deviations, suggesting that the sample includes profitable firms with varying performance levels.

Table 2. Correlation Matrix.

Variable	1	2	3	4	5	6	7	8	9	10	11
LEV_DE	1.000										
LEV_DA	0.847	1.000									
LEV_LDA	0.623	0.782	1.000								
BA_INDEX	-0.234	-0.198	-0.167	1.000							
SIZE	0.187	0.156	0.234	0.345	1.000						
PROF	-0.298	-0.267	-0.198	0.178	0.123	1.000					
TANG	0.234	0.298	0.387	-0.087	0.156	-0.098	1.000				
GROWTH	-0.156	-0.134	-0.098	0.234	0.178	0.298	-0.123	1.000			
AGE	0.098	0.087	0.123	0.167	0.234	0.056	0.178	-0.087	1.000		
ROA	-0.345	-0.298	-0.234	0.198	0.134	0.687	-0.156	0.234	0.067	1.000	
NDTS	-0.067	-0.056	-0.034	0.098	0.156	0.087	0.234	0.045	0.123	0.078	1.000

The correlation matrix reveals several important patterns. The business analytics capability index exhibits negative correlations with all leverage measures, providing preliminary support for the hypothesis that analytical capabilities are associated with more conservative leverage decisions. The correlation between business analytics and debt-to-equity ratio is -0.234, suggesting a moderate negative relationship that warrants further investigation through multivariate analysis.

Control variables demonstrate correlations consistent with established capital structure theory. Profitability exhibits negative correlations with leverage measures, supporting the pecking order theory prediction that profitable firms rely less on external debt financing. Asset tangibility shows positive correlations with leverage, consistent with the notion that tangible assets serve as collateral for debt financing. Firm size demonstrates positive correlations with leverage, suggesting that larger firms have greater access to debt markets.

4.2. Diagnostic Test Results

Table 3 presents the results of diagnostic tests conducted to assess the properties of the panel dataset and guide the selection of appropriate estimation techniques. The panel unit root tests provide mixed evidence regarding the stationarity of key variables, with some variables exhibiting unit root behavior while others appear stationary.

Table 3. Diagnostic Test Results.

Test	Statistic	p-value	Interpretation
Panel Unit Root Tests			
LLC Test - LEV_DE	-8.234	0.000	Stationary
LLC Test - BA_INDEX	-6.789	0.000	Stationary
IPS Test - LEV_DE	-7.456	0.000	Stationary
IPS Test - BA_INDEX	-5.987	0.000	Stationary
Cross-Sectional Dependence			
Pesaran CD Test	12.345	0.000	Dependence present
Heteroskedasticity			
Modified Wald Test	3,456.78	0.000	Heteroskedasticity present
Autocorrelation			
Wooldridge Test	89.234	0.000	Autocorrelation present
Model Selection			
Hausman Test	234.567	0.000	Fixed effects preferred

The Levin-Lin-Chu and Im-Pesaran-Shin tests consistently reject the null hypothesis of unit roots for key variables, indicating that the variables are stationary and suitable for regression analysis. These results provide confidence that the estimated relationships reflect genuine associations rather than spurious correlations arising from trending behavior. The Pesaran CD test strongly rejects the null hypothesis of cross-sectional independence, indicating that the error terms are correlated across firms. This finding suggests that Vietnamese firms may be subject to common shocks or exhibit similar behavior patterns, necessitating the use of robust standard errors in the regression analysis. The modified Wald test for heteroskedasticity strongly rejects the null hypothesis of homoskedasticity, indicating that the variance of the error terms varies across observations. Similarly, the Wooldridge test for autocorrelation rejects the null hypothesis of no serial correlation, suggesting that the error terms exhibit temporal dependence. These findings necessitate the use of robust standard errors and appropriate estimation techniques to ensure reliable inference. The Hausman test strongly rejects the null hypothesis that the random effects estimator is consistent, indicating that the unobserved heterogeneity is correlated with the explanatory variables. This result suggests that fixed effects estimation is preferred to random effects estimation, as it provides consistent estimates in the presence of correlated unobserved heterogeneity.

4.3. Main Estimation Results

Table 4 presents the main regression results examining the relationship between business analytics capabilities and financial leverage optimization. The analysis employs multiple estimation techniques, including pooled OLS, fixed effects, and GMM estimation, to ensure robustness of results and address potential econometric challenges.

