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When Does Digital Transformation Pay Off Under Customer Dependence? Evidence from Chinese A-Share Listed Firms

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Research Article

Keywords: digital transformation, customer concentration, firm performance, financing constraints, market competition, information asymmetry

Posted Date: April 15th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-9404252/v1

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Additional Declarations: The authors declare no competing interests.

Abstract

Drawing on information asymmetry theory and the dynamic capabilities perspective, this study examines whether digital transformation improves firm performance and whether it attenuates the performance penalty associated with customer concentration. Using 18,542 firm-year observations for Chinese A-share non-financial listed firms during 2019–2024, we construct a digital transformation indicator from annual-report text and measure customer concentration by the sales share of the top five customers. The results show that digital transformation is positively associated with financial performance, whereas customer concentration is negatively associated with performance on average. More importantly, the interaction between digital transformation and customer concentration is positive and statistically significant, indicating that digital transformation mitigates the adverse performance implications of heavy dependence on major customers. Additional analyses provide supportive evidence that lower financing constraints are one pathway through which digital transformation is associated with better performance, and that stronger market competition amplifies the positive digital transformation-performance relationship. These findings remain robust when we replace the performance measure, lag explanatory variables, exclude pandemic-period observations, include firm fixed effects, and use instrumental-variable estimation. By bringing customer dependence into the analysis of digital transformation, the paper clarifies a relational boundary condition of digital value creation and shows that the value of digitalization depends not only on internal capability development but also on the structure of firms' external exchange relationships.

JEL Classification: G32; L25; L81; M10; O33

1. Introduction

Digital technologies, data-intensive coordination, and platform-enabled interdependence are reshaping how firms create, protect, and appropriate value. In recent years, digital transformation has evolved from the adoption of isolated information technologies into a broader organizational process that combines data infrastructure, workflow redesign, governance adaptation, and business-model renewal. For listed firms, this transformation is not simply about deploying new software. It is increasingly tied to strategic resilience, supply-chain coordination, capital-market visibility, and the reconfiguration of competitive advantage. At the same time, firms do not undertake digital transformation in a vacuum. They remain embedded in external exchange relationships that can either amplify or constrain the returns to digital investment. One of the most consequential such relationships is the structure of the customer base.

Customer concentration is a central feature of many firms' revenue architecture. A moderate degree of concentration can generate learning, trust, lower contracting costs, and relationship-specific investments that improve exchange efficiency. Yet dependence on a limited set of major customers can also expose firms to price pressure, demand volatility, switching risk, and weakened bargaining power. These concerns are especially salient under conditions of heightened uncertainty, because a highly concentrated customer base can transmit shocks quickly into revenues, cash flows, and external financing conditions. In corporate settings where a small number of customers account for a large share of sales, the managerial question is therefore not only whether concentration is beneficial or harmful on average, but also under what conditions firms can offset its downside risks.

This paper argues that digital transformation is one such condition. The core intuition is straightforward but underexplored. Digital transformation can improve the quality, timeliness, and integration of information within the firm; enhance process visibility across organizational units; support demand sensing, delivery monitoring, and inventory coordination; and enlarge the reach of firms' customer acquisition and channel management capabilities. These changes may make firms less vulnerable to the operational and bargaining risks associated with dependence on major customers. If so, the performance consequences of customer concentration should not be treated as fixed. They should vary with the firm's digital capability to process information, coordinate responses, and reorganize resources under relational dependence.

The possibility that digital transformation moderates the performance consequences of customer concentration speaks to a broader debate in management research. A large literature suggests that digital transformation can enhance productivity, innovation, and financial outcomes by improving information flows and enabling organizational reconfiguration (Verhoef et al. 2021; Hanelt et al. 2021). A parallel literature shows that the concentration of a firm's customer base has important implications for profitability, risk exposure, and market valuation (Patatoukas 2012; Irvine et al. 2016). However, these literatures have often progressed in parallel rather than in dialogue. Existing studies typically ask whether digital transformation is beneficial overall, or whether customer concentration influences firms' strategic choices, including their willingness to digitalize. Much less is known about whether digital transformation changes the performance consequences of customer dependence itself.

This gap matters for at least three reasons. First, the average effect of digital transformation may conceal substantial relational heterogeneity. A digital investment that yields only moderate returns in firms with diversified customers may become especially valuable when customer dependence is high and coordination demands are stronger. Second, customer concentration is not merely a marketing variable; it has implications for finance, strategy, governance, and operations. Studying digital transformation in this setting therefore helps connect multiple

subfields of management research. Third, the external validity and managerial usefulness of digital transformation research depend on identifying the circumstances under which digitalization is most consequential. Knowing that digital transformation is useful is less informative than knowing when and why it becomes particularly valuable.

To address these issues, we study Chinese A-share non-financial listed firms over the period 2019–2024. This setting is suitable for several reasons. China has experienced rapid and heterogeneous digital upgrading across firms and industries, providing meaningful cross-sectional variation in digital transformation intensity. At the same time, listed firms operate in a market environment marked by intense competition, evolving data infrastructures, and a wide range of customer dependence profiles. The sample therefore provides a nationally broad and institutionally relevant setting rather than a narrow local context. We construct a digital transformation indicator from annual-report text, measure customer concentration using the sales share of the top five customers, and estimate the relationship among digital transformation, customer concentration, and firm financial performance using a panel framework with year and industry fixed effects and standard errors clustered at the firm level.

The empirical results support four core conclusions. First, digital transformation is positively associated with firm financial performance. Second, customer concentration is negatively associated with performance on average in our sample period and context. Third, and most importantly, the interaction between digital transformation and customer concentration is positive and statistically significant, suggesting that digital transformation buffers the negative performance implications of strong customer dependence. Fourth, additional analyses provide supportive evidence that digital transformation is associated with lower financing constraints, and that this pattern is consistent with a partial transmission pathway to better performance. We also find that stronger market competition enhances the positive association between digital transformation and performance.

The analysis further shows that these findings are not driven by a single specification choice. The main conclusions remain stable when we replace return on assets with Tobin's Q, lag the explanatory variables, exclude observations from the pandemic period, include firm fixed effects, and estimate an instrumental-variable specification based on peer firms' digital transformation in the same industry and province. These exercises do not eliminate all identification concerns, and the paper does not claim definitive causality. Nevertheless, they strengthen the interpretation that the documented relationships reflect robust empirical regularities rather than fragile artifacts of a narrow specification.

The paper contributes to the management literature in three interrelated ways. First, it reframes digital transformation as a relationally contingent capability whose value depends on the structure of the customer base. Second, it integrates information asymmetry theory with the dynamic capabilities perspective to explain why customer dependence creates both informational opacity and adaptation pressure, and why digital transformation can mitigate both. Third, it offers a transparent empirical design that combines a text-based digital transformation measure, interaction tests, supportive pathway evidence, and multiple robustness checks while maintaining a deliberately cautious interpretation of causality.

The managerial relevance of the study is equally clear. Executives often face pressure to justify digital investment by demonstrating observable financial returns. Our findings suggest that the strongest returns may arise not from generic digital spending, but from digital transformation that is aligned with specific organizational vulnerabilities. Firms heavily dependent on major customers appear to benefit particularly from digital capabilities that improve order forecasting, process visibility, channel extension, and risk monitoring. Thus, managers should view digital transformation not as a stand-alone technology project but as an instrument for redesigning how the firm manages dependence, uncertainty, and bargaining exposure in key exchange relationships.

Customer concentration is also analytically distinctive from other forms of external dependence. Supplier concentration, alliance dependence, and geographic concentration all matter, but customer concentration is the most immediate expression of revenue dependence and therefore the most direct channel through which relational asymmetry is translated into performance volatility. When a small set of customers accounts for a large fraction of sales, the firm faces a concentrated source of bargaining pressure, forecast error, switching risk, and cash-flow uncertainty. This feature makes customer concentration an especially relevant setting for studying whether digital transformation changes not merely how firms operate, but how they manage strategically consequential external dependence.

The paper therefore advances a sharper argument than the usual claim that digital transformation is generally beneficial. The central proposition is that digital transformation pays off especially when firms must process, monitor, and respond to dependence-related vulnerabilities embedded in concentrated customer relationships. Framed this way, the study contributes to management research on digital transformation, customer dependence, and organizational adaptation simultaneously. It does so while remaining careful about inference: the study aims to establish robust and managerially meaningful patterns in archival data, not to overstate causal certainty where the data cannot support it.

2. Theory and hypotheses

2.1 Integrating information asymmetry and dynamic capabilities

Our conceptual framework combines information asymmetry theory with the dynamic capabilities perspective. Information asymmetry theory emphasizes that unequal access to relevant information distorts exchange, weakens contracting efficiency, and can produce suboptimal allocation outcomes (Akerlof 1970; Stiglitz and Weiss 1981). In the present context, asymmetry arises not only between firms and capital providers but also between firms and their customers, suppliers, and other exchange partners. Where a firm depends heavily on a limited number of major customers, informational imbalances can intensify: large customers may possess superior knowledge about purchasing alternatives, quality benchmarks, or future demand, while the focal firm may have limited outside options and incomplete information about replacement opportunities. These conditions can reduce bargaining power and increase exposure to revenue shocks.

The dynamic capabilities perspective complements this logic by shifting attention from the existence of environmental pressure to the firm's capacity to respond effectively. Dynamic capabilities refer to the ability to sense opportunities and threats, seize opportunities through timely action, and reconfigure resources to maintain alignment under changing conditions (Teece 2007). In a digital transformation context, dynamic capabilities are expressed through data collection, analytics, process integration, workflow redesign, cross-unit coordination, and the organizational embedding of digital routines. Rather than viewing technology as an isolated resource, this perspective highlights the managerial and organizational capabilities through which technology alters action possibilities and performance outcomes.

The two perspectives are analytically complementary. Information asymmetry theory explains why concentrated customer relationships can create performance pressure and financing frictions. Dynamic capabilities explain how firms can respond by improving visibility, responsiveness, and resource reconfiguration. Digital transformation is therefore not treated here as a deterministic engine of superior performance. Instead, it is conceptualized as a capability-enabling process whose performance implications depend on the relational and competitive environment in which the firm operates.

Customer concentration is the focal relational contingency in this study because it sits at the intersection of two theoretical mechanisms. First, it intensifies information asymmetry. Outside investors, creditors, and even internal decision makers may find it difficult to assess whether revenues tied to a handful of customers are durable, whether relationship-specific investments are recoverable, and whether a change in one customer's procurement strategy could materially alter future cash flows. Second, it heightens the need for dynamic response. Because revenue exposure is concentrated, changes in order timing, product specifications, compliance standards, or payment behavior must be detected and absorbed quickly. A contingency that simultaneously raises informational opacity and adaptation pressure is therefore particularly suitable for an integrated information-asymmetry and dynamic-capabilities explanation.

This integrated perspective yields a more precise prediction than either theory can provide on its own. Information asymmetry theory explains why concentrated customer relationships can be penalized by both market participants and contractual counterparties. Dynamic capabilities explain why some firms can sense dependence-related threats, seize digitally enabled responses, and reconfigure processes quickly enough to reduce their performance exposure. The combination suggests that digital transformation should be especially valuable when firms face dependence on major customers, because it helps convert a structurally risky relational position into a more manageable one.

2.2 Digital transformation and firm performance

Digital transformation can improve firm performance through several pathways. First, digital tools increase the accuracy and timeliness of information flows. Enterprise resource planning systems, customer relationship management systems, data platforms, and business intelligence tools reduce delays, fragmentation, and coordination losses across business units. Better information processing helps firms align procurement, production, delivery, and customer service with actual demand conditions, which in turn reduces waste and raises operational efficiency. These benefits are especially relevant in environments characterized by product complexity, uncertain demand, or dispersed organizational activities.

Second, digital transformation can strengthen managerial cognition and decision quality. Digital systems generate structured, traceable, and often real-time data that support monitoring, forecasting, and scenario analysis. Managers are better able to identify deviations from targets, emerging customer risks, or supply bottlenecks before these evolve into severe performance problems. Such informational advantages can improve capacity utilization, reduce inventory mismatches, and increase the speed with which firms adapt their commercial and operational priorities. In settings where information quality has historically been uneven, the gains from digital upgrading can be substantial.

Third, digital transformation can facilitate organizational reconfiguration. The performance consequences of a technology investment do not arise from automation alone; they depend on whether the organization changes routines, allocates decision rights appropriately, and embeds new patterns of coordination. When digital transformation is accompanied by process redesign and organizational adjustment, firms can better integrate front-end demand information with back-end execution. This reduces frictions between marketing, operations, finance, and supply-chain functions, enabling the organization to capture more of the value generated by new digital tools.

Fourth, digital transformation can enhance firms' external legitimacy and market-facing capabilities. Richer digital disclosure, better reporting systems, and more standardized internal data can improve the credibility of the firm to investors, creditors, and strategic partners. At the same time, digital platforms, analytics, and customer-management systems can support product customization, targeted communication, and more efficient customer acquisition. These effects broaden the strategic relevance of digital transformation beyond pure cost reduction and make it plausible that financial performance improves when digitalization is substantive rather than symbolic.

These arguments are consistent with prior research showing that digital transformation is associated with improved productivity, stronger market responses, and better organizational outcomes (Verhoef et al. 2021; Hanelt et al. 2021; Zhao et al. 2021). In line with that literature, yet with due caution regarding causal interpretation, we expect a positive empirical association between digital transformation and firm financial performance.

Importantly, the expected positive association does not imply that digital transformation is automatically productive. Its performance value depends on whether digital tools are embedded in coordination routines, decision processes, and managerial attention structures. A digital investment that remains superficial or symbolic is unlikely to alter performance meaningfully. The theory in this paper concerns substantive digital transformation - that is, digitalization sufficiently salient in formal reporting and organizational routines to affect how the firm processes information and responds to external demands.

2.3 Customer concentration, digital transformation, and firm performance

Customer concentration is inherently double-edged. On the one hand, long-term relationships with major customers may reduce search costs, support relationship-specific investment, and stabilize order flows. Repeated interaction can encourage learning-by-doing, improve product adaptation, and reduce the need for constant renegotiation. For some firms, especially business-to-business suppliers, these advantages may be central to their growth model. On the other hand, concentration also creates dependence. When a small number of customers account for a large share of revenue, those customers gain leverage over price, payment terms, delivery standards, and relationship continuity. The focal firm may find it difficult to resist demands or recover quickly from a sudden contraction in purchases.

In the present sample context, we expect the downside risks to dominate on average. Strong customer concentration can compress profit margins because key customers have more bargaining power and more credible exit options. It can also increase cash-flow volatility when customer demand fluctuates or procurement policies change. Moreover, concentrated customer structures can worsen external financing conditions if creditors and investors perceive the firm's revenues to be highly dependent on a narrow set of counterparties. These arguments align with prior evidence showing that customer-base concentration can affect profitability, valuation, and the life cycle of buyer-supplier relationships (Patatoukas 2012; Irvine et al. 2016).

The crucial question, however, is whether digital transformation changes this relationship. We argue that it does. First, digital transformation improves demand visibility and operational responsiveness. With better order forecasting, digitalized inventory management, and delivery tracking, firms can anticipate the needs of major customers more accurately while also identifying shifts in ordering behavior earlier. This helps firms reduce the operational disruption associated with concentrated demand and maintain service quality without excessive slack.

Second, digital transformation can support channel broadening and customer acquisition. Digital marketing systems, platform-based interfaces, and data-driven customer segmentation lower the information and matching costs of reaching new customers. Even when existing major customers remain important, the firm's outside options may improve, thereby weakening dependence at the margin. Improved customer discovery does not require an immediate reduction in concentration for all firms. It may still enhance bargaining power by making the threat of diversification more credible.

Third, digital transformation can enhance the quality of execution within existing concentrated customer relationships. Major customers often impose stringent requirements concerning delivery precision, traceability, inventory coordination, and reporting. Digitalized processes make it easier to satisfy these requirements, reduce errors, and provide verifiable operational information. As a result, digital transformation can strengthen the focal firm's reputation for reliability and improve its ability to negotiate from a position of competence rather than vulnerability.

Fourth, digital transformation may allow firms to learn faster from concentrated relationships. Major customers often generate rich streams of demand, quality, and operational data. Firms with superior digital capabilities are better positioned to absorb and exploit such information, converting customer intimacy into broader organizational knowledge rather than remaining locked into a narrow transactional dependency. In this sense, digital transformation changes not only the exposure associated with concentration but also the firm's capacity to appropriate learning value from concentrated exchange ties.

Taken together, these arguments suggest two expectations. On average and within the sample range, customer concentration should be negatively associated with performance. At the same time, digital transformation should attenuate this negative relationship by reducing

informational frictions, strengthening coordination, expanding strategic options, and improving execution quality in customer-facing processes.

Hypothesis 2a. Customer concentration is negatively associated with firm financial performance on average.

Hypothesis 2b. Digital transformation weakens the negative association between customer concentration and firm financial performance; accordingly, the coefficient on the interaction term between digital transformation and customer concentration is expected to be positive.

This logic also clarifies why the paper does not treat customer concentration as universally harmful in all conceivable settings. Relationship-specific investments, repeated interaction, and joint process learning may generate value when dependence is moderate and governance is balanced. The argument advanced here is narrower and empirically grounded: within the observed sample range for Chinese listed firms during 2019-2024, the downside risks of concentrated customer dependence dominate on average, but their severity is contingent on the firm's digital capability base.

2.4 Supportive transmission evidence through financing constraints

A further implication of the information asymmetry perspective concerns financing constraints. Firms facing severe information problems tend to have more difficulty obtaining external capital on favorable terms, because investors and creditors discount opaque, hard-to-monitor cash flows (Stiglitz and Weiss 1981). Digital transformation may ease these constraints in several ways. More standardized data structures, improved reporting systems, and better visibility into operations can reduce uncertainty about the firm's activities and prospects. Digitalized control systems can also improve cash-flow management and forecasting, which lowers the perceived risk of misallocation or unexpected distress.

The financing channel is particularly relevant in the context of customer dependence. When revenues rely heavily on a small number of customers, outside financiers may fear abrupt sales declines, weakened bargaining conditions, or renegotiation risk. If digital transformation helps firms demonstrate stronger monitoring, better process control, and more diversified market-facing capabilities, it may partially offset these concerns. Lower financing constraints can in turn support sustained investment in innovation, process optimization, and customer-development activities that reinforce performance.

At the same time, caution is necessary. In nonexperimental panel data, mediation claims are difficult to identify causally because the sequential exogeneity assumptions required for strict causal mediation are strong (Imai et al. 2010). For this reason, we treat the financing-constraint analysis as supportive transmission evidence rather than definitive causal mediation. The analysis is informative because it helps assess whether the data are consistent with an important theoretical pathway, even though it does not establish that pathway beyond doubt.

Hypothesis 3. Lower financing constraints provide supportive transmission evidence for the positive association between digital transformation and firm financial performance.

For that reason, the financing-constraint analysis is framed deliberately as supportive transmission evidence rather than as a strict causal mediation test. It is theoretically relevant because customer dependence can magnify external financiers' concerns about revenue concentration and bargaining exposure. If digital transformation improves data visibility, process transparency, and earnings quality, then it may partially ease those concerns and broaden the firm's financing room. Yet the paper does not claim that this is the only channel, nor that the available panel data identify the complete mechanism with experimental precision.

2.5 Market competition as a boundary condition

The performance returns to digital transformation are also likely to depend on the intensity of product-market competition. One perspective holds that competition increases the value of efficiency, responsiveness, and customer insight, thereby raising the marginal payoff to digital transformation. When rivals compete aggressively, firms must improve speed, accuracy, and adaptability in order to protect margins and sustain demand. Under such pressure, digital tools that sharpen forecasting, reduce costs, and improve customer responsiveness may more readily translate into observable performance advantages.

An alternative perspective suggests that competition could reduce the returns to digital transformation because successful practices diffuse more rapidly when rivals monitor one another closely. If digital technologies become commoditized and easily imitated, the performance edge from digitalization may erode. The net effect is therefore theoretically ambiguous. We expect the first mechanism to dominate in our setting for two reasons. First, digital transformation is not simply a matter of acquiring technology; it requires organizational learning, process change, and capability embedding. These elements create path dependence and make exact imitation difficult. Second, competitive markets raise the cost of operational inefficiency and strategic delay, which increases the value of capabilities that improve sensing and reconfiguration.

Thus, although competition may stimulate imitation at the level of visible technologies, the performance implications of digitally enabled dynamic capabilities should remain stronger where firms must continually translate information into action under tighter competitive pressure. In this sense, competition does not merely coexist with digital transformation; it conditions how effectively digital transformation is turned into financial performance.

Hypothesis 4. Market competition positively moderates the relationship between digital transformation and firm financial performance, such that the positive association is stronger in more competitive markets.

3. Research design

3.1 Sample and data sources

The empirical analysis uses Chinese Shanghai and Shenzhen A-share non-financial listed firms from 2019 to 2024 as the initial observation window. This period is substantively meaningful because it captures an era in which digital transformation became more central to corporate strategy, while also encompassing pandemic-related disruption and subsequent adjustment. The data structure is therefore well suited to assessing whether digital transformation is associated with performance under changing external conditions and whether its value is particularly salient in firms facing concentrated customer relationships.

The digital transformation indicator is constructed from firms' annual reports. Customer concentration, financial variables, and corporate-governance variables are drawn primarily from the CSMAR and Wind databases. Industry classifications follow the China Securities Regulatory Commission's listed-firm industry classification guidelines. To improve comparability and reduce noise, we exclude financial firms, ST or *ST firms, and observations with missing values on key variables. Continuous variables are winsorized at the 1st and 99th percentiles to mitigate the influence of outliers. The final sample contains 18,542 firm-year observations in an unbalanced panel.

The national breadth of the sample also strengthens the relevance of the study because it spans heterogeneous industries, regions, and digitalization trajectories within a common disclosure regime.

The final dataset is an unbalanced firm-year panel. The screening sequence begins with all Shanghai and Shenzhen A-share listed companies in the observation window, excludes financial firms because their balance-sheet structures, regulatory environment, and disclosure conventions differ systematically from those of non-financial corporations, removes ST and *ST firms to avoid extreme distress and special-treatment cases, drops observations with missing focal variables, and winsorizes continuous variables at the 1st and 99th percentiles. This sequence follows standard archival practice and is intended to improve comparability rather than to engineer favorable results. The final sample contains 18,542 firm-year observations.

The Chinese setting is substantively important for the paper's broader relevance. The country combines large-scale industrial heterogeneity, rapid digital upgrading, varied regional digital infrastructure, and extensive mandatory disclosure by listed firms. These features create meaningful variation in both digital transformation and customer dependence, while preserving a common institutional backbone for panel estimation. The setting is therefore useful not because it is idiosyncratic, but because it offers a demanding environment in which to observe how digitalization interacts with external dependence at scale.

3.2 Variable measurement and construct validity

Dependent variable. The baseline dependent variable is return on assets (ROA), defined as net profit divided by average total assets. ROA captures profitability relative to the asset base and is widely used as a compact measure of firm financial performance. To assess whether the findings depend on an accounting-based outcome, we replace ROA with Tobin's Q in a robustness test. Tobin's Q is measured as firm market value divided by total assets and captures a market-based performance dimension.

Core explanatory variable: digital transformation (DT). Following the information-disclosure approach increasingly used in the literature, we measure digital transformation using textual evidence from annual reports. The text extraction focuses on sections such as the board report, management discussion and analysis, review of operations, and future development outlook. The keyword dictionary is organized around five dimensions: foundational technologies, platform and systems infrastructure, data governance, intelligent manufacturing, and scenario applications. Chinese word segmentation is conducted with the Python jieba package. To reduce contamination from vague rhetoric, generic terms without a direct digital meaning are removed, and the identification results are manually checked. The final indicator is the natural logarithm of one plus the frequency count of digital keywords in the selected annual-report sections. We interpret this measure cautiously as a composite proxy that captures both digital disclosure intensity and underlying digital practice intensity.

A central concern in digital-transformation research is whether a text-based indicator captures genuine organizational change or merely managerial rhetoric. We address this concern in three ways. First, the text source is the annual report rather than publicity material. Annual reports are formal disclosures with legal and reputational consequences, which makes them a more disciplined source than discretionary

marketing language. Second, the keyword architecture emphasizes concrete digital content - for example foundational technologies, enterprise systems, data-governance language, intelligent operations, and application scenarios - instead of counting generic modernization rhetoric. Third, the identification results are manually reviewed so that vague expressions without a clear digital referent are excluded. These design choices do not eliminate measurement error, but they make the measure more conservative and substantively meaningful.

The resulting variable should therefore be interpreted as a disclosure-practice composite rather than as a direct engineering measure of IT capital stock. That interpretation is appropriate for the managerial question studied here. The paper is concerned with whether digital transformation is sufficiently salient in a firm's strategy, reporting, and operating language to influence performance under customer dependence. A disclosure-based proxy is informative for that purpose because it reflects not only technological adoption but also managerial prioritization, organizational articulation, and the integration of digital themes into the firm's formal strategic narrative.

Construct validity is strengthened by three design features that match the paper's theoretical focus. First, the text is drawn from board reports, management discussion, operating review, and forward-looking sections rather than from promotional materials. Second, generic modernization rhetoric is excluded unless it carries a direct digital referent tied to systems, data, manufacturing, or application scenarios. Third, the variable is interpreted conservatively as a strategic-information and coordination signal, which is precisely the organizational layer relevant to information asymmetry and dynamic capabilities in this study.

Table 1 summarizes the architecture of the text-based digital transformation measure. The examples are illustrative rather than exhaustive, but they make the content logic transparent and show why the indicator is broader than a narrow count of technology buzzwords. After presenting this architecture, Table 2 reports the formal variable definitions used in estimation.

Table 1
Architecture of the text-based digital transformation measure

Dimension	Illustrative annual-report terms or examples	Inclusion logic
Foundational technologies	cloud computing; artificial intelligence; big data; blockchain; Internet of Things	References to the underlying digital technologies adopted, deployed, or planned by the firm.
Platform and systems infrastructure	ERP; CRM; MES; SCM; enterprise platforms; integrated information systems	Evidence that digitalization is embedded in enterprise-wide systems or coordination platforms.
Data governance and analytics	data governance; data sharing; data middle platform; business intelligence; algorithmic analysis	Statements about collecting, standardizing, integrating, or analyzing data for managerial decision-making.
Intelligent manufacturing and operations	smart factory; digital workshop; predictive maintenance; intelligent production scheduling	Digital tools applied to production, logistics, or operations to improve automation, coordination, or responsiveness.
Scenario applications and business processes	digital marketing; online channels; customer analytics; supply-chain collaboration; digital finance	Digital applications embedded in sales, service, supply-chain management, finance, or other business processes.

Core explanatory variable: customer concentration (SCC). Customer concentration is measured as the ratio of annual sales to the top five customers to total annual sales. This measure captures dependence on major customers and is consistent with prior research on customer-base concentration. High values indicate that a firm's sales are disproportionately tied to a small number of buyers.

Transmission variable: financing constraints (FC). Financing constraints are measured by the absolute value of the SA index proposed by Hadlock and Pierce (2010). Larger values indicate stronger financing constraints. We use the absolute value because it offers a convenient monotonic interpretation: a higher number means tighter constraints.

Boundary-condition variable: market competition (COMP). Market competition is measured as one minus the Herfindahl-Hirschman Index calculated at the industry level. Larger values indicate a more competitive market environment. This operationalization reflects the degree to which industry sales are dispersed across firms rather than dominated by a few incumbents.

Control variables. We control for firm size (Size), leverage (Lev), growth opportunities (Growth), ownership concentration measured by the largest shareholder's stake (Top1), board size (Board), the proportion of independent directors (Indep), and CEO-chair duality (Dual). These controls capture differences in scale, financial structure, growth, ownership, and governance that may correlate with both digital transformation and performance.

Table 2
reports the variable definitions used in the main estimations.

Category	Variable	Label	Definition
Dependent variable	ROA	Return on assets	Net profit divided by average total assets.
Alternative dependent variable	Tobin's Q	Market-based performance	Firm market value divided by total assets; used in robustness analysis.
Core explanatory variable	DT	Digital transformation	Natural logarithm of one plus the total frequency count of retained digital-transformation terms in selected annual-report sections.
Relational condition	SCC	Customer concentration	Annual sales to the top five customers divided by total annual sales.
Supportive transmission variable	FC	Financing constraints	Absolute value of the SA index; larger values indicate tighter financing constraints.
Boundary-condition variable	COMP	Market competition	One minus the industry Herfindahl-Hirschman Index (HHI); larger values indicate more intense competition.
Control variable	Size	Firm size	Natural logarithm of total assets.
Control variable	Lev	Leverage	Total liabilities divided by total assets.
Control variable	Growth	Growth opportunities	Annual revenue growth rate.
Control variable	Top1	Ownership concentration	Shareholding percentage of the largest shareholder.
Control variable	Board	Board size	Natural logarithm of the number of directors.
Control variable	Indep	Independent directors	Number of independent directors divided by total number of directors.
Control variable	Dual	CEO-chair duality	Indicator equal to 1 if the CEO and board chair are held by the same person, and 0 otherwise.

3.3 Empirical models

The baseline specification is:

$$Performance_{i}t = \alpha\,0 + \alpha\,1DT_{i}t + \alpha\,2Controls_{i}t + YearFE + IndustryFE + \epsilon\,_{i}t$$

1

$$Performance_{i}t = \beta\,0 + \beta\,1SCC_{i}t + \beta\,2Controls_{i}t + YearFE + IndustryFE + \epsilon\,_{i}t$$

2

$$Performanceit = \gamma\,0 + \gamma\,1DTit + \gamma\,2SCCit + \gamma\,3(DTit \times\ SCCit) + \gamma\,4Controlsit + YearFE + IndustryFE + \epsilon\,it$$

3

For the financing-constraint analysis, we estimate the following pair of equations:

$$FCit = \delta\,0 + \delta\,1DTit + \delta\,2Controlsit + YearFE + IndustryFE + \epsilon\,it$$

4

$$Performanceit = \theta\,0 + \theta\,1DTit + \theta\,2FCit + \theta\,3Controlsit + YearFE + IndustryFE + \epsilon\,it$$

5

To assess the boundary condition associated with competition, we estimate:

$$Performanceit = \lambda\,0 + \lambda\,1DTit + \lambda\,2COMPit + \lambda\,3(DTit \times\ COMPit) + \lambda\,4Controlsit + YearFE + IndustryFE + \epsilon\,it$$

6

In all specifications, i indexes firms and t indexes years. The baseline estimations include year and industry fixed effects, whereas firm fixed effects are introduced only as a robustness test. In models with interaction terms, the coefficients on the constituent main effects reflect the

marginal effect when the moderator equals zero and are therefore not overinterpreted. Our inferential focus is placed on the sign and significance of the interaction coefficients.

3.4 Identification strategy and interpretive boundaries

The paper relies on observational panel data, so identification must be discussed carefully. Several features of the design are intended to improve inferential discipline. First, the use of industry and year fixed effects removes common sectoral and temporal shocks. Second, clustering standard errors at the firm level accounts for within-firm serial correlation. Third, lagged specifications help address simultaneity concerns. Fourth, firm fixed effects absorb stable unobserved heterogeneity. Fifth, the instrumental-variable approach offers an external source of variation related to peer firms' digital transformation in the same industry-province cell. None of these strategies alone is definitive, but together they provide a layered approach to robustness that is suitable for an archival management study.

For the financing-constraint pathway, the study complements stepwise regressions with a bias-corrected nonparametric bootstrap based on 5,000 resamples to construct a confidence interval for the indirect effect. For the comparison between high-competition and low-competition subsamples, a seemingly unrelated regression framework is used to test whether the DT coefficients differ significantly across groups. These procedures help strengthen statistical interpretation while preserving the paper's cautious stance on causality.

Several additional design choices reinforce this disciplined interpretive stance. Year fixed effects absorb macro shocks common to all firms, while industry fixed effects absorb time-invariant sectoral differences in profitability and digital intensity. The lagged specification addresses the possibility that current performance affects current digital disclosure. The firm fixed-effects specification absorbs stable, unobserved firm characteristics, such as enduring managerial style or organizational culture. None of these strategies alone is decisive, but together they reduce the likelihood that the main findings are driven by one narrow source of omitted heterogeneity.

The peer-based instrumental-variable design is best understood in the same spirit: as a demanding robustness device rather than a definitive causal solution. Average digital transformation among other firms in the same industry and province captures local and sectoral digital diffusion that is plausibly related to a focal firm's digitalization incentives. At the same time, the exclusion restriction remains contestable because regional infrastructure, local policy, and knowledge spillovers may also affect performance directly. Accordingly, the IV results are reported as supportive evidence that the main association is not trivially reverse-causal, but not as grounds for an unconditional causal claim.

The paper also adopts a conservative language policy throughout the results section. Terms such as "associated with," "buffers," and "is consistent with" are used intentionally. This wording is not rhetorical caution for its own sake. It reflects the inferential boundary appropriate to well-executed but observational panel research. A manuscript is stronger, not weaker, when its empirical claims are matched carefully to what the data can identify.

4. Empirical results

4.1 Descriptive statistics and preliminary diagnostics

Table 3 reports descriptive statistics for the main variables. ROA has a mean of 0.042 and a median of 0.038, indicating substantial variation in profitability across firms. DT has a mean of 2.875 and a standard deviation of 1.214, suggesting pronounced heterogeneity in digital transformation intensity. SCC has a mean of 0.213 and a maximum of 0.895, revealing that some firms are highly dependent on a small number of major customers. FC and COMP also show meaningful dispersion, which is useful for the mechanism and boundary-condition tests.

Pairwise diagnostics indicate that DT is positively related to ROA, whereas SCC is negatively related to ROA. In addition, the absolute values of the correlations among explanatory variables are below 0.5 and the maximum variance inflation factor is 2.45, indicating that severe multicollinearity is unlikely to threaten the regression estimates. These diagnostics support the feasibility of estimating the focal models without major concern that the coefficients merely reflect unstable correlation structures among predictors.

Table 3
Descriptive statistics

Variable	Obs.	Mean	Std. dev.	Median	Min	Max
ROA	18,542	0.042	0.081	0.038	-0.256	0.289
DT	18,542	2.875	1.214	2.944	0.000	5.681
SCC	18,542	0.213	0.198	0.147	0.015	0.895
FC	18,542	3.854	0.421	3.812	2.978	5.112
COMP	18,542	0.881	0.095	0.912	0.523	0.998
Size	18,542	22.561	1.345	22.398	20.123	25.897
Lev	18,542	0.453	0.211	0.441	0.089	0.856
Growth	18,542	0.126	0.374	0.075	-0.468	1.745
Top1	18,542	0.352	0.147	0.335	0.091	0.772
Board	18,542	2.176	0.241	2.197	1.609	2.708
Indep	18,542	0.376	0.051	0.364	0.333	0.571
Dual	18,542	0.281	0.450	0.000	0.000	1.000
Note: Continuous variables are winsorized at the 1st and 99th percentiles.						

4.2 Baseline relationship between digital transformation and performance

Model 1 of Table 3 shows that the coefficient on DT is 0.012 and significant at the 1% level (t = 4.58). This result supports Hypothesis 1 and indicates a positive association between digital transformation and firm performance. The coefficient is not only statistically significant but also economically meaningful. A one-standard-deviation increase in DT is associated with an increase in ROA of approximately 1.46 percentage points (0.012 × 1.214 = 0.0146), which corresponds to roughly 34.7% of the sample mean of ROA. This magnitude suggests that digital transformation is associated with more than a marginal efficiency gain; it corresponds to a sizable improvement in accounting performance relative to the average profitability level in the sample.

From a managerial-science perspective, this finding is consistent with the idea that digital transformation operates through multiple reinforcing mechanisms: improved information quality, tighter process integration, stronger monitoring, and better organizational responsiveness. Because the estimate is obtained after controlling for a rich set of firm characteristics and time and industry effects, it is less likely to be driven solely by broad sectoral shifts or macro trends. Nevertheless, the result is best interpreted as a robust statistical association rather than definitive evidence that digital transformation itself causes the increase in ROA.

4.3 Customer concentration and the buffering role of digital transformation

Model 2 of Table 3 shows that SCC is negatively related to ROA, with a coefficient of − 0.035 that is significant at the 1% level (t = − 3.98). This result supports Hypothesis 2a and indicates that, on average and within the observed sample range, higher customer concentration is associated with lower firm performance. The estimate is consistent with the argument that dependence on major customers can reduce bargaining power, increase vulnerability to demand fluctuations, and worsen the terms under which external stakeholders evaluate the firm.

Model 3 of Table 4 includes both DT and SCC simultaneously. Both variables retain their expected signs and remain statistically significant, suggesting that the positive digital transformation–performance relationship and the negative customer-concentration–performance relationship are not merely proxies for each other. Instead, they appear to capture distinct dimensions of firm heterogeneity: one related to digitally enabled capability development and the other related to revenue dependence on major customers.

Model 4 of Table 4 introduces the interaction term DT × SCC. The interaction coefficient is 0.021 and significant at the 5% level (t = 2.33), supporting Hypothesis 2b. This is the focal empirical result of the paper. The positive interaction implies that the negative association between customer concentration and performance becomes weaker as digital transformation increases. Put differently, digital transformation appears to buffer firms against the performance penalty associated with concentrated customer structures.

This moderating result is substantively important because it changes how we interpret the risk of customer dependence. Customer concentration is often treated as a structural feature that mechanically reduces performance beyond some threshold. The present evidence suggests a more contingent view. Concentration is still problematic on average, but its performance implications depend on whether the focal firm has developed digital capabilities that improve coordination, visibility, and adaptive response. In managerial terms, firms facing strong

customer dependence are not passive recipients of relational risk; they may actively reshape the consequences of that dependence through digital transformation.

The economic significance of the interaction is also nontrivial. Using the the sample standard deviation reported in Table 3, a one-standard-deviation increase in the interaction component is associated with roughly a 0.5 percentage point increase in ROA. While this number is smaller than the main DT effect, it remains meaningful given the typical size of accounting-return changes in listed-firm panel data. Moreover, interaction effects often capture conditional value creation that is highly relevant for managerial allocation decisions even when the absolute coefficient appears modest.

Figure 2 visualizes the main focal coefficients together with approximate confidence intervals derived from the reported coefficients and t-statistics. The figures are intended to improve readability and are fully consistent with the reported results rather than replacing the formal table evidence.

The interaction can also be restated in marginal-effect terms. When digital transformation is low, the slope linking customer concentration to performance is more negative; when digital transformation is high, that negative slope becomes flatter. This is precisely the empirical manifestation expected by the theoretical argument. Digital transformation does not eliminate dependence on major customers, but it weakens the degree to which that dependence translates into lower performance. For reviewers concerned that interaction models sometimes produce coefficients with little substantive meaning, the present result is economically interpretable and conceptually aligned with the theory developed earlier.

Table 4
Baseline regressions and buffering effect of digital transformation

Variables	(1) ROA	(2) ROA	(3) ROA	(4) ROA
DT	0.012***		0.011***	0.009***
	(4.58)		(4.21)	(3.52)
SCC		-0.035***	-0.033***	-0.048***
		(-3.98)	(-3.75)	(-4.15)
DT x SCC				0.021**
				(2.33)
Controls	Included	Included	Included	Included
Year fixed effects	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
Obs.	18,542	18,542	18,542	18,542
R^2	0.158	0.155	0.163	0.165
Adjusted R^2	0.152	0.149	0.157	0.158

4.4 Robustness tests

Note

Approximate 95% confidence intervals are derived from the reported coefficients and t-statistics in Tables 4, 6, and 7. *The figure is a compact visual summary of focal effects rather than a replacement for formal regression output.*

The paper also notes that the quadratic term of customer concentration is not significant in supplementary tests. This suggests that a linear specification for the concentration-performance relationship is reasonable within the observed sample range. The result is useful because customer concentration could theoretically produce nonlinear effects if moderate concentration were beneficial but extreme concentration harmful. The absence of a significant quadratic term indicates that, in this sample and period, the average relationship is adequately summarized as monotonic and negative.

The study undertakes five classes of robustness checks, yielding six specific tests. First, the dependent variable is replaced with Tobin's Q. The coefficient on DT remains positive and significant (0.185***), and the interaction DT × SCC also remains positive and significant (0.312**). This result suggests that the findings are not confined to an accounting-based performance metric; they also appear when performance is assessed through a market-based lens.

Second, the explanatory variables and controls are lagged by one period to reduce concerns that contemporaneous performance affects reported digital transformation intensity or other regressors. The lagged specification continues to show a positive coefficient on DT (0.010***) and a positive coefficient on DT × SCC (0.019**), with the expected signs unchanged. This test is useful because reverse timing is a common concern in digital transformation research: better-performing firms may have more resources to digitalize, or managers may intensify digital disclosure after favorable performance. The lagged results indicate that the core relationships are not wholly dependent on same-period measurement.

Third, pandemic-period observations are excluded in two ways: by dropping 2020 only and by dropping both 2020 and 2021. In both cases, DT remains positively related to performance and the interaction with SCC stays positive and significant. This matters because the pandemic may have changed both digital urgency and customer dependence patterns in ways that could distort average estimates. The persistence of the results suggests that the documented relationships are not driven solely by extraordinary pandemic conditions.

Fourth, the model is re-estimated with firm fixed effects. The coefficient on DT remains positive and significant (0.008***), and the interaction term remains positive and significant (0.018**). Firm fixed effects absorb time-invariant unobserved heterogeneity, such as stable managerial style, sector niche, or organizational culture, thereby imposing a more demanding identification strategy. The retention of the core patterns under firm fixed effects strengthens confidence that the results are not merely cross-sectional correlations due to omitted stable characteristics.

Fifth, the study uses an instrumental-variable approach in which the instrument for a focal firm's digital transformation is the average digital transformation intensity of other firms in the same industry and province, excluding the focal firm. The first-stage F-statistic is 48.73, suggesting that weak-instrument concerns are not severe. The second-stage coefficient on DT remains positive and significant (0.015***). Although the exclusion restriction cannot be guaranteed beyond debate, the IV evidence is directionally consistent with the baseline findings and therefore supports a cautious interpretation that the DT–performance association is not wholly attributable to reverse causality or simple omitted variables.

The paper also notes that the quadratic term of customer concentration is not significant in supplementary tests. This suggests that a linear specification for the concentration-performance relationship is reasonable within the observed sample range. The result is useful because customer concentration could theoretically produce nonlinear effects if moderate concentration were beneficial but extreme concentration harmful. The absence of a significant quadratic term indicates that, in this sample and period, the average relationship is adequately summarized as monotonic and negative.

Overall, the robustness exercises tell a coherent story. They do not prove causality, but they show that the positive role of digital transformation and its buffering interaction with customer concentration are stable across alternative metrics, temporal structures, crisis-exclusion samples, more demanding fixed-effect designs, and an external-instrument approach. In empirical management research, especially with archival panel data, such convergence across designs is an important source of inferential credibility.

Table 5
Robustness checks

Test	Implementation	DT	DT x SCC	Obs.	Conclusion
Alternative dependent variable	Replace ROA with Tobin's Q	0.185***	0.312**	18,542	Consistent
Lagged specification	Lag explanatory variables and controls by one period	0.010***	0.019**	15,218	Consistent
Exclude 2020	Remove initial pandemic year	0.013***	0.023**	15,436	Consistent
Exclude 2020–2021	Remove pandemic years	0.011***	0.020**	12,328	Consistent
Firm fixed effects	Include firm FE instead of industry FE	0.008***	0.018**	18,542	Consistent
Instrumental variables (2SLS)	Industry-province peer average DT	0.015***	-	18,542	Consistent

Note: In the IV specification, the first-stage F-statistic is 48.73. The table summarizes the robustness exercises most relevant to the focal argument and preserves the direction and significance of the central coefficients.

Within the observed sample range, the nonsignificant quadratic term for customer concentration is best interpreted as sample-bounded evidence that the downside of concentration is monotonic rather than sharply nonlinear. The paper therefore treats the negative SCC slope as an empirically grounded pattern for this context, not as a universal law applying to all customer portfolios in all settings.

5. Mechanism and boundary-condition analyses

5.1 Supportive transmission evidence through financing constraints

Table 5 examines whether lower financing constraints provide supportive transmission evidence for the positive association between digital transformation and firm performance. In Model 2, DT is negatively associated with FC, with a coefficient of − 0.058 significant at the 1% level (t = − 5.12). Because FC is measured so that higher values indicate tighter constraints, this result suggests that digital transformation is associated with easier access to external financing or, more broadly, a less constrained financing position.

Model 3 of Table 5 includes both DT and FC in the performance regression. FC is negatively associated with ROA, with a coefficient of − 0.041 significant at the 1% level (t = − 4.88). At the same time, the coefficient on DT falls from 0.012 in the baseline model to 0.009 but remains significant. This pattern is consistent with partial transmission: some of the positive association between digital transformation and performance appears to run through lower financing constraints, while a substantial direct association remains.

The bias-corrected bootstrap procedure provides additional support. The reported 95% confidence interval for the indirect effect is [0.0008, 0.0042], which excludes zero, and the indirect component accounts for approximately 19.8% of the total effect. These numbers should not be overstated as causal mediation in the strict sense. However, they are informative because they show that the data fit the theoretical proposition that digital transformation can improve the information environment and thereby ease financing frictions, which in turn supports better firm performance.

This mechanism is especially relevant to the managerial-science framing of the paper. Much discussion of digital transformation focuses on internal efficiency gains. The financing analysis broadens the lens by showing that digitalization may also alter how external capital providers view the firm. Better data systems, stronger transparency, and more disciplined internal processes can reduce uncertainty for lenders and investors. In settings where customer concentration heightens concerns about cash-flow dependence, such informational improvements can be especially valuable.

This financing pathway is conceptually relevant to the focal interaction argument because customer dependence often intensifies external concerns about revenue fragility and bargaining exposure. Digital transformation can partly offset that concern by improving traceability, forecasting quality, and process visibility, even though the present data do not permit a clean moderated-mediation test.

Table 6
Supportive transmission evidence through financing constraints

Variables	(1) ROA	(2) FC	(3) ROA
DT	0.012***	-0.058***	0.009***
	(4.58)	(-5.12)	(3.67)
FC			-0.041***
			(-4.88)
Controls	Included	Included	Included
Year fixed effects	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes
Obs.	18,542	18,542	18,542
R^2	0.158	0.201	0.172
Bootstrap 95% CI			[0.0008, 0.0042]
Indirect effect share			19.8%

5.2 Market competition as a boundary condition

Table 6 analyzes whether product-market competition conditions the performance value of digital transformation. In Model 2, the interaction term DT × COMP is positive and significant, with a coefficient of 0.015 (t = 2.47). This result supports Hypothesis 4 and indicates that the positive digital transformation–performance association becomes stronger as market competition intensifies.

The split-sample evidence tells the same story. When the sample is divided at the median level of market competition, the coefficient on DT is 0.016*** in the high-competition subsample but only 0.008*** in the low-competition subsample. A seemingly unrelated regression test of the difference in coefficients yields $\chi^2 = 4.38$ ($p = 0.036$), confirming that the digital transformation coefficient is significantly larger in more competitive markets. These results are consistent with the argument that competition sharpens the value of fast information processing, process coordination, and strategic adaptability.

This finding also clarifies an important managerial boundary condition. Digital transformation is often justified as a necessary response to digital-era uncertainty, but the urgency of such investments is not uniform across markets. Where competitive pressure is mild, firms may still benefit from digitalization, yet the performance gains may be less pronounced because inefficiencies are less severely punished and rivals are less aggressive. By contrast, in more competitive markets, even modest improvements in responsiveness, cost control, and customer insight can have greater financial impact. Thus, market structure affects not only the incentive to digitalize but also the realized performance payoff from doing so.

The competition result is also theoretically useful because it helps distinguish between two interpretations of digital transformation. One view treats digitalization as a largely generic technology trend whose benefits should appear irrespective of market structure. The present evidence is more consistent with a capability interpretation: digital transformation matters more when competitive pressure raises the value of rapid information processing, coordinated execution, and adaptive response.

Table 7
Market competition as a boundary condition

Variables	(1) ROA	(2) ROA	(3) ROA High competition	(4) ROA Low competition
DT	0.012***	0.007**	0.016***	0.008***
	(4.58)	(2.51)	(4.89)	(2.87)
COMP		0.028**		
		(2.25)		
DT x COMP		0.015**		
		(2.47)		
Controls	Included	Included	Included	Included
Year fixed effects	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
Obs.	18,542	18,542	9,271	9,271
R^2	0.158	0.161	0.168	0.152
SUR chi^2 test			4.38** (p = 0.036)	

Note: The group comparison is based on a median split in product-market competition. The SUR chi-squared statistic tests whether the DT coefficient differs across the two subsamples.

6. Discussion

6.1 Theoretical contributions

The first theoretical contribution of the paper is to reposition digital transformation as a relationally contingent capability rather than a universally uniform performance enhancer. Much of the digital transformation literature asks whether digitalization improves outcomes on average. While that question remains important, average effects reveal only part of the story. By demonstrating that digital transformation attenuates the negative association between customer concentration and performance, the paper shows that the value of digital capabilities depends on the structure of external dependence. This insight matters because many managerial problems arise not from abstract inefficiency but from concrete exposure to powerful exchange partners. The study therefore helps move digital transformation research from the question of "whether it works" to the question of "under which relational conditions it works more strongly."

The second contribution lies in the integration of information asymmetry theory and dynamic capabilities. Information asymmetry theory explains why customer concentration and financing constraints are consequential: unequal information, limited outside options, and dependence can distort exchange and increase vulnerability. Dynamic capabilities explain why digital transformation changes this picture: firms can sense, coordinate, and reconfigure more effectively when digital systems support timely and integrated action. Combining the two perspectives offers a more complete account than either would provide alone. It links the sources of pressure to the organizational capacities that moderate those pressures.

Third, the paper contributes to research on the boundary conditions of digital value creation by highlighting market competition as an external amplifier. Competition does not merely provide background noise. It changes the performance premium associated with digital transformation

by increasing the managerial value of accurate information, rapid coordination, and operational agility. This complements prior work on digital transformation and competition by showing that competitive pressure helps determine how strongly digitalization becomes visible in financial outcomes.

Fourth, the study contributes to broader management debates concerning how firms manage dependence on important stakeholders. Customer concentration is often studied from accounting or finance perspectives, whereas digital transformation is frequently examined in information systems, strategy, or innovation research. Bringing these streams together reveals that dependence management is not solely a matter of contract design or portfolio diversification. It is also a capability-development problem. Firms can alter the consequences of dependence by improving how they gather information, coordinate workflows, and redeploy resources.

6.2 Managerial implications

The findings imply that managers should diagnose the organizational vulnerabilities to which digital transformation is expected to respond. A common mistake is to justify digital initiatives in generic language—efficiency improvement, modernization, or digital upgrading—without linking them to the firm's specific constraints. Our results suggest that the performance payoff is particularly meaningful when digital transformation addresses a concrete structural risk such as heavy dependence on a few major customers. Managers should therefore prioritize digital applications that directly improve customer-risk monitoring, order forecasting, fulfillment coordination, demand sensing, and channel expansion.

For firms with concentrated customers, digital transformation should be treated as a portfolio of mutually reinforcing managerial interventions. Front-end systems can improve customer analytics and market development. Middle-office systems can coordinate inventory, scheduling, and delivery. Back-end data governance can improve reporting quality, traceability, and financial transparency. When these elements are aligned, the firm is better equipped not only to serve major customers effectively but also to strengthen bargaining power and reduce vulnerability to abrupt demand shifts.

Executives should also recognize that digital transformation may improve performance partly by easing financing constraints. This is a strategically relevant insight because digital projects often require sustained investment over time. If digital transformation strengthens external confidence in the firm's information environment and operational discipline, it may create a favorable feedback loop: better digital systems support better financing conditions, which in turn support further capability building. Managers responsible for digital strategy should therefore coordinate closely with finance and investor-relations functions rather than treating digitalization as an isolated operations or IT project.

The competition results offer an additional lesson for prioritization. In highly competitive markets, the opportunity cost of delayed digital upgrading is likely to be higher. Managers in such markets should move earlier and more decisively, because the performance premium from responsiveness and coordination is greater. In less competitive markets, firms may still benefit from digital transformation, but they should be realistic that observable financial returns may materialize more gradually and may depend more heavily on complementary organizational changes.

6.3 Policy implications

The study also carries policy implications. If digital transformation helps firms mitigate dependence-related vulnerabilities and ease financing constraints, then digital infrastructure and data-governance institutions may have broad productivity consequences that extend beyond technology-intensive firms alone. Policymakers seeking to support the real economy should continue improving digital infrastructure, facilitating data integration where appropriate, and strengthening the institutional conditions under which firms can credibly demonstrate operational transparency. These efforts can improve not only innovation capacity but also the resilience of firms that operate in concentrated customer networks.

From a competition-policy perspective, the evidence suggests that healthy market rivalry can intensify the performance gains from digital transformation. This does not imply that competition policy should be designed around digitalization alone, but it does indicate that fair and contestable markets create stronger incentives for firms to convert digital investment into actual efficiency and service improvements. In other words, the value of digital policy and the value of competitive market institutions may be mutually reinforcing rather than independent.

6.4 Implications for future management research

The paper also points toward a broader research agenda. One promising avenue is to examine whether digital transformation moderates other forms of interorganizational dependence, such as reliance on dominant suppliers, platforms, distributors, or ecosystem orchestrators. Another is to investigate which component of digital transformation matters most under customer dependence—analytics capability, process integration, platform connectivity, or organizational redesign. Such work would move the literature from composite indicators toward more fine-grained capability bundles and could reveal stronger contingencies than those captured by aggregate digitalization measures.

A second avenue concerns managerial microfoundations. The present paper documents firm-level patterns, but future studies could analyze how top-management cognition, digital leadership, incentive systems, and cross-functional collaboration determine whether digital investments actually become buffering capabilities under dependence risk. This would enrich the dynamic-capabilities perspective by specifying the managerial routines through which digital resources are turned into adaptive responses. Because RMS welcomes theoretically motivated and methodologically diverse research, this topic is particularly suitable for mixed-method or multi-level follow-up studies that connect archival evidence with organizational-process data.

7. Conclusion, limitations, and future research

This paper examines the relationships among digital transformation, customer concentration, and firm performance using Chinese A-share non-financial listed firms from 2019 to 2024. The evidence indicates that digital transformation is positively associated with financial performance, customer concentration is negatively associated with performance on average, and digital transformation mitigates the adverse performance implications of concentrated customer dependence. Additional analyses suggest that lower financing constraints are consistent with an important transmission pathway and that stronger market competition amplifies the digital transformation–performance relationship.

Equally important is what the study does not claim. It does not equate text-based annual-report disclosure with a direct engineering audit of digital assets, it does not claim that the financing pathway is a definitive causal mediation result, and it does not claim that the peer-based instrument completely resolves endogeneity. The contribution is instead to show a stable and theoretically interpretable pattern: digital transformation is especially consequential when firms confront concentrated customer dependence.

Several limitations should be acknowledged. First, the digital transformation indicator is based on annual-report text. Although the measure is constructed carefully and interpreted cautiously, it remains a proxy that likely captures both disclosure intensity and underlying digital practice. Future work could triangulate this measure with patents, software expenditures, IT investment data, or survey-based assessments. Second, the financing-constraint analysis provides supportive transmission evidence rather than strict causal mediation. Stronger causal designs, such as policy shocks, infrastructure rollouts, or quasi-natural experiments, would help identify more precisely how digital transformation affects performance through capital-market channels.

Third, despite the use of lagged variables, firm fixed effects, and instrumental-variable estimation, reverse causality and omitted-variable concerns cannot be ruled out completely. Future research could exploit staggered digital policy interventions, broadband expansion, industrial internet pilots, or smart-manufacturing initiatives to strengthen causal identification. Fourth, the study focuses on customer concentration but does not examine supplier concentration. Because firms often face dependence on both downstream customers and upstream suppliers, future work could compare how digital transformation moderates dependence risk on each side of the value chain.

Finally, the external validity of the findings should be examined in other institutional settings and organizational populations. China's listed-firm environment offers broad coverage and rich variation, but the consequences of customer concentration and the value of digital transformation may differ in private firms, SMEs, or firms operating under different legal, financial, and technological regimes. Cross-country comparative work could help determine which parts of the present framework are general and which are more context-specific.

Despite these limitations, the paper advances the literature by showing that digital transformation has strategic value not only because it may improve efficiency on average, but also because it helps firms manage the performance consequences of relational dependence. That insight opens a promising avenue for future research at the intersection of digital strategy, interorganizational dependence, and firm performance.

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Figures

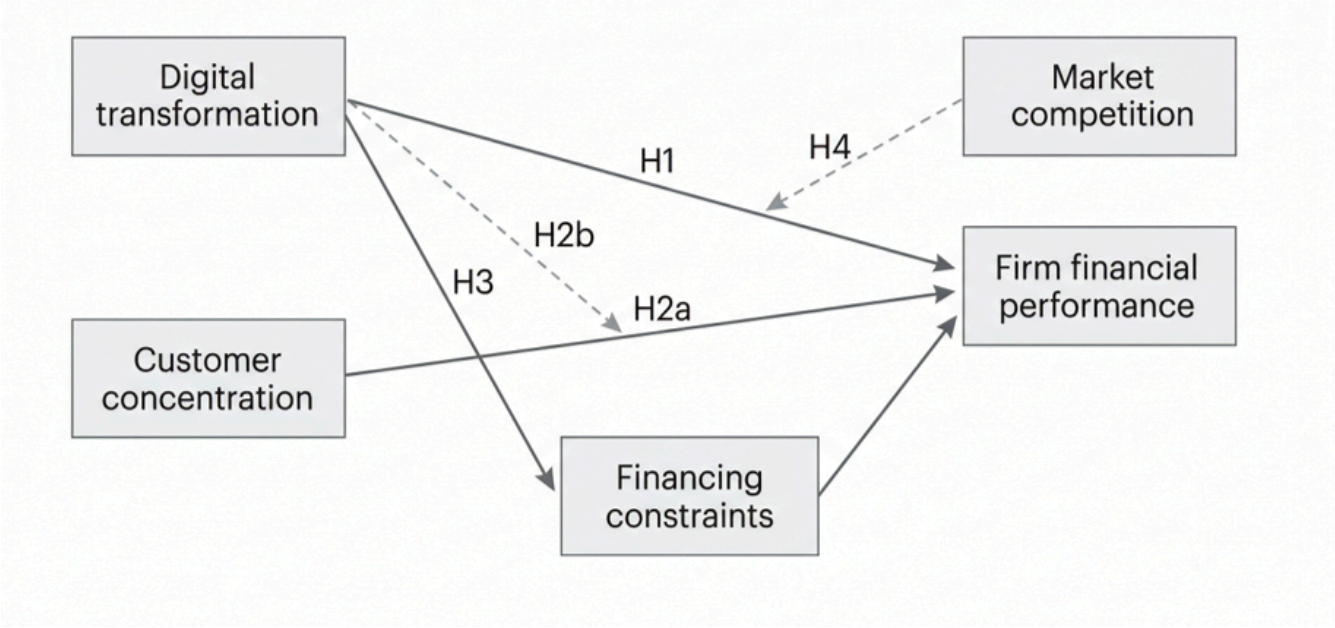


Figure 1

Relational contingency framework

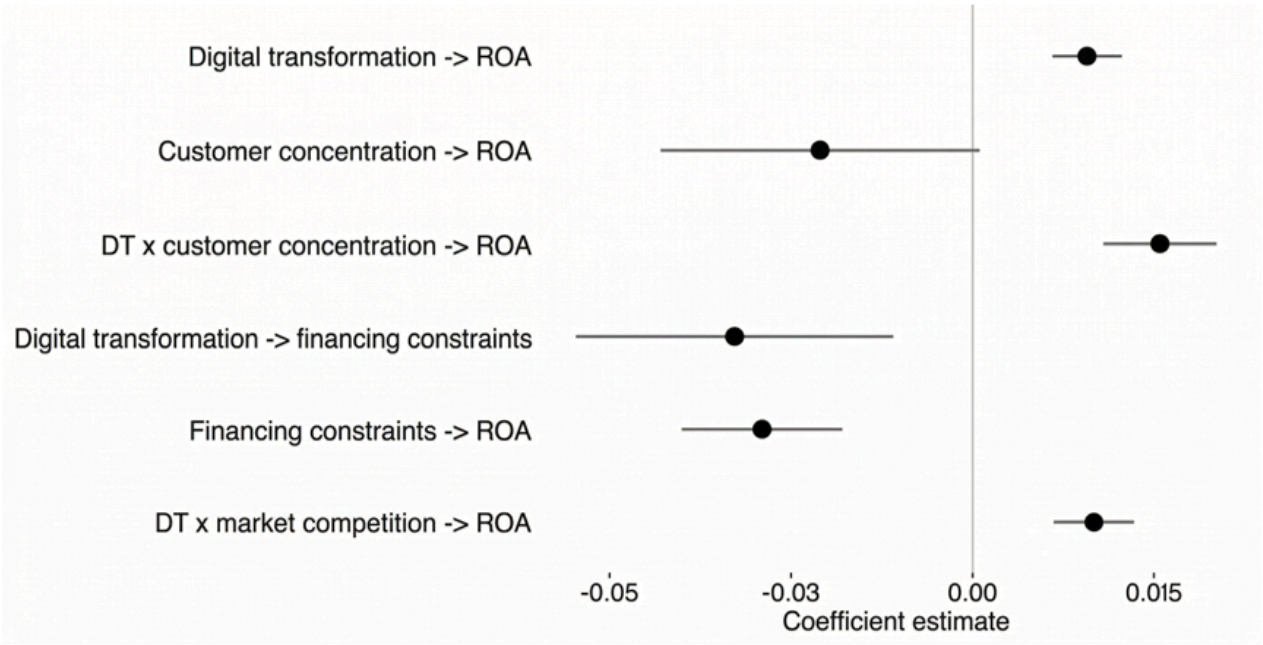


Figure 2

Summary of focal empirical coefficients