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Digital Transformation and Capital Structure Decisions in Developing Countries: A Theoretical Framework and Research Agenda

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Abstract

Digital transformation is altering the informational, institutional, and transactional landscape in which companies make financing decisions. However, capital structure theory has been slow to adapt to this change, especially for firms in developing nations. This paper presents a comprehensive theoretical framework that connects firm-level digital transformation to capital structure outcomes through three interrelated channels: the information asymmetry channel, the transaction cost channel, and the agency cost channel. Each channel is posited to function differently based on the robustness of a country's financial, legal, and digital institutions. Building upon traditional capital structure theories — including trade-off theory, pecking order theory, agency theory, and market timing theory — as well as the emerging discourse on fintech, digital infrastructure, and financial inclusion, the paper proposes six testable hypotheses regarding the direction, magnitude, and institutional moderation of the relationship between digital transformation and leverage. A thorough empirical research design is outlined, which includes sample construction across various emerging economies, the operationalization of a firm-level digital transformation index, panel data model specifications, and methods for addressing endogeneity through instrumental variables, dynamic panel GMM estimation, and quasi-natural experiments resulting from staggered digital infrastructure rollouts. This paper enhances corporate finance theory by broadening the determinants of capital structure to encompass the digital realm, provides valuable guidance for corporate financial managers making financing decisions in the context of digitalization, and offers policy-relevant insights for regulators aiming to strengthen capital markets in developing economies through investments in digital infrastructure. The paper also discusses limitations, boundary conditions, and future empirical research directions.

Keywords: *Capital structure; digital transformation; developing countries; information asymmetry; fintech; leverage*

1. Introduction

Capital structure decisions is the selection between debt, equity, and hybrid instruments for financing a firm to continue to be one of the most thoroughly examined yet unresolved issues in corporate finance. Following Modigliani and Miller's (1958) irrelevance proposition and its subsequent modification through the incorporation of taxes, bankruptcy costs, information asymmetries, and agency conflicts, a significant amount of theory and evidence has emerged to elucidate why firms opt for specific financing mixes. Trade-off theory, pecking order theory, agency theory, and market timing theory each provide partial insights, and empirical research across both developed and developing economies has pinpointed a consistent array of firm-level determinants, profitability, tangibility, size, growth opportunities, and non-debt tax shields — that are associated with leverage in various institutional contexts (Titman & Wessels, 1988; Rajan & Zingales, 1995; Booth, Aivazian, Demirguc-Kunt, & Maksimovic, 2001; Frank & Goyal, 2009).

What this body of literature has yet to fully incorporate is the structural transformation of the informational and transactional landscape instigated by digital technologies. In the past decade, developing economies have witnessed rapid, albeit uneven, digitalization: mobile financial services, digital credit registries, e-invoicing platforms, cloud-based accounting systems, and algorithmic credit scoring have transformed how firms create, store, and convey the information that lenders and investors utilize to assess capital pricing. Firms themselves have experienced similar transformations, implementing enterprise resource planning systems, digital payment infrastructures, and data analytics capabilities that modify their cost structures, monitoring abilities, and visibility to external financiers. These advancements are not merely operational; they likely alter the fundamental parameters, information asymmetry, transaction costs, and agency conflicts, upon which capital structure theory is founded.

The context of developing countries is particularly significant for this inquiry, for three primary reasons. First, the information asymmetries that exist between firms and capital providers are often more pronounced in developing economies, where credit bureaus are less comprehensive, the enforcement of financial reporting standards is inconsistent, and collateral registries are underdeveloped (La Porta, Lopez-de-Silanes, Shleifer, &Vishny, 1998; Demirguc-Kunt & Maksimovic, 1999). Consequently, digital technologies that mitigate information asymmetry are likely to have a disproportionately greater impact on access to financing and its terms in these environments compared to economies where information intermediation is already well established. Second, financial systems in developing nations are often characterized by a dominance of banks and a lack of depth, with corporate bond and equity markets being underdeveloped. This means that any digitally facilitated expansion of the credit supply base, such as through digital lending platforms or supplychain finance solutions, can significantly enhance the financing opportunities available to firms. Third, the speed and inconsistency of digital infrastructure development across and within developing countries, encompassing mobile network coverage, broadband access, national digital identity systems, and interoperable payment systems, generate substantial cross-sectional and temporal variations that can be empirically analyzed, providing opportunities for identification strategies that are more challenging to formulate in the more digitally uniform developed markets.

Despite these factors, the corporate finance literature that connects digital transformation directly to capital structure decisions remains relatively sparse, especially concerning firms in developing countries. A related yet distinct body of literature has explored financial inclusion and fintech lending at the household and small business levels (Demirguc-Kunt, Klapper,

Singer, & Ansar, 2018; Claessens, Frost, Turner, & Zhu, 2018), while a separate management and information systems literature has conceptualized digital transformation as an organizational phenomenon described by Vial (2019). Which highlights a significant gap in the existing literature. Specifically, there is a lack of a framework that links firm-level digital transformation in contrast to macrolevel fintech penetration, to the capital structure decisions of established, non-financial corporations in developing economies, while also detailing how the quality of institutions at the country level influences this relationship.

This paper aims to fill that gap by making three key contributions. Firstly, it constructs an integrative theoretical framework that breaks down the impact of digital transformation on capital structure into three distinct channels: the reduction of information asymmetry, the decrease in transaction costs, and the alleviation of agency costs. It also elucidates why the effectiveness of each channel may differ based on the financial and institutional development of a country. Secondly, it formulates six testable hypotheses regarding the direction, magnitude, and moderation of the relationship between digital transformation and leverage, along with additional hypotheses concerning debt maturity structure and the cost of capital. Lastly, it outlines a comprehensive empirical research design, which includes the creation of a firm-level digital transformation index, specifications for panel data models, and a series of complementary identification strategies. These strategies encompass instrumental variables derived from the rollout of telecommunications infrastructure, dynamic panel generalized method of moments (GMM) estimation, and difference-in-differences designs that leverage the staggered implementation of national digital payment or credit infrastructure. These approaches are intended to mitigate the endogeneity issues that are critical when estimating the causal effects of technology adoption on financing outcomes.