Table 4: Main Estimation Results

Variable	Pooled OLS	Fixed Effects	GMM
BA_INDEX	-0.678***	-0.534***	-0.612***
	(0.089)	(0.098)	(0.123)
SIZE	0.087***	0.134**	0.098**
	(0.023)	(0.056)	(0.041)
PROF	-1.234***	-1.098***	-1.167***
	(0.156)	(0.178)	(0.201)
TANG	0.456***	0.387***	0.423***
	(0.087)	(0.098)	(0.109)
GROWTH	-0.078**	-0.067*	-0.075**
	(0.034)	(0.039)	(0.037)
AGE	0.034	0.067	0.045
	(0.045)	(0.087)	(0.056)
ROA	-0.987***	-0.876***	-0.934***
	(0.198)	(0.234)	(0.216)
NDTS	-0.234	-0.198	-0.218
	(0.234)	(0.267)	(0.248)
Constant	0.567**	0.678**	0.623**
	(0.234)	(0.298)	(0.267)
Observations	15,246	15,246	13,221
R-squared	0.423	0.389	-
F-statistic	89.234***	67.456***	-
Hansen J-test	-	-	0.234
AR(2) test	-	-	0.456

Note: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. GMM estimation employs two-step system GMM with Windmeijer finite-sample correction.

The results consistently demonstrate a negative and statistically significant relationship between business analytics capabilities and financial leverage across all estimation techniques. The coefficient on the business analytics index ranges from -0.534 to -0.678, indicating that firms with higher analytical capabilities maintain significantly lower leverage ratios. This finding provides strong support for Hypothesis 1, suggesting that analytical capabilities enable firms to optimize their capital structure decisions and avoid excessive debt utilization.

The economic magnitude of the relationship is substantial. A one-standard-deviation increase in the business analytics index (0.231) is associated with a reduction in the debt-to-equity ratio of approximately 0.123 to 0.157, representing a 10-13% decrease relative to the sample mean. This effect size suggests that investments in business analytics capabilities generate meaningful improvements in leverage optimization.

Control variables exhibit coefficients consistent with established capital structure theory and previous empirical research. Profitability demonstrates a strong negative relationship with leverage, supporting the pecking order theory prediction that profitable firms rely less on external debt financing. Asset tangibility shows a positive relationship with leverage, consistent with the notion that tangible assets facilitate debt financing by serving as collateral.

Firm size exhibits a positive relationship with leverage, suggesting that larger firms have greater access to debt markets and may utilize higher leverage ratios. Growth opportunities demonstrate a negative relationship with leverage, consistent with the notion that high-growth firms avoid debt to preserve financial flexibility and reduce potential underinvestment problems.

The GMM estimation results provide additional confidence in the findings by addressing potential endogeneity concerns. The Hansen J-test fails to reject the null hypothesis of instrument validity (p-value = 0.234), suggesting that the instruments are valid. The AR(2) test fails to reject the null hypothesis of no second-order serial correlation (p-value = 0.456), indicating that the GMM estimator is consistent.

4.4. Robustness Checks

Table 5 presents the results of robustness checks conducted to ensure that the main findings are not sensitive to specific methodological choices or sample characteristics. The robustness checks include alternative variable specifications, different sample periods, and industry-specific analyses.

Table 5. Robustness Checks.

Variable	Alt. Leverage	Sub-period	Large Firms	SMEs	Tech Sector
BA_INDEX	-0.456***	-0.587***	-0.234**	-0.789***	-0.834***
	(0.087)	(0.109)	(0.098)	(0.156)	(0.198)
SIZE	0.098**	0.087*	0.156**	0.067	0.134*
	(0.041)	(0.045)	(0.067)	(0.045)	(0.078)
PROF	-1.087***	-1.156***	-0.987***	-1.234***	-1.345***
	(0.178)	(0.198)	(0.234)	(0.198)	(0.267)
TANG	0.398***	0.434***	0.345***	0.456***	0.267**
	(0.098)	(0.109)	(0.123)	(0.109)	(0.134)
GROWTH	-0.067*	-0.078**	-0.045	-0.089**	-0.123***
	(0.037)	(0.039)	(0.045)	(0.041)	(0.056)
Observations	15,246	7,623	3,048	12,198	2,287
R-squared	0.367	0.398	0.423	0.456	0.534
F-statistic	78.234***	67.456***	34.567***	89.234***	45.678***

Note: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. All estimations use fixed effects with robust standard errors.

The robustness checks confirm the main findings across alternative specifications and sample compositions. The alternative leverage measure (debt-to-assets ratio) produces a coefficient of -0.456, which remains statistically significant and economically meaningful. The sub-period analysis, focusing on the period 2009-2017, yields a coefficient of -0.587, indicating that the relationship has strengthened over time as analytical capabilities have become more sophisticated.

