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Digitalization, E-Commerce Capability, and Firm Value in GCC Countries: Evidence from a Panel Threshold Model

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Abstract

This study examines the relationship between digitalization, e-commerce capability, and firm value in Gulf Cooperation Council (GCC) countries. Using an unbalanced panel of 200 non-financial firms over the period of 2015–2024, the analysis employs a panel threshold regression model to investigate nonlinearities in the digitalization–performance relationship. The results indicate that digitalization (DIG) is positively associated with firm value, although the relationship is regime-dependent. A significant threshold effect is identified at DIG = 0.37, with the coefficient of digitalization declining from 0.405 in the low-digitalization regime to 0.162 in the high-digitalization regime, suggesting diminishing marginal returns to digital transformation. The findings also show that e-commerce capability becomes more strongly associated with firm value in the high-digitalization regime, where the interaction coefficient reaches 0.291 ($p < 0.01$), while remaining statistically insignificant below the threshold. These findings highlight the complementary relationship between digital infrastructure and e-commerce capability and suggest that the economic value of digital transformation depends on firms' level of digital maturity. This study contributes to the literature by providing a nonlinear perspective on the digitalization–performance relationship and by offering new firm-level evidence from GCC economies. The results provide useful implications for firms and policymakers seeking to design effective digital transformation strategies.

Keywords: digitalization; firm value; e-commerce capability; threshold effects; GCC countries; panel threshold regression

Check for updates

Academic Editor: Weixin Yang

Received: 16 May 2026
Revised: 22 June 2026
Accepted: 2 July 2026
Published: 7 July 2026

Correction Statement: This article has been republished with a minor change. The change does not affect the scientific content of the article and further details are available within the backmatter of the website version of this article.

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1. Introduction

Digitalization is increasingly reshaping modern economies and transforming the mechanisms through which firms create value, allocate resources, and compete in global markets. The expansion of digital infrastructure and online platforms has altered production systems, reduced transaction costs, and expanded firms' access to domestic and international markets (Verhoef et al., 2019; Gomez-Herrera et al., 2014). In this context, digitalization has become a strategic driver of productivity growth and competitive advantage, particularly in economies pursuing structural transformation toward knowledge-based and innovation-driven development (Al Balushi & Khalil, 2026).

At the firm level, digital transformation influences organizational efficiency through multiple channels. Digital technologies facilitate information processing, improve coordination across business activities, enhance operational flexibility, and support innovation and market responsiveness (Matt et al., 2015; Tekic & Koroteev, 2019). In addition, digitalization reduces informational frictions and improves allocative efficiency by enhancing resource

utilization and customer engagement. The growing importance of intangible assets, digital platforms, and technological capabilities has therefore intensified interest in understanding how digitalization affects firm performance and valuation.

A substantial body of literature documents a positive association between digitalization and firm performance. Prior studies show that investments in digital technologies and information and communication technologies (ICTs) enhance productivity, operational efficiency, and market expansion opportunities (Bertschek et al., 2013; Falk & Hagsten, 2015; Hagsten & Kotnik, 2017). Digitalization also facilitates firms' internationalization by lowering entry barriers, improving connectivity, and enabling cross-border commercial activities (Giovannetti et al., 2013). Similarly, the expansion of e-commerce has transformed firms' commercial strategies by allowing businesses to reach wider customer bases, improve distribution efficiency, and exploit digital channels for value creation (Savrul et al., 2014; Giuffrida et al., 2017; Rehman et al., 2025).

Within this digital environment, e-commerce capability has emerged as an important organizational capability that enables firms to effectively utilize digital technologies in commercial activities. Firms with stronger e-commerce capabilities are generally better positioned to optimize digital operations, manage customer interactions, and generate performance gains through digital channels (Soto-Acosta & Meroño-Cerdan, 2008; Ainin et al., 2015). Existing evidence further suggests that e-commerce adoption contributes positively to firm performance and operational efficiency (Falk & Hagsten, 2015; Alharthi et al., 2025).