The structure of the remainder of the paper is as follows. Section 2 provides a review of the classical literature on capital structure, examines specific evidence related to capital structure in developing countries, and discusses the emerging literature on digital transformation and firm financing. Section 3 elaborates on the theoretical framework that connects digital transformation to capital structure through the three channels previously identified. Section 4 outlines the hypotheses of the paper. Section 5 details the proposed research methodology. Section 6 examines the theoretical, managerial, and policy implications of the proposed research. Section 7 addresses limitations and boundary conditions, while Section 8 provides a conclusion.

2. Literature Review

2.1 Classical Theories of Capital Structure

Modigliani and Miller (1958) established the foundational benchmark for capital structure research by demonstrating that, under a set of restrictive assumptions no taxes, no bankruptcy costs, symmetric information, and perfect capital markets the value of a firm is independent of its financing mix. The theoretical and empirical literature that followed can be understood largely as a systematic relaxation of these assumptions. Once corporate taxation is introduced, debt financing generates an interest tax shield that increases firm value with leverage, up to the point where the expected costs of financial distress offset this benefit (Modigliani & Miller, 1963). This insight underlies trade-off theory, which posits that firms select a target leverage ratio that balances the tax advantages of debt against the expected costs of financial distress and bankruptcy.

A second major strand, pecking order theory, dispenses with the notion of a target leverage ratio altogether. Myers (1977) and Myers and Majluf (1984) show that when

managers possess private information about firm value that outside investors do not have, the issuance of new equity is interpreted by the market as a signal that shares are overvalued, depressing the share price on announcement. To avoid this adverse selection cost, firms are predicted to follow a financing hierarchy, relying first on internally generated funds, then on debt, and resorting to external equity only as a last resort. Myers (1984) further argues that this hierarchy, rather than any target debt ratio, best explains observed patterns of corporate financing behavior, particularly the tendency of profitable firms to carry lower leverage a pattern difficult to reconcile with a strict trade-off framework.

A third strand emphasizes agency conflicts. Jensen and Meckling (1976) identify two countervailing agency problems: conflicts between shareholders and managers, which can be mitigated by debt's disciplining effect on the free use of corporate cash flow, and conflicts between shareholders and debtholders, which arise because equity holders have incentives to take on risky, value-destroying projects (asset substitution) when the firm is highly levered. Jensen (1986) extends this logic to argue that debt disciplines managers of firms with substantial free cash flow by committing them to fixed payment obligations, thereby reducing the resources available for potentially wasteful or empire-building investment. Finally, market timing theory (Baker & Wurgler, 2002) proposes that observed capital structures are, to a significant degree, the cumulative outcome of past attempts to time equity markets issuing equity when market valuations are perceived as high relative to fundamentals and repurchasing or issuing debt when valuations are perceived as low rather than the result of any optimizing target.

Empirically, a broadly consistent set of firm-level determinants of leverage has emerged across studies conducted in a wide range of institutional settings. Titman and Wessels (1988) find that uniqueness of a firm's products and, to a lesser extent, size and profitability are systematically related to leverage. Rajan and Zingales (1995) extend this analysis across the G7 economies and find that tangibility, market-to-book ratio, size, and profitability are correlated with leverage in broadly similar ways across institutionally diverse developed economies, suggesting that some capital structure determinants may travel well across contexts even as institutional detail varies. Frank and Goyal (2009) identify median industry leverage, market-to-book ratio, tangibility, profitability, firm size, and anticipated inflation as the most consistently associated factors with leverage in data from the United States. This finding is frequently utilized as a benchmark for comparative studies in other institutional settings, including those in developing economies.

2.2 Capital Structure in Developing-Country Contexts

A distinct yet related body of literature has investigated whether the determinants and dynamics of capital structure recognized in developed-market environments are applicable to developing economies, where there are significant differences in legal enforcement, financial market depth, and information infrastructure. Booth, Aivazian, Demirguc-Kunt, and Maksimovic (2001), in a significant study involving firms from ten developing countries, reveal that many of the same firm-level factors that account for leverage in developed markets such as profitability, tangibility, and growth—also account for leverage in developing markets. However, they note that the levels of leverage and the relative significance of debt maturity choices vary systematically, reflecting disparities in tax systems, the structure of the banking sector, and the availability of long-term debt markets. La Porta, Lopez-de-Silanes, Shleifer, and Vishny (1998) offer a foundational perspective on how legal origin and the robustness of investor and creditor protections influence the depth and structure of financial markets across different countries, a framework that has been

extensively applied to elucidate cross-country variations in corporate financing patterns. Demirguc-Kunt and Maksimovic (1999) demonstrate that firms located in countries with more advanced legal frameworks and more vibrant stock markets enjoy enhanced access to long-term debt financing. This highlights the significance of institutional quality beyond merely firm-specific attributes — in influencing the financing options available to businesses. Similarly, Fan, Titman, and Twite (2012), in their analysis of an international sample that includes both developed and developing nations, identify that a country's legal and financial institutions, as well as its tax regime, play crucial roles in determining both the level of leverage and the maturity profile of corporate debt. They observe that firms in nations with weaker institutional frameworks tend to depend more on short-term debt, a trend that aligns with lenders' preference for shorter maturities to alleviate the heightened information and enforcement challenges prevalent in such environments. Together, this body of literature affirms that the institutional context is not merely an ancillary factor but a fundamental determinant of capital structure outcomes in developing economies, a notion that underpins this paper's focus on the institutional moderation of the relationship between digital transformation and leverage.

Furthermore, it is important to recognize that developing economies are not uniform regarding the institutional characteristics that are most pertinent to this analysis. For example, economies in Sub-Saharan Africa are often marked by underdeveloped banking sectors and a lack of depth in corporate bond markets. However, they have, in some instances, witnessed some of the fastest global growth rates in mobile money adoption, resulting in a unique blend of fragile traditional financial institutions and relatively advanced digital payment infrastructures. In contrast, several South and Southeast Asian economies exhibit a different scenario: they possess moderately developed banking sectors alongside swiftly evolving digital public infrastructures, which include national digital identity systems and interoperable real-time payment systems, frequently introduced as explicit government policy initiatives.

Latin American economies exhibit significant disparities in the depth of their banking sectors and have experienced considerable growth in both digital banking and non-bank fintech lending over the last ten years. However, the progress made in national digital identity and credit registry integration has been more varied compared to certain Asian economies. This regional diversity is not merely incidental to the framework established in this paper; it represents the type of cross-country variation in the combined distribution of traditional institutional quality and the maturity of digital infrastructure that Hypotheses H4 through H6 aim to leverage. Furthermore, it highlights the necessity of a multi-country research design, as elaborated in Section 5, rather than relying on a single-country case study, to effectively evaluate the proposed institutional moderation effects.

2.3 Digital Transformation: Concept and Dimensions

Digital transformation is defined in the management and information systems literature as an organizational process through which companies utilize digital technologies such as cloud computing, data analytics, mobile platforms, and automation to fundamentally change their value propositions, business processes, and organizational structures (Vial, 2019). This body of literature underscores that digital transformation is a multidimensional concept rather than merely a decision to adopt a single technology. It encompasses, at a minimum: (i) the digitalization of internal processes, including accounting, inventory, and enterprise resource planning systems; (ii) the digitalization of transactions with customers and suppliers, such as e-commerce and digital payments; (iii) the adoption of data analytics and algorithmic

decision-making capabilities; and (iv) engagement with digital financial infrastructure, including mobile money, digital lending platforms, and electronic invoicing or supply-chain finance systems.

From a corporate finance standpoint, each of these aspects has unique implications for the informational presence that a company presents to external capital providers. Digital accounting and enterprise resource planning systems produce more detailed, timely, and verifiable financial records compared to manual or paper-based systems, which can, in theory, be shared with lenders at a lower cost and with enhanced credibility. Digital payment and transaction systems yield transaction-level data including cash flow timing, customer concentration, and payment reliability that can be utilized, with the necessary consent and data-sharing agreements, as an alternative or complement to traditional financial statements in credit evaluations. The capabilities of data analytics may enhance a firm's internal financial planning, cash flow forecasting, and working capital management, thereby indirectly influencing both its demand for external financing and its capacity to reliably service debt.

2.4 Digital Transformation and Firm Financing: Emerging Evidence

A rapidly expanding body of literature has explored the macro-level relationship between fintech development, financial inclusion, and access to finance, particularly for households and small enterprises in developing economies. The World Bank's Global Findex initiative has recorded significant increases in account ownership and the utilization of digital financial services across developing regions over the last decade, largely driven by mobile money platforms (Demirguc-Kunt, Klapper, Singer, & Ansar, 2018). Claessens, Frost, Turner, and Zhu (2018), in their examination of the global expansion of fintech credit, document considerable cross-country differences in the scale of digital lending markets and correlate this variation with indicators of financial development, banking sector concentration, and regulatory frameworks, indicating that the provision of digital credit both substitutes for and complements traditional bank lending depending on the institutional context.

Gomber, Koch, and Siering (2017) present a comprehensive overview of the literature on digital finance and fintech, outlining research areas that include digital payments, digital financing (such as crowdfunding and digital lending), digital investment, and digital currencies. They observe that the majority of existing empirical studies have concentrated on retail and small-business finance, rather than examining the capital structure decisions of established corporations.

This focus on retail and small-business contexts raises an important question that this paper seeks to address: how does digital transformation at the level of individual corporate borrowers, particularly those that are larger and more established, influence their capital structure choices? Additionally, how does this relationship differ based on the institutional environment in which the firm operates? To explore this question, it is necessary to integrate the corporate finance literature regarding capital structure determinants with the digital transformation and fintech literatures previously discussed, a task that will be undertaken in the theoretical framework outlined in the following section.

3. Theoretical Framework

This section formulates an integrative framework that connects firm-level digital transformation to capital structure decisions through three primary channels: the reduction of information asymmetry, the decrease of transaction costs, and the mitigation of agency costs. Furthermore, the framework posits that the quality of country-level institutions which includes factors such as the depth of financial markets, the enforcement of legal standards,

and the state of digital infrastructure moderates the effectiveness of each channel. Consequently, it is anticipated that the marginal impact of digital transformation on leverage will be most pronounced in settings with underdeveloped institutions, where the baseline levels of information asymmetry, transaction friction, and agency conflict are at their highest.

3.1 The Information Asymmetry Channel

Pecking order theory is based on the idea that adverse selection costs arising from information asymmetry between company insiders and external capital providers create a financing hierarchy that favors internal funds and debt over external equity (Myers & Majluf, 1984). Digital transformation likely reduces this information gap in various ways. Digital accounting systems and enterprise resource planning platforms generate financial records that are more detailed, timely, and easily verifiable by external auditors and lenders compared to manually maintained records, thereby lowering the costs lenders face in evaluating borrower quality. Digital transaction data — including point-of-sale records, digital payment histories, and e-invoicing records offer lenders, especially those employing algorithmic credit-scoring models, a more comprehensive and continuously updated information set than periodic financial statements alone. When national credit registries or credit bureaus are integrated with firms' digital transaction systems, the informational opacity that has historically limited lending to firms in developing economies may be significantly diminished.

To the extent that digital transformation mitigates information asymmetry, its impact on capital structure should primarily manifest as an expansion of the debt financing margin accessible to the firm at a given cost, rather than altering the relative appeal of debt versus equity for a firm that already has full access to both. This is due to the fact that information asymmetry, within the framework proposed by Myers and Majluf (1984), is what renders equity issuance more expensive compared to debt; thus, reducing information asymmetry should generally decrease the cost of external finance, but its differential impact is anticipated to be more pronounced for debt than for equity in developing-country contexts, as debt (particularly secured or asset-based debt) is disproportionately hindered by information and verification challenges that digitization can address. In contrast, the unique frictions inherent to equity markets, such as limited trading activity, inadequate protections for minority shareholders, and a lack of analyst coverage, are not as directly influenced by digital transformation at the firm level. Consequently, the overall expectation is that digital transformation will correlate with an increase in leverage, facilitated by enhanced and more affordable access to debt.

3.2 The Transaction Cost Channel

A second mechanism functions through both the direct and indirect transaction costs associated with obtaining and managing external financing. In developing economies, traditional lending relationships frequently entail significant fixed costs related to loan origination, including the necessity for physical branch visits, manual documentation, and in-person collateral assessments. These costs remain largely unchanged regardless of loan size, thereby disproportionately impacting smaller loans and firms. The advent of digital lending platforms, digital collateral registries, and electronic documentation systems serves to diminish these fixed transaction costs, potentially rendering external debt financing feasible for firms and loan amounts that would have previously been unprofitable for lenders to address. Additionally, digital payment systems alleviate the costs and delays linked to loan disbursement and repayment collection, thereby enhancing the financial dynamics of lending relationships for both borrowers and lenders.

This mechanism not only forecasts an increase in the accessibility of debt financing but also suggests a possible alteration in its maturity structure and pricing. When digital monitoring, such as continuous access to a borrower's digital transaction data, replaces the expensive periodic verification of covenants, lenders may be inclined to offer longer-maturity debt than they would under traditional manual monitoring systems. This is because one of the reasons for shorter maturities in lending within developing countries is to enable lenders to frequently reassess borrower quality at a lower cost than what continuous monitoring would necessitate (Fan, Titman, & Twite, 2012). Digital transformation can thus be linked not only to increased leverage but also to an extension of the average maturity of debt, especially among companies that implement digital transaction and reporting systems compatible with the risk-assessment frameworks of their lenders.

3.3 The Agency Cost Channel

The third channel addresses the agency conflicts that arise between shareholders and managers, as well as between shareholders and debtholders. Jensen and Meckling (1976) and Jensen (1986) highlight that debt can fulfill a disciplining role; however, this role is contingent upon the ability of debtholders to oversee managerial conduct and enforce covenants. Digital transformation, by enhancing internal financial reporting, providing real-time visibility into cash flows, and establishing data-driven internal controls, can lower the costs for external debtholders in monitoring compliance with loan covenants. This improvement makes debt governance mechanisms more effective and, potentially, more appealing to both firms and lenders. Concurrently, enhanced internal analytics and forecasting capabilities may directly mitigate the free cash flow agency problem by refining the quality of capital allocation decisions made by firms and diminishing the perceived necessity for external debt discipline. This indicates that the agency channel may exhibit an ambiguous net effect, which is likely influenced by the initial intensity of agency conflicts within the firm. This intensity is plausibly linked to ownership concentration, a prevalent characteristic in many developing economies where family-controlled and closely-held firms are common.

3.4 Institutional Moderation

The proposed framework suggests that the effectiveness of each of the three channels mentioned above is influenced by the quality of institutions at the country level across three dimensions: the depth of financial markets (the presence of alternative financing options that compete with digitally enabled debt), the legal and contracting institutions (which establish the fundamental costs associated with enforcing debt contracts, thereby affecting the additional value of digitally enabled monitoring and verification), and the maturity of digital infrastructure (the extent of mobile network coverage, national identification systems, and interoperable payment systems that determine the feasibility of leveraging firm-level digital transformation by external capital providers). In contexts where the baseline quality of institutions is low, the additional impact of firm-level digital transformation on diminishing information asymmetry, transaction costs, and monitoring expenses is anticipated to be the most significant, as the existing informational and contracting landscape allows for the greatest potential for enhancement. Conversely, in environments where the baseline institutional quality is already high, the influence of firm-level digital transformation on capital structure is expected to be less pronounced, since information intermediaries, credit bureaus, and contract enforcement mechanisms already fulfill many of the roles that digital transformation would typically address. This moderation rationale leads to the institutional-interaction hypotheses that will be elaborated upon in the subsequent section.

4. Hypothesis Development

Building upon the theoretical framework outlined above, this section formulates six key hypotheses regarding the connection between firm-level digital transformation and capital structure choices among firms in developing nations.

4.1 Direct Impact on Leverage

The channels of information asymmetry and transaction costs both indicate that digital transformation increases the accessibility and reduces the expense of external debt financing for a firm, especially in developing countries where significant information frictions exist. This leads to the central hypothesis of the paper:

H1: There is a positive correlation between firm-level digital transformation and corporate leverage in firms located in developing nations.

4.2 Structure of Debt Maturity

The transaction cost channel implies that continuous monitoring enabled by digital means can replace the need for periodic reassessment that typically drives reliance on short-term debt in environments with weak institutions, thereby allowing lenders to offer longer maturities to borrowers who have undergone digital transformation.

H2: There is a positive association between firm-level digital transformation and the share of long-term debt within the total debt of firms in developing countries.

4.3 Debt Cost

To the extent that digital transformation diminishes information asymmetry and reduces the fixed costs associated with loan origination and monitoring, lenders are likely to provide credit on more favorable terms to borrowers who have undergone digital transformation, assuming other observable risk factors remain constant.

H3: There is a negative relationship between firm-level digital transformation and the cost of debt capital for firms in developing countries.

4.4 Institutional Moderation by Financial Development

The institutional moderation framework outlined in Section 3.4 suggests that the leverage-increasing effect of digital transformation will be most pronounced in contexts where alternative, non-digital methods for addressing information asymmetry and transaction frictions are underdeveloped.

H4: The positive correlation between firm-level digital transformation and leverage is more pronounced in countries with lower levels of financial market development.

4.5 Institutional Moderation by Legal and Creditor Rights Environment

Due to the ability of digitally verified transaction and repayment data to partially replace formal contract enforcement, this supports lenders' readiness to provide credit. The framework indicates that the significance of digital transformation increases in contexts where the legal enforcement of creditor rights is less robust.

H5: The positive correlation between firm-level digital transformation and leverage is more pronounced in nations with weaker legal protections for creditor rights.

4.6 Moderation by National Digital Infrastructure

Both the transaction cost and information asymmetry channels rely on the presence of a national digital infrastructure including mobile network coverage, digital identification, and interoperable payment systems which enables the sharing and trust of firm-level digital data by external lenders. In regions where this infrastructure is underdeveloped, firm-level digital transformation may lead to internal efficiency improvements without enhancing access to external financing, as lenders may lack the means to verify or utilize the firm's digital information.

H6: The positive correlation between firm-level digital transformation and leverage is stronger in countries with a more advanced national digital financial infrastructure, contingent upon firm-level digital transformation.

Hypotheses H4 through H6 collectively suggest a more intricate institutional prediction than a straightforward monotonic relationship: the leverage-increasing effect of digital transformation is expected to be most significant in environments where foundational financial and legal institutions are weak, yet the national digital infrastructure is sufficiently advanced to facilitate the transmission and reliance on firm-level digital information by external capital providers. This indicates an interaction between H4/H5 and H6, which the proposed methodology, elaborated upon next, is specifically designed to evaluate.

5. Proposed Research Methodology

This section delineates a research design that is capable of testing the hypotheses formulated earlier. As this paper is conceptual and focused on theory development, the design is presented in a prospective manner, serving as a blueprint for the empirical study that would operationalize and evaluate the framework; no empirical findings are included in this section.

5.1 Research Philosophy and Design

The proposed research adopts a post-positivist philosophy, aligning with conventional empirical research in corporate finance, and employs a quantitative, deductive research design where hypotheses derived from established theories are tested using archival panel data. This methodology is suitable given the paper's aim to estimate generalizable relationships between digital transformation and capital structure outcomes across a broad sample of firms and countries, rather than developing context-specific interpretive insights into the digitalization experiences of individual firms, which would necessitate a qualitative or mixed-methods approach.

5.2 Population, Sampling Frame, and Data Sources

The target population consists of publicly listed non-financial firms located in developing countries, as categorized by the World Bank's income and regional classifications, over a sufficiently extended sample period to capture significant variations in both firm-level digital transformation and national digital infrastructure for example, a fifteen-year panel starting in the early 2010s, when mobile financial services began to expand rapidly across numerous developing regions, continuing through the most recent fiscal year for which audited financial statements are accessible. Limiting the sample to listed firms is a practical necessity due to the need for consistent, audited financial statement data; however, this is recognized as a limitation discussed in Section 7, as listed firms do not represent the broader population of firms in developing economies, the majority of which are small, unlisted, and frequently informal.

Firm-level financial statement data will be sourced from standard commercial databases commonly utilized in cross-country corporate finance research, such as Refinitiv/Datastream, Compustat Global, or Orbis/Moody's BvD. This will be supplemented by manually collected data from annual reports when necessary to develop the digital transformation index outlined below. Country-level institutional variables will be obtained from reputable sources: financial development indicators from the World Bank Global Financial Development Database (including private credit to GDP and stock market capitalization to GDP); creditor rights and contract enforcement metrics from the World Bank Doing Business/Business Ready indicators, along with updated creditor rights indices following the methodology of La Porta et al. (1998); and the maturity of national digital infrastructure will be assessed using International Telecommunication Union (ITU) indicators for mobile and broadband penetration, in conjunction with World Bank Global Findex measures of digital financial account ownership and usage at the national level.

5.3 Measurement of Key Variables

5.3.1 Dependent Variables

- Book leverage: total debt (both short-term and long-term) as a proportion of total assets, which is the conventional measure employed in Rajan and Zingales (1995) and subsequent research on capital structure.
- Market leverage: total debt as a proportion of the market value of assets (the book value of debt plus the market value of equity), included as a robustness check due to the known sensitivity of results to the definition of leverage (Welch, 2004, and related studies on the mechanical influence of equity price fluctuations on observed leverage).
- Debt maturity structure: long-term debt (due beyond one year) expressed as a proportion of total debt, in order to test H2.
- Cost of debt: interest expenses as a proportion of average total interest-bearing debt over the fiscal year, aimed at testing H3, with an alternative measure based on bond yield spreads for the subset of firms with rated public debt.

5.3.2 Independent Variable: Firm-Level Digital Transformation Index

In alignment with the multidimensional framework of digital transformation discussed in Section 2.3, the primary independent variable is proposed as a composite index formed from four sub-components. Each sub-component is scored on a uniform scale and aggregated, either through equal weighting or, as a robustness check, weights derived from principal component analysis. The components include: (i) digital process adoption, assessed through textual analysis of annual reports and management discussions for references to enterprise resource planning systems, cloud computing, automation, and digital process terminology, following the increasingly utilized computational text-based measurement approach in accounting and finance research; (ii) digital sales and payments adoption, derived from disclosed e-commerce revenue shares and the acceptance of digital payments where available, supplemented by industry-level digital adoption benchmarks in the absence of firm-specific disclosures; (iii) data analytics capability, indicated by disclosed investments in information technology and data infrastructure, scaled by total assets or revenue; and (iv) participation in digital financial ecosystems, measured through disclosed utilization of supply-chain finance platforms, e-invoicing systems, or digital lending relationships. The index will be validated against alternative, more concise proxies, such as capitalized software and IT asset intensity, or disclosures related to firm-level patents and digital-technology-related intangible assets, to evaluate robustness concerning measurement choices.

5.3.3 Moderating (Institutional) Variables

- Financial development: private credit to GDP and stock market capitalization to GDP (country-year), testing H4.
- Creditor rights index: an updated version of the La Porta et al. (1998) creditor rights index, or the equivalent World Bank indicator, testing H5.
- The maturity of national digital infrastructure is assessed through a composite measure that includes ITU mobile broadband subscription rates, internet penetration, and Global Findex digital account ownership at the country-year level, in order to test hypothesis H6.

5.3.4 Control Variables

In alignment with the established literature on capital structure determinants (Titman & Wessels, 1988; Rajan & Zingales, 1995; Frank & Goyal, 2009), the firm-level control variables will encompass: firm size (logarithm of total assets), asset tangibility (net property, plant, and equipment as a proportion of total assets), profitability (EBITDA as a proportion of total assets), growth opportunities (market-to-book ratio), non-debt tax shields (depreciation as a proportion of total assets), firm age (logarithm of years since incorporation), and effective tax rate. Country-year control variables will include GDP growth, inflation, and a measure of banking sector concentration. Fixed effects for industry and year will be incorporated in all specifications to account for time-invariant industry characteristics and common macroeconomic shocks.

5.4 Model Specification

The foundational specification is a panel regression with firm and year fixed effects, represented as follows:

$$\text{Leverage}(i,t) = \alpha + \beta 1\ \text{DigitalTransformation}(i,t-1) + \gamma' \text{Controls}(i,t-1) + \eta i + \lambda t + \varepsilon(i,t)$$

where i represents firms, t represents fiscal years, ηi indicates firm fixed effects, λt indicates year fixed effects, and both the digital transformation index and firm-level controls are lagged by one year to reduce simultaneity bias and to reflect the time necessary for changes in digital capabilities to influence financing outcomes. Standard errors will be clustered at the firm level to address serial correlation in the residuals, with an alternative robustness check involving country-level clustering due to the country-level moderating variables of interest.

To evaluate the institutional moderation hypotheses (H4–H6), the model is expanded to include interaction terms between the digital transformation index and each institutional moderator: $\text{Leverage}(i,t) = \alpha + \beta 1\ \text{DigitalTransformation}(i,t-1) + \beta 2\ [\text{DigitalTransformation}(i,t-1) \times \text{Institution}(c,t-1)] + \beta 3\ \text{Institution}(c,t-1) + \gamma' \text{Controls}(i,t-1) + \eta i + \lambda t + \varepsilon(i,t)$where c represents the country of domicile for the firm, and Institution(c,t−1) refers to financial development, creditor rights, and the maturity of digital infrastructure, which are entered separately and, in a fully saturated specification, collectively with their triple interaction to evaluate the compound prediction outlined at the conclusion of Section 4. Hypothesis H1 is validated by a positive and statistically significant β1; Hypotheses H4 and H5 are confirmed by a negative and significant β2 (indicating a more pronounced effect of digital transformation in contexts of lower institutional quality), while Hypothesis H6 is supported by a positive and significant β2 regarding the interaction with digital infrastructure (indicating a stronger effect in environments with more mature digital infrastructure). Similar specifications, replacing the debt maturity ratio and cost of debt as dependent variables, will be employed to assess Hypotheses H2 and H3.

5.5 Addressing Endogeneity

The primary empirical challenge confronting this research design is the probable endogeneity of firm-level digital transformation in relation to capital structure: firms that exhibit higher profitability, superior governance, or enhanced access to capital may inherently possess a greater capacity to invest in digital transformation, leading to reverse causality and omitted-variable bias that a straightforward fixed-effects specification cannot adequately address. Three complementary strategies are proposed to mitigate this issue.

5.5.1 Instrumental Variables

In line with an identification logic prevalent in the broader literature on technology adoption and access to finance, this study intends to instrument firm-level digital transformation by utilizing variations in the timing and geographic deployment of national telecommunications and mobile broadband infrastructure at the sub-national (regional or district) level within the vicinity of the firms' headquarters.

The exclusion restriction stipulates that the rollout of regional infrastructure influences a firm's capital structure solely through its impact on digital adoption at the firm level, without any direct effects on local economic activity. This assumption will be evaluated through placebo tests examining leverage trends prior to the rollout and by flexibly controlling for regional economic conditions.

5.5.2 Dynamic Panel GMM Estimation

Considering the well-established persistence of leverage ratios over time, the study will also estimate a dynamic panel model that includes a lagged dependent variable, utilizing the system GMM estimator as per the methodologies of Arellano and Bover, and Blundell and Bond, which are frequently employed in research on capital structure dynamics. This approach addresses the Nickell bias that arises from the correlation between the lagged dependent variable and the fixed effect, and through the use of internal instrumentation with suitably lagged levels and differences of the regressors, it offers an additional verification of the robustness of the digital transformation coefficient against dynamic misspecification.

5.5.3 Quasi-Natural Experiments

When possible, the study will take advantage of quasi-natural experiments that emerge from staggered national rollouts of digital financial infrastructure. Examples include national digital identity initiatives, real-time gross settlement systems, interoperable payment systems, or centralized registries for movable-asset collateral. A staggered difference-in-differences design will be employed, adhering to recent econometric recommendations on staggered adoption designs, as outlined in the methodological literature by Callaway and Sant’Anna, and Sun and Abraham, to mitigate the negative-weighting issues identified in two-way fixed-effects estimators under staggered treatment timing.

This design provides the most robust foundation for causal inference among the three strategies, contingent upon the presence of clean, plausibly exogenous rollout variation and an adequate number of treated and control country-periods.

5.6 Robustness and Sensitivity Analyses

In addition to the alternative leverage and digital transformation metrics mentioned earlier, the planned robustness checks will include: re-estimation that excludes years of financial crises to ensure that the results are not influenced by credit contractions during crisis periods; sub-sample analysis based on firm size and ownership concentration to evaluate whether the anticipated effects are particularly pronounced among specific types of firms; alternative

clustering of standard errors (firm, country, and firm-country); and placebo tests utilizing a randomly reassigned, spuriously lagged digital transformation index to verify that the estimated effects are not artifacts of the panel structure.

5.7 Sample Size, Statistical Power, and Data Quality Considerations

A study of this nature necessitates a sufficiently large sample to identify economically significant interaction effects, which are generally more challenging to estimate accurately than main effects due to the diminished effective variation in interaction terms compared to their constituent variables. A minimum target of approximately 150 to 200 firms per country across at least fifteen to twenty developing countries, observed over a ten- to fifteen-year panel, is recommended as an initial benchmark, resulting in a firm-year panel comprising between 20,000 and 40,000 observations after accounting for missing data and the lagging of key regressors. Power calculations based on plausible effect sizes derived from similar studies on technology adoption and access to finance will be performed at the design stage to ensure that the proposed sample is sufficient to detect interaction effects of the magnitude suggested by the theoretical framework.

Data quality issues pertinent to financial statement data from developing countries — such as the inconsistent application of international financial reporting standards, instances of currency redenomination, and periods of hyperinflation in certain sample nations — must be addressed through established data-cleaning protocols (including winsorization of extreme ratios, exclusion of firm-years with negative equity or missing essential variables, and inflation-adjustment of nominal figures where applicable) before estimation.

5.8 Ethical and Data Governance Considerations

Given that the proposed digital transformation index partially relies on textual analysis of corporate disclosures and, when available, third-party data regarding firms' participation in the digital financial ecosystem, the research design introduces data governance issues that require careful consideration. All firm-level data will be sourced from public disclosures or licensed commercial databases utilized under standard academic data use agreements, ensuring that no proprietary transaction-level data from individual lenders or firms is collected without the necessary consent and data protection measures. Should the research design be expanded in future studies to include proprietary bank lending or credit registry microdata, as indicated in Section 7, adherence to relevant data protection regulations in each sample country, along with suitable anonymization and secure data handling practices, will be essential for obtaining research ethics approval.

6. Expected Contributions and Implications

6.1 Theoretical Contribution

The main theoretical contribution of this paper lies in the synthesis of the digital transformation and capital structure literatures into a unified framework that delineates distinct, testable channels namely, information asymmetry, transaction costs, and agency costs through which the adoption of digital technology is anticipated to influence financing decisions, while also clarifying how these channels are moderated by the quality of institutions at the country level.

This research expands upon traditional capital structure theory, which has largely been developed without considering digital information technology, into an area of growing empirical significance. It provides a systematic framework for reconciling findings that may seem contradictory across various studies conducted in different institutional contexts: for instance, a positive relationship between digital transformation and leverage observed in one

country and a null or weaker relationship in another should not be viewed as inconsistent. Instead, these findings can be understood through the lens of institutional moderation proposed in this study.

6.2 Managerial and Practical Implications

For financial managers in developing economies, the proposed framework indicates that investing in digital transformation—especially in digitalized accounting, transaction, and reporting systems—may offer a previously overlooked financing advantage. This investment could enhance access to debt capital and potentially improve its terms, in addition to any direct operational efficiency benefits. This insight has significant implications for how firms prioritize their digital investments and how they communicate their digital capabilities to lenders and investors. Companies may gain from explicitly integrating digital transformation initiatives into their communications with investors and lenders, particularly in contexts where formal financial disclosures are limited in scope or credibility. For lenders and financial institutions operating in developing markets, the framework suggests that enhancing the ability to receive, verify, and assess digital transaction data from potential borrowers could unlock a previously underserved segment of creditworthy yet information-poor firms.

6.3 Policy Implications

For policymakers and regulators, the anticipated results of institutional moderation as outlined in hypotheses H4 through H6 present a specific and actionable implication: The financial advantages of digital transformation at the firm level depend on the presence of complementary national digital infrastructure, which includes interoperable payment systems, digital identity, and, when relevant, centralized digital collateral or credit registries. In the absence of such infrastructure, the digitalization of firms may not lead to enhanced access to external financing. This indicates that policies designed to strengthen capital markets and enhance financial access in developing countries should consider investments in digital infrastructure and support for firm-level digitalization as complementary rather than as alternatives to traditional financial sector development strategies, such as bolstering creditor rights and enhancing contract enforcement. The framework suggests that digital transformation is particularly beneficial in contexts where these traditional institutions are weak, but only if the necessary digital infrastructure is concurrently established to ensure that firm-level information is accessible to external capital providers.

6.4 Illustrative Application of the Framework

To make the framework's predictions concrete, consider two stylized firms operating in a hypothetical developing economy with a shallow banking sector, weak collateral enforcement, but recently upgraded national digital payment and identity infrastructure. The first firm, a manufacturing enterprise that continues to rely on manual bookkeeping and paper-based invoicing, presents lenders with an information set limited to annual audited statements, filed with a lag and subject to only partial verification. The second firm, otherwise similar in size, sector, and profitability, has adopted an integrated enterprise resource planning system, accepts digital payments from its distributors, and participates in a supply-chain finance platform that shares real-time receivables data with a partner lender. Under the framework developed in this paper, the second firm is predicted to access a larger volume of debt, on more favorable terms and over longer maturities, than the first, not because it is a fundamentally lower-risk borrower in an economic sense, but because its digital transformation has reduced the lender's cost of verifying and monitoring that risk. This stylized contrast illustrates why the digital transformation index proposed in Section 5.3.2 is designed to capture verifiable, lender-relevant digital capability rather than digital

adoption in general, and it is precisely this differential — between digitally legible and digitally illegible, but otherwise similar, firms — that the empirical design is intended to isolate.

7.0 Limitations and Directions for Future Research

There are several limitations and constraints associated with the proposed framework and research design that warrant recognition. Firstly, as highlighted in Section 5.2, the dependence on publicly listed companies for consistent financial statement data limits the empirical analysis to a portion of the corporate sector that does not accurately reflect the wider array of firms in developing economies. In these regions, small and medium-sized enterprises, which are often unlisted or operate informally, dominate and may experience the relationship between digital transformation and capital structure differently. This is largely due to their generally higher levels of information opacity and restricted access to formal credit markets. Future studies that utilize proprietary bank lending datasets, credit registry microdata, or firm-level survey tools such as the World Bank Enterprise Surveys would be instrumental in broadening the framework to encompass this segment.

Secondly, the development of a firm-level digital transformation index inherently involves various measurement decisions including which dimensions to incorporate, how to assign weights, and how to derive meaningful insights from disclosure-based text analysis. These choices introduce the possibility of measurement errors and may lead to correlations between the constructed index and unobserved firm quality.

The proposed research design incorporates various robustness checks against alternative measures; however, it cannot be assumed that any single index will completely encapsulate the underlying construct. Future efforts aimed at refining and validating the measurement of digital transformation, potentially through direct surveys administered to selected firms, would enhance the reliability of results derived from disclosure-based proxies.

Furthermore, while the suggested strategies of instrumental variable, dynamic panel, and quasi-natural experiments provide a reasonably extensive toolkit for addressing endogeneity, it cannot be assumed a priori that they will fully meet the exclusion restrictions or parallel trends assumptions upon which they depend. The credibility of causal assertions will ultimately hinge on the specific institutional and data contexts in which the study is conducted, and results should be interpreted with due caution regarding their external validity across the diverse range of countries categorized as "developing."

Additionally, the framework as it stands considers digital transformation to influence the supply and demand for external finance primarily through the three identified channels. However, it is conceivable that other channels such as the impact on a firm's own risk profile due to operational digitalization, or effects on covenant design and contract structureare also significant and may not be fully represented by the leverage-focused dependent variables proposed in this study. Future research that expands the framework to include contract-level terms (such as covenant intensity, collateral requirements, and loan pricing at origination) using detailed loan-level data would provide a valuable enhancement to the firm-level, financial-statement-based analysis suggested in this paper.

Ultimately, the institutional moderators discussed in this paper financial development, creditor rights, and the maturity of digital infrastructure are unlikely to encompass all significant sources of cross-country variability; the regulatory approaches to digital lending and the evolving open banking/open finance data-sharing frameworks, which are currently

developing at a rapid and uneven pace across emerging economies, may emerge as equally or even more critical moderators as these frameworks advance. Future iterations of this research agenda should monitor and integrate this regulatory aspect as data becomes accessible.

7.1 A Note on Generalizability Across the "Developing Country" Category

The designation "developing countries" encompasses a vast spectrum of income levels, financial system configurations, and digital infrastructure maturity, ranging from lower-middle-income nations with emerging stock markets to large developing markets with advanced, albeit still incomplete, financial systems. The framework outlined in this paper is designed to be applicable across this spectrum precisely because its key moderating variables- financial development, creditor rights, and digital infrastructure maturity are assessed continuously rather than through a binary classification of developed versus developing. This approach enables the empirical design to capture variability both within and across the extensive category of developing economies. However, researchers utilizing this framework for a specific subset of countries such as a particular region or income category should exercise caution when extrapolating estimated coefficients to nations with significantly different institutional characteristics than those included in the estimation sample. It is advisable to report sub-sample results by region or income group routinely, rather than relying exclusively on pooled estimates.

Conclusion

This paper has established a comprehensive theoretical framework that connects firm-level digital transformation to capital structure decisions in developing countries. It posits that digital transformation influences financing outcomes through three interrelated channels: the reduction of information asymmetry, the decrease of transaction costs, and the mitigation of agency costs. The effectiveness of these channels is contingent upon the quality of a country's financial, legal, and digital institutions. Six hypotheses were formulated, predicting a positive direct correlation between digital transformation and leverage, an extension of debt maturity, and a decrease in the cost of debt linked to digital transformation. Additionally, it suggests a pattern of institutional moderation where the financing advantages of digital transformation are most pronounced in environments with weak traditional financial and legal institutions, provided that the national digital infrastructure is sufficiently developed to render firm-level digital information accessible to external capital providers.

A comprehensive empirical research design was proposed to validate these hypotheses, integrating a firm-level digital transformation index derived from financial disclosures and textual analysis with panel data methodologies. These include fixed-effects, dynamic GMM, instrumental variable, and staggered difference-in-differences estimators, all aimed at addressing the significant endogeneity issues associated with the simultaneous examination of technology adoption and financing outcomes. Should the empirical evidence support this framework, it would enhance capital structure theory within the digital context, provide actionable insights for corporate managers and lenders facing financing decisions in the context of ongoing digitalization, and furnish policymakers in developing economies with a solid evidentiary foundation for viewing investments in digital infrastructure as complementary to, rather than a replacement for, traditional financial sector development strategies.As digital transformation persistently alters the informational and transactional underpinnings of corporate finance, incorporating this trend into the conventional capital structure theory is not just a minor enhancement of current models but an essential advancement of the fundamental explanatory framework for companies functioning within the institutional contexts prevalent in many developing nations.

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Appendix: Summary of Key Variables

Table A1 summarizes the primary variables proposed for the empirical study described in Section 5, including their conceptual role, operational definition, and data source.

Variable	Role	Operational Definition	Primary Source
Book leverage	Dependent (H1)	Total debt / total assets	Firm financial statements
Market leverage	Dependent (robustness)	Total debt / (total debt + market value of equity)	Firm financial statements + market data
Long-term debt ratio	Dependent (H2)	Long-term debt / total debt	Firm financial statements
Cost of debt	Dependent (H3)	Interest expense / average interest-bearing debt	Firm financial statements
Digital transformation index	Independent	Composite of process, sales, analytics, and ecosystem digitalization sub-scores	Annual reports, textual analysis, IT expenditure disclosure
Financial development	Moderator (H4)	Private credit to GDP; stock market capitalization to GDP	World Bank Global Financial Development Database
Creditor rights index	Moderator (H5)	Composite legal index of secured creditor protection	World Bank Doing Business/Business Ready; La Porta et al. tradition
Digital infrastructure maturity	Moderator (H6)	Mobile broadband penetration; digital account ownership	ITU; World Bank Global Findex
Firm size	Control	Log of total assets	Firm financial statements
Tangibility	Control	Net PP&E / total assets	Firm financial statements
Profitability	Control	EBITDA / total assets	Firm financial statements
Growth opportunities	Control	Market-to-book ratio	Firm financial statements + market data
Non-debt tax shield	Control	Depreciation / total assets	Firm financial statements
Firm age	Control	Log of years since incorporation	Firm records
GDP growth / inflation	Control	Annual percentage change	World Bank World Development Indicators