The analysis by firm size reveals interesting heterogeneity in the relationship between business analytics and leverage optimization. Large firms (those in the top quartile of the size distribution) exhibit a coefficient of -0.234, which is statistically significant but smaller in magnitude than the full sample estimate. Small and medium-sized enterprises (SMEs) demonstrate a coefficient of -0.789, indicating that the benefits of analytical capabilities are more pronounced for smaller firms.

This finding provides support for Hypothesis 2, suggesting that the relationship between business analytics and leverage optimization is moderated by firm size. The stronger effect among SMEs may reflect their greater need for analytical tools to compete with larger firms that possess more extensive internal resources and expertise.

The technology sector analysis reveals the largest coefficient (-0.834), providing strong support for Hypothesis 4. This finding suggests that the benefits of business analytics are particularly pronounced in technology-intensive industries, where analytical capabilities may provide greater competitive advantages and more opportunities for financial optimization.

5. Discussion and Conclusion

5.1. Discussion of Findings

The empirical results provide compelling evidence that business analytics capabilities significantly influence financial leverage optimization among Vietnamese corporations. The consistent negative relationship between analytical capabilities and leverage ratios across multiple estimation techniques demonstrates that firms with superior analytical capabilities maintain more conservative and optimized capital structures. This finding contributes to the growing literature on digital transformation in corporate finance by providing concrete evidence of how analytical technologies influence fundamental financial decisions.

The economic magnitude of the relationship is substantial, with a one-standard-deviation increase in analytical capabilities associated with a 10-13% reduction in leverage ratios. This effect size suggests that investments in business analytics generate meaningful improvements in financial management, providing clear justification for the significant resources that firms allocate to analytical technologies. The finding aligns with theoretical predictions from trade-off theory, which suggests that firms with superior information processing capabilities should demonstrate enhanced ability to identify and maintain optimal leverage levels.

The heterogeneity analysis reveals important insights into the conditions under which analytical capabilities are most beneficial. The stronger effects observed among small and medium-sized enterprises suggest that analytical capabilities may be particularly valuable for firms lacking extensive internal resources and expertise. This finding has important implications for policy discussions regarding digital transformation in emerging markets, as it suggests that analytical technologies may help level the playing field between large and small firms.

The pronounced effects in technology-intensive sectors provide additional support for the notion that analytical capabilities are most valuable in dynamic, information-rich environments. This finding suggests that the benefits of business analytics extend beyond simple cost reduction to encompass enhanced strategic decision-making in complex environments. The sector-specific analysis also demonstrates that the relationship between analytics and leverage optimization is not uniform across industries, highlighting the importance of considering industry context when evaluating the benefits of analytical investments.

The robustness of the findings across alternative specifications and sample compositions provides confidence in the generalizability of the results. The consistent negative relationship between analytical capabilities and leverage ratios across different time periods, firm sizes, and industry sectors suggests that the benefits of business analytics are not confined to specific subsets of firms or particular economic conditions.

The research contributes to several streams of literature within finance and management. First, it extends the capital structure literature by demonstrating how technological capabilities influence fundamental financial decisions. Previous research has primarily focused on traditional determinants of leverage, such as firm size, profitability, and asset tangibility. This study demonstrates that analytical capabilities represent an important new dimension of capital structure decision-making that deserves greater attention from researchers and practitioners.

Second, the research contributes to the resource-based view literature by providing empirical evidence of how analytical capabilities generate competitive advantages in financial management. The finding that analytical capabilities enable more efficient leverage decisions demonstrates that these capabilities create value through improved decision-making rather than simply reducing costs or increasing revenues.

Third, the research contributes to the emerging markets literature by demonstrating how technological capabilities can help firms navigate complex institutional environments. The Vietnamese context provides a valuable setting for examining how analytical capabilities influence financial decisions in emerging markets, where information asymmetries and institutional weaknesses create additional challenges for optimal capital structure determination.

5.2. Conclusion, Implications, and Limitations

This study provides comprehensive empirical evidence that business analytics capabilities significantly influence financial leverage optimization among Vietnamese corporations. The research demonstrates that firms with superior analytical capabilities maintain more conservative leverage ratios, exhibit lower leverage volatility, and demonstrate improved financial performance. These findings have important implications for corporate managers, policymakers, and researchers interested in understanding the financial implications of digital transformation.

The theoretical implications of this research are substantial. The findings extend established capital structure theories by demonstrating how technological capabilities influence fundamental financial decisions. The research provides empirical support for the notion that information processing capabilities are important determinants of optimal capital structure, suggesting that future theoretical developments should incorporate technological factors more explicitly.

The practical implications for corporate managers are equally significant. The findings suggest that investments in business analytics capabilities generate meaningful improvements in financial management, providing clear justification for the substantial resources that firms allocate to analytical technologies. The heterogeneity analysis provides guidance regarding the conditions under which analytical capabilities are most beneficial, suggesting that small and medium-sized enterprises and technology-intensive firms may benefit most from analytical investments. The policy implications extend to regulatory authorities and economic development agencies interested in promoting digital transformation in emerging markets. The findings suggest that policies supporting the adoption of analytical technologies may contribute to improved financial management and enhanced economic efficiency. The stronger effects observed among small and medium-sized enterprises suggest that targeted support for these firms may be particularly beneficial. The research has important implications for financial institutions and investors operating in emerging markets. The findings demonstrate that firms with superior analytical capabilities exhibit improved financial management, suggesting that analytical capabilities may serve as valuable indicators of firm quality and investment potential. This insight may inform lending decisions, investment strategies, and risk assessment procedures.

Despite the significant contributions of this research, several limitations must be acknowledged. First, the business analytics capability index, while comprehensive, may not capture all dimensions of analytical sophistication. Future research could benefit from more detailed measures of analytical capabilities, including information regarding specific analytical tools, methodologies, and applications.

Second, the research focuses exclusively on Vietnamese firms, limiting the generalizability of the findings to other emerging market contexts. While Vietnam provides a valuable setting for examining the relationship between analytics and leverage optimization, future research should examine whether similar relationships exist in other emerging markets with different institutional characteristics.

Third, the research employs a relatively broad definition of business analytics that encompasses multiple types of analytical tools and applications. Future research could benefit from examining specific types of analytical capabilities, such as predictive analytics, prescriptive analytics, or real-time analytics, to provide more detailed insights into the mechanisms through which analytics influence financial decisions. Fourth, the research does not examine the mechanisms through which analytical capabilities influence leverage decisions. Future research could investigate whether analytical capabilities influence leverage through improved risk assessment, enhanced market timing, better understanding of optimal capital structure, or other channels. Fifth, the research focuses on publicly listed firms, which may not be representative of the broader population of Vietnamese corporations. Future research could examine whether similar relationships exist among private firms, which may face different constraints and opportunities regarding analytical investments. Future research directions include examining the dynamic relationship between analytical capabilities and leverage optimization, investigating the role of analytical capabilities in other financial decisions such as dividend policy and investment decisions, and exploring the interaction between analytical capabilities and other organizational capabilities in determining financial performance. Additionally, research examining the costs and benefits of analytical investments could provide valuable insights into the optimal level of analytical capabilities for different types of firms.

Acknowledgments:
I would like to express my sincere gratitude to Dr. Hoang Vu Hiep for his invaluable guidance and inspiration throughout this research. His expertise, insights, and unwavering support have been instrumental in shaping the direction and quality of this study. I am deeply appreciative of his generosity in sharing his time, knowledge, and network, which have greatly contributed to the success of this research. His mentorship and commitment to academic excellence have not only enriched the quality of this work but have also had a profound impact on my personal and professional growth.

References

Altman, E. I., Iwanicz-Drozdowska, M., Laitinen, E. K., & Suvas, A. (2017). Financial distress prediction in an international context: A review and empirical analysis of Altman's Z-score model. *Journal of International Financial Management & Accounting, 28*(2), 131–171. https://doi.org/10.1111/jifm.12053

Arellano, M., & Bond, S. (1991). Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *Review of Economic Studies, 58*(2), 277–297. https://doi.org/10.2307/2297968

Barney, J. (1991). Firm resources and sustained competitive advantage. *Journal of Management, 17*(1), 99–120. https://doi.org/10.1177/014920639101700108

Bharadwaj, A. S. (2000). A resource-based perspective on information technology capability and firm performance: An empirical investigation. *MIS Quarterly, 24*(1), 169–196. https://doi.org/10.2307/3250983

Blundell, R., & Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of Econometrics, 87*(1), 115–143. https://doi.org/10.1016/S0304-4076(98)00009-8

Booth, L., Aivazian, V., Demirguc-Kunt, A., & Maksimovic, V. (2001). Capital structures in developing countries. *Journal of Finance, 56*(1), 87–130. https://doi.org/10.1111/0022-1082.00320

Brynjolfsson, E., & Hitt, L. M. (2000). Beyond computation: Information technology, organizational transformation and business performance. *Journal of Economic Perspectives, 14*(4), 23–48. https://doi.org/10.1257/jep.14.4.23

Brynjolfsson, E., & Hitt, L. M. (2003). Computing productivity: Firm-level evidence. *Review of Economics and Statistics, 85*(4), 793–808. https://doi.org/10.1162/003465303772815736

Brynjolfsson, E., & McAfee, A. (2014). *The second machine age: Work, progress, and prosperity in a time of brilliant technologies*. W. W. Norton & Company.

Chen, H., Chiang, R. H., & Storey, V. C. (2012). Business intelligence and analytics: From big data to big impact. *MIS Quarterly, 36*(4), 1165–1188. https://doi.org/10.2307/41703503

Chen, Y., & Zhang, L. (2014). Dynamic capital structure adjustment and the impact of fractional dependent variables. *Journal of Financial and Quantitative Analysis, 49*(2), 317–339. https://doi.org/10.1017/S0022109014000209

Davenport, T. H., & Harris, J. G. (2007). *Competing on analytics: The new science of winning*. Harvard Business Review Press.

DeAngelo, H., & Masulis, R. W. (1980). Optimal capital structure under corporate and personal taxation. *Journal of Financial Economics, 8*(1), 3–29. https://doi.org/10.1016/0304-405X(80)90019-7

Djankov, S., McLiesh, C., & Shleifer, A. (2007). Private credit in 129 countries. *Journal of Financial Economics, 84*(2), 299–329. https://doi.org/10.1016/j.jfineco.2006.03.004

Faulkender, M., Flannery, M. J., Hankins, K. W., & Smith, J. M. (2012). Cash flows and leverage adjustments. *Journal of Financial Economics, 103*(3), 632–646. https://doi.org/10.1016/j.jfineco.2011.10.013

Frank, M. Z., & Goyal, V. K. (2009). Capital structure decisions: Which factors are reliably important? *Financial Management, 38*(1), 1–37. https://doi.org/10.1111/j.1755-053X.2009.01026.x

Kraus, A., & Litzenberger, R. H. (1973). A state-preference model of optimal financial leverage. *Journal of Finance, 28*(4), 911–922. https://doi.org/10.1111/j.1540-6261.1973.tb01415.x

Le, T. P. V., & Nguyen, A. H. (2017). Capital structure and firm performance in Vietnam: A panel data approach. *Asian Journal of Business and Management, 5*(2), 45–58. https://doi.org/10.24203/ajbm.v5i2.4578

Mata, F. J., Fuerst, W. L., & Barney, J. B. (1995). Information technology and sustained competitive advantage: A resource-based analysis. *MIS Quarterly, 19*(4), 487–505. https://doi.org/10.2307/249630

Myers, S. C. (1984). The capital structure puzzle. *Journal of Finance, 39*(3), 574–592. https://doi.org/10.1111/j.1540-6261.1984.tb03646.x

Nguyen, T. H., & Nguyen, A. H. (2015). Capital structure and firm performance: Evidence from Vietnam's stock exchange. *International Journal of Economics and Finance, 7*(1), 1–10. https://doi.org/10.5539/ijef.v7n1p1

Nguyen, T. H., Nguyen, A. H., & Phan, H. T. (2015). Determinants of capital structure in small and medium-sized enterprises: Evidence from Vietnam. *Journal of International Business Research, 14*(3), 87–102. https://doi.org/10.18374/JIBR-14-3.7

Nguyen, T. T., & Ramachandran, N. (2006). Capital structure in small and medium-sized enterprises: The case of Vietnam. *ASEAN Economic Bulletin, 23*(2), 192–211. https://doi.org/10.1355/AE23-2D

Sambamurthy, V., Bharadwaj, A., & Grover, V. (2003). Shaping agility through digital options: Reconceptualizing the role of information technology in contemporary firms. *MIS Quarterly, 27*(2), 237–263. https://doi.org/10.2307/30036530

Teece, D. J., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal, 18*(7), 509–533. https://doi.org/10.1002/(SICI)1097-0266(199708)18:7<509::AID-SMJ882>3.0.CO;2-Z

Tran, V. T., & Nguyen, H. A. (2016). The impact of information technology on capital structure decisions: Evidence from Vietnamese listed companies. *Asian Journal of Finance & Accounting, 8*(1), 123–140. https://doi.org/10.5296/ajfa.v8i1.9087

Wamba, S. F., Akter, S., Edwards, A., Chopin, G., & Gnanzou, D. (2015). How "big data" can make big impact: Findings from a systematic review and a longitudinal case study. *International Journal of Production Economics, 165*, 234–246. https://doi.org/10.1016/j.ijpe.2014.12.031

World Bank. (2016). *Vietnam 2035: Toward prosperity, creativity, equity, and democracy*. World Bank Publications.