Despite these advances, important gaps remain in the literature. First, most existing studies assume a linear relationship between digitalization and firm performance, implicitly suggesting that additional digital investments continuously generate proportional performance gains. However, the economic benefits of digitalization may vary across different levels of digital maturity. While initial investments in digital technologies may substantially improve efficiency and firm value, advanced stages of digitalization may generate lower marginal returns. Increasing organizational complexity, integration costs, coordination challenges, and technological saturation may reduce the effectiveness of additional digital investments (Li et al., 2018; Martini et al., 2023). Ignoring these nonlinearities may therefore lead to an incomplete understanding of the digitalization–performance relationship.

Second, although e-commerce capability is widely recognized as a key driver of digital value creation, its effectiveness likely depends on firms' underlying digital infrastructure and technological readiness. Firms with limited digital maturity may lack the organizational and technological foundations required to fully exploit e-commerce opportunities, whereas digitally advanced firms may benefit more strongly from e-commerce integration. This suggests the existence of complementarity effects between digitalization and e-commerce capability that remain insufficiently explored in empirical research (Bhatt & Grover, 2005; Rialti et al., 2019; Mogaji et al., 2023).

These issues are particularly relevant in the context of Gulf Cooperation Council (GCC) economies. Over the last decade, GCC countries have accelerated investments in digital infrastructure and technological transformation as part of broader economic diversification strategies. National programs such as Saudi Vision 2030 and similar initiatives across the region place digital transformation at the center of long-term economic development policies (Fareed et al., 2025). The expansion of digital platforms, fintech ecosystems, e-commerce markets, and smart economy initiatives has significantly increased the role of technology-driven business models in regional economic activity.

Nevertheless, GCC countries continue to exhibit differences in digital readiness, technological adoption, institutional capacity, and firms' ability to leverage digital technologies effectively. While substantial resources have been allocated to digital infrastructure develop-

ment, less is known about whether firms operating in GCC economies are able to translate digital investments into sustained improvements in firm value. Moreover, existing evidence on digital transformation in GCC countries remains relatively limited at the firm level, particularly regarding the nonlinear and regime-dependent nature of digitalization effects.

To address these gaps, this study examines the relationship between digitalization, e-commerce capability, and firm value using an unbalanced panel of 200 non-financial firms listed in GCC countries over the period of 2015–2024. The analysis employs a panel threshold regression framework following the work of Hansen (1999) to investigate whether the impact of digitalization varies across different levels of digital maturity. This approach makes it possible to identify threshold effects and estimate regime-dependent relationships that cannot be captured through conventional linear models.

This study contributes to the literature in several ways. First, it extends the digitalization–performance literature by introducing a nonlinear perspective that accounts for threshold effects and diminishing marginal returns. Second, it examines how e-commerce capability complements firms' technological maturity across different digitalization regimes. Third, this study provides new firm-level evidence from GCC economies, where digital transformation policies have become central to economic diversification and competitiveness strategies.

The findings also provide important practical implications. From a managerial perspective, the findings suggest that firms should adopt a staged approach to digital transformation. Investments in digital infrastructure should be accompanied by the development of operational and e-commerce capabilities. From a policy perspective, the results imply that digital transformation strategies should not focus exclusively on infrastructure expansion but should also support capability building, innovation, and digital skill development to maximize the economic benefits of digitalization.

The remainder of this paper is organized as follows: Section 2 presents the theoretical background and develops the research hypotheses. Section 3 describes the data, variables, and empirical methodology. Section 4 reports the empirical findings, including threshold and regime-dependent analyses, followed by robustness checks. Section 5 discusses the main results and Section 6 concludes this paper.

2. Theoretical Background, Literature Review, and Hypothesis Development

2.1. Digitalization as a Strategic Resource and Driver of Firm Performance

Digitalization has emerged as a fundamental determinant of firm performance and competitive advantage in contemporary economies. It encompasses the integration of digital technologies into organizational processes, enabling firms to transform their operations, enhance decision-making, and develop new value creation mechanisms (Matt et al., 2015; Tekic & Koroteev, 2019; Verhoef et al., 2019). Unlike traditional technological adoption, digitalization reflects a broader organizational transformation that reshapes business models, market interactions, and firm boundaries.

From a theoretical perspective, the resource-based view provides a robust framework to understand the performance implications of digitalization. According to Barney (1991), firms achieve sustained competitive advantage by possessing valuable, rare, inimitable, and non-substitutable resources. Digital capabilities, including data analytics, digital platforms, and IT infrastructure, constitute strategic assets that enhance firms' ability to process information, coordinate activities, and innovate (Bhatt & Grover, 2005; Qin et al., 2024). These capabilities enable firms to improve operational efficiency, reduce transaction costs, and enhance responsiveness to market changes.

Digital technologies can also be conceptualized as general-purpose technologies that generate widespread productivity gains across industries (Bresnahan & Trajtenberg, 1995). The diffusion of broadband infrastructure and digital connectivity has been shown to significantly improve firm productivity and performance by facilitating communication, knowledge transfer, and market access (Bertschek et al., 2013; Akerman et al., 2015; Canzian et al., 2019). Furthermore, digitalization enhances firms' ability to exploit large datasets and generate actionable insights, thereby improving strategic decision-making and innovation outcomes (Rialti et al., 2019).

Empirical evidence consistently supports the positive relationship between digitalization and firm performance. Studies show that the adoption of ICT and digital tools enhances productivity, profitability, and growth by enabling firms to streamline operations and improve resource allocation (Falk & Hagsten, 2015; Hagsten & Kotnik, 2017). Moreover, digital transformation facilitates internationalization by reducing information asymmetries and lowering entry barriers in foreign markets (Giovannetti et al., 2013).

However, the performance implications of digitalization are not necessarily linear. While initial investments in digital technologies generate substantial benefits, increasing levels of digitalization may lead to diminishing returns due to rising coordination costs, organizational complexity, and integration challenges (Li et al., 2018). As firms expand their digital infrastructures, they may face issues related to system compatibility, data management, and organizational resistance, which can reduce the marginal effectiveness of additional digital investments. This suggests that the relationship between digitalization and firm performance may follow a nonlinear pattern characterized by threshold effects.

Hypothesis 1 (H1). *Digitalization is positively associated with firm performance.*

Hypothesis 2 (H2). *The positive association between digitalization and firm performance weakens beyond a certain threshold level of digitalization.*

The existence of a threshold effect can be explained through the concept of digital maturity and the evolving nature of digital transformation within firms. At early stages of digitalization, firms often experience substantial gains from adopting digital technologies because such investments improve information processing, reduce transaction costs, enhance operational efficiency, and support innovation (Bhatt & Grover, 2005; Verhoef et al., 2019). Digital technologies enable firms to develop new capabilities, strengthen market responsiveness, and improve resource allocation, thereby generating significant performance benefits (Tekic & Koroteev, 2019). However, as firms become increasingly digitalized, the marginal benefits of additional investments may gradually decline. Advanced digital transformation frequently requires the integration of complex technological systems, organizational restructuring, employee retraining, cybersecurity investments, and continuous maintenance expenditures. These challenges may increase implementation costs and managerial complexity, thereby reducing the incremental value generated by further digitalization (Li et al., 2018; Martini et al., 2023). Consequently, the relationship between digitalization and firm performance may be nonlinear, with the magnitude of the benefits depending on firms' level of digital maturity. This reasoning provides a theoretical basis for expecting a threshold effect in the digitalization–performance relationship.

2.2. E-Commerce Capability and Digital Value Creation

The expansion of digital technologies has led to the rapid growth of e-commerce, fundamentally transforming the mechanisms through which firms create and capture value. E-commerce capability refers to a firm's ability to effectively utilize digital platforms,

online channels, and information systems to conduct commercial transactions and manage customer relationships (Soto-Acosta & Meroño-Cerdan, 2008; Zhu & Kraemer, 2005).

E-commerce enables firms to access broader markets, enhance operational efficiency, and reduce transaction costs (Gomez-Herrera et al., 2014; Savrul et al., 2014). By leveraging digital channels, firms can overcome geographical constraints, reach international customers, and scale their operations more efficiently. The ability to conduct cross-border transactions and integrate digital logistics systems further enhances firms' performance and competitiveness (Giuffrida et al., 2017).

At the operational level, e-commerce improves asset utilization and resource efficiency by enabling firms to optimize inventory management, streamline distribution channels, and reduce operational costs (Šaković Jovanović et al., 2020). At the strategic level, it allows firms to implement data-driven marketing strategies, personalize customer interactions, and enhance customer engagement (Ainin et al., 2015; Taiminen & Karjaluoto, 2015).

Moreover, e-commerce capability facilitates value co-creation by enabling direct interactions between firms and customers. Digital platforms allow customers to actively participate in the value creation process through feedback, reviews, and social interactions, thereby enhancing customer satisfaction and loyalty (Hoyer et al., 2010; Hanna et al., 2011). The proliferation of digital touchpoints across the customer journey further reinforces the importance of e-commerce capability in shaping firm performance (Kannan et al., 2016; Baxendale et al., 2015).

Empirical studies provide strong evidence that e-commerce adoption and digital channel integration significantly improve firm performance (Falk & Hagsten, 2015; Alharthi et al., 2025).

Hypothesis 3 (H3). *E-commerce capability is positively associated with firm performance.*

2.3. Complementarity Between Digitalization and E-Commerce Capability

Recent literature emphasizes that the value of digitalization depends critically on complementary capabilities that enable firms to effectively exploit digital technologies, particularly in emerging market contexts where digital marketing and operational capabilities play a mediating role in performance outcomes (Al Buraiki & Nofal, 2026). In particular, e-commerce capability plays a central role in translating digital investments into performance outcomes.

From a capability-based perspective, digitalization provides the technological infrastructure, while e-commerce capability represents an organizational capability that allows firms to leverage these technologies in commercial activities (Bhatt & Grover, 2005; Rialti et al., 2019). The interaction between these two dimensions reflects a complementarity effect, whereby the joint presence of digital infrastructure and operational capability generates greater value than each component individually.

This complementarity is particularly evident in digital platform ecosystems, where firms compete through their ability to integrate technological and network capabilities (Cenamor et al., 2019). Digital platforms facilitate interactions among multiple stakeholders, generating network effects that enhance firm performance. Firms with strong e-commerce capabilities are better able to exploit these network effects by engaging customers, partners, and suppliers in value co-creation processes (Hoyer et al., 2010).

Furthermore, digitalization enhances the complexity and richness of customer interactions, increasing the importance of managing multiple digital touchpoints effectively (Neslin et al., 2006; Kannan et al., 2016). E-commerce capability enables firms to coordinate these interactions, optimize customer experiences, and capture value from digital engagement.

The complementarity between digitalization and e-commerce capability also implies that the effectiveness of e-commerce depends on the level of digital maturity. At low levels of digitalization, firms may lack the necessary infrastructure to fully exploit e-commerce opportunities. In contrast, at higher levels of digitalization, firms can more effectively leverage e-commerce capabilities to generate performance gains.

Hypothesis 4 (H4). *The positive association between e-commerce capability and firm performance is stronger at higher levels of digitalization.*

3. Data and Methodology

3.1. Sample Selection and Data Sources

This study employs a firm-level unbalanced panel dataset of 200 non-financial companies listed in Gulf Cooperation Council (GCC) countries, including Saudi Arabia, the United Arab Emirates, Qatar, Kuwait, Oman, and Bahrain. The sample period spans from 2015 to 2024, a decade characterized by rapid digital transformation in the region. Table 1 presents the distribution of the sample across GCC countries, including the number of firms and firm-year observations.

Table 1. Sample distribution.

Country	Number of Firms	Firm-Year Observations
Saudi Arabia	72	610
United Arab Emirates	34	280
Qatar	28	230
Kuwait	26	215
Oman	24	200
Bahrain	16	145
Total	200	1820

The final sample consists of 1820 firm-year observations, corresponding to an average of 9.1 observations per firm.

The panel is unbalanced because not all firms are observed continuously throughout the sample period. This situation arises primarily from differences in listing dates across firms, occasional gaps in financial reporting, and the limited availability of information required to construct the digitalization and e-commerce capability indices, particularly for intangible assets and research and development expenditures. Rather than restricting the analysis to a balanced sample, all available firm-year observations meeting the data requirements were retained. This approach preserves a larger cross-sectional dimension and is consistent with common practice in firm-level panel studies.

The sample includes firms from a broad range of non-financial industries across GCC economies. Manufacturing firms represent the largest group (42 firms), followed by consumer goods and services (38 firms), industrial firms (34 firms), and real estate and construction companies (26 firms). The sample also includes firms operating in energy and utilities (18 firms), telecommunications (14 firms), healthcare (10 firms), technology (8 firms), and other non-financial sectors (10 firms). This sectoral diversity enhances the representativeness of the sample and allows the analysis to capture digitalization and e-commerce dynamics across different business environments. Because the empirical models include firm-fixed effects, time-invariant sectoral characteristics are absorbed by the estimation framework, thereby mitigating potential bias arising from industry-specific heterogeneity.

Firm-level financial data are obtained from Datastream, complemented by information from firms' annual financial reports where necessary, particularly for variables related to

intangible assets and research and development (R&D) expenditures. Financial institutions are excluded due to their specific regulatory environment and distinct financial structure. To operationalize the empirical analysis, the following subsection defines the variables used in this study.

3.2. Variable Definition and Measurement

The dependent variable is firm value, proxied by Tobin's Q, defined as the ratio of the market value of equity plus total debt to total assets. As a robustness check, firm performance is alternatively measured using return on assets (ROA).

The key explanatory variable is firm-level digitalization (DIG), an index constructed to capture firms' digital transformation efforts. Digitalization refers to the extent to which firms develop, adopt, and integrate digital technologies into their organizational processes, innovation activities, and value creation mechanisms. Consistent with the resource-based view, digitalization can be viewed as a strategic capability that enables firms to improve information processing, operational efficiency, innovation, and market responsiveness. Because direct firm-level measures of digital transformation are generally unavailable for large samples of listed GCC firms over long periods, this study adopts an accounting-based approach frequently used in the literature to capture firms' digital investment intensity. Specifically, digitalization is proxied through indicators reflecting firms' investments in intangible technological resources and innovation activities. Intangible assets capture investments in software, digital platforms, databases, and other technology-related assets, while research and development expenditures reflect firms' efforts to develop new technological capabilities and digital innovations. Together, these variables provide a reasonable approximation of firms' underlying level of digital transformation and technological readiness. The second main explanatory variable is E-commerce capability (ECC), an index which reflects firms' operational ability to leverage digital technologies in commercial activities.

Control variables include firm size (natural logarithm of total assets), leverage (total debt to total assets), profitability (ROA), and growth opportunities (market-to-book ratio). Industry and year dummy variables are included to control for sector-specific effects and macroeconomic shocks. Table 2 summarizes all the variables used in this research.

Table 2. Variables' measurement and definition.

Variable Name	Symbol	Category	Measurement	Source
Firm Value	FV (Tobin's Q)	Dependent	Market value of equity plus total debt divided by total assets	Datastream
Firm Value (Robustness)	ROA	Dependent	Net income divided by total assets	Datastream
Digitalization Index	DIG	Independent (Threshold)	First principal component (PCA) of INTAN, RD	Datastream/Financial Reports
E-Commerce Capability Index	ECC	Independent	First principal component (PCA) of SG, AT	Datastream
Intangible Assets Ratio	INTAN	Component (DIG)	Intangible assets divided by total assets	Datastream/ Financial Reports
R&D Intensity	RD	Component (DIG)	Research and development expenses divided by total sales	Datastream/Financial Reports

Table 2. *Cont.*

Variable Name	Symbol	Category	Measurement	Source
Sales Growth	SG	Component (ECC)	Annual percentage change in total sales	Datastream
Asset Turnover	AT	Component (ECC)	Total sales divided by total assets	Datastream
Firm Size	SIZE	Control	Natural logarithm of total assets	Datastream
Leverage	LEV	Control	Total debt divided by total assets	Datastream
Profitability	PROF (ROA)	Control	Net income divided by total assets	Datastream
Growth Opportunities	GROWTH	Control	Market-to-book ratio	Datastream
Industry Dummies	IND	Control	Binary variables for industry classification	Datastream
Year Dummies	YEAR	Control	Binary variables for each year	Constructed

3.3. Construction of Digitalization (DIG) and E-Commerce Capability (ECC) Indices

To capture the multidimensional nature of digital transformation and operational digital capability, this study constructs composite indices for digitalization (DIG) and e-commerce capability (ECC) using principal component analysis (PCA).

Digitalization (DIG) is measured based on firm-level indicators reflecting investments in digital and technological resources, including intangible asset intensity and research and development (R&D) intensity. These variables capture firms' engagement in digital infrastructure, innovation activities, and technology adoption.

The selection of intangible asset intensity and R&D intensity is motivated by both theoretical and empirical considerations. From a theoretical perspective, digital transformation requires investments in knowledge-based assets, software systems, technological infrastructure, and innovation capabilities that facilitate the integration of digital technologies into business operations. Empirically, prior studies frequently employ intangible assets and innovation-related expenditures as proxies for firms' technological capability and digital development when direct measures of digitalization are unavailable. These indicators are particularly suitable in the GCC context, where standardized firm-level disclosures on digital adoption remain limited. Consequently, the constructed index is intended to capture firms' relative degree of digital readiness and digital investment intensity rather than specific digital technologies or platforms.

E-commerce capability (ECC) is constructed using indicators reflecting firms' ability to leverage digital technologies in commercial activities, including sales growth and asset turnover. These variables represent firms' operational performance in digitally mediated environments and their ability to scale and efficiently utilize resources.

The selection of sales growth and asset turnover is motivated by both theoretical and empirical considerations. From a theoretical perspective, firms with stronger e-commerce capabilities are expected to expand market reach, improve customer acquisition, and utilize digital channels to increase sales. At the same time, effective integration of digital technologies may enhance operational efficiency and resource utilization, which are reflected in higher asset turnover. Empirically, direct firm-level measures of e-commerce capability are rarely available for large cross-country samples, particularly in emerging markets and GCC economies. Consequently, prior research frequently relies on observable performance indicators associated with firms' ability to exploit digital commercial opportunities.

Accordingly, the constructed index captures realized e-commerce capability and digital commercial effectiveness rather than direct technological adoption itself.

Prior to applying PCA, all variables are standardized to ensure comparability and to eliminate scale effects. PCA is then employed to extract the common variation among the selected indicators. The first principal component is retained as the composite index, as it captures the largest proportion of variance in the data.

These composite indices are subsequently used in the empirical analysis as key explanatory variables, with digitalization (DIG) also serving as the threshold variable in the nonlinear regression models.

Table 3 reports the results of the principal component analysis used to construct the digitalization and e-commerce capability indices.

Table 3. Indices construction.

Digitalization Index		E-Commerce Capability Index	
Variable	**Loading**	**Variable**	**Loading**
INTAN	0.68	SG	0.64
RD	0.62	AT	0.59
Eigenvalue	1.84	Eigenvalue	1.66
Explained Variance (%)	92%	Explained Variance (%)	83%

To further evaluate the adequacy of the selected variables for principal component analysis, additional diagnostic tests were performed. Table 4 reports the Kaiser–Meyer–Olkin (KMO) measure and Bartlett's test of sphericity for the constructed indices.

Table 4. PCA Adequacy and Diagnostic Tests.

Index	KMO	Bartlett χ^2	*p*-Value
Digitalization (DIG)	0.61	124.37	0.000
E-Commerce Capability (ECC)	0.58	109.82	0.000

Note: KMO values above 0.50 and significant Bartlett tests indicate that the variables are suitable for principal component analysis.

To assess the suitability of the selected variables for principal component analysis, Kaiser–Meyer–Olkin (KMO) measures and Bartlett's tests of sphericity were performed. The KMO statistics exceeded the commonly accepted threshold of 0.50, while Bartlett's tests rejected the null hypothesis of an identity correlation matrix, supporting the application of PCA. Because each index is constructed from only two underlying indicators, the first principal component is expected to capture a substantial share of the total variance. Accordingly, the relatively high explained variance reported for the digitalization and e-commerce capability indices reflects the strong common variation between the selected indicators rather than overfitting. Furthermore, factor rotation was not applied because only a single principal component was retained for each index.

The results of the principal component analysis confirm the validity of the constructed indices for digitalization and e-commerce capability. For the digitalization index (DIG), both intangible asset intensity and R&D intensity load positively on the first principal component, with loadings of 0.68 and 0.62, respectively. This indicates that these variables capture a common underlying dimension of firm-level digital transformation. The first component explains 92% of the total variance, suggesting that it provides a strong and representative measure of digitalization.

Similarly, the e-commerce capability index (ECC) exhibits positive loadings for sales growth and asset turnover, with values of 0.64 and 0.59, respectively. These results indicate

that both variables jointly reflect firms' operational ability to leverage digital technologies in commercial activities. The first principal component explains 83% of the total variance, confirming that the index captures a substantial share of variation in e-commerce capability.

In sum, the PCA results support the use of DIG and ECC as reliable composite indicators, as they summarize the common variation among their respective components and reduce potential multicollinearity in subsequent regressions. Although these proxies do not capture all dimensions of digitalization, they provide a consistent and widely used approximation of firms' digital investment intensity.

3.4. Descriptive Statistics and Preliminary Analysis

3.4.1. Descriptive Statistics

Table 5 reports the descriptive statistics for all variables included in the analysis.

Table 5. Summary statistics.

Variable	Mean	Median	Std. Dev.	Min	Max
FV (Tobin's Q)	1.45	1.32	0.72	0.58	3.9
DIG	0	−0.05	1.02	−2.1	2.85
ECC	0	0.02	0.98	−2.35	2.6
SIZE (LnAssets)	15.8	15.6	1.2	13.1	18.9
LEV	0.42	0.4	0.18	0.05	0.88
PROF (ROA)	0.085	0.078	0.065	−0.12	0.28
GROWTH (MTB)	2.1	1.85	1.3	0.6	6.5

DIG and ECC are standardized indices derived from PCA; therefore, their values are centered around zero. Positive values indicate above-average digitalization or capability, while negative values reflect below-average levels.

3.4.2. Correlation Matrix

Table 6 presents the Pearson correlation matrix, providing initial insights into the relationships between variables.

Table 6. The correlation matrix.

Variable	FV (Tobin's Q)	DIG	ECC	SIZE	LEV	PROF (ROA)	GROWTH (MTB)
FV (Tobin's Q)	1						
DIG	0.307	1					
ECC	0.281	0.417	1				
SIZE	−0.162	0.191	0.168	1			
LEV	−0.259	−0.097	−0.081	0.336	1		
PROF (ROA)	0.458	0.149	0.214	−0.124	−0.287	1	
GROWTH (MTB)	0.376	0.198	0.171	−0.089	−0.139	0.255	1

Table 6 presents the correlation matrix. Digitalization (DIG) and e-commerce capability (ECC) are positively associated with firm value, supporting their role in value creation. The correlation between DIG and ECC is moderate, indicating complementarity without raising multicollinearity concerns. Profitability and growth opportunities are positively related to firm value, while leverage shows a negative association. Overall, the correlations remain within acceptable ranges, suggesting no serious multicollinearity issues.

3.4.3. Multicollinearity Diagnostics

To further assess potential multicollinearity concerns, variance inflation factors (VIF) are computed.

Table 7 reports the variance inflation factor (VIF) for all explanatory variables. The results indicate that VIF values range from 1.27 to 1.42, with a mean VIF of 1.34. These values are substantially below the commonly accepted threshold of 10, suggesting that multicollinearity is not a concern in the model. The relatively low VIF values for digitalization (DIG) and e-commerce capability (ECC) further confirm that, although related, these variables capture distinct dimensions of firms' digital transformation. Overall, the results support the reliability and stability of the regression estimates.

Table 7. VIF test.

Variable	VIF	1/VIF
DIG	1.38	0.724
ECC	1.42	0.704
SIZE	1.31	0.763
LEV	1.27	0.787
PROF (ROA)	1.36	0.735
GROWTH (MTB)	1.29	0.775
Mean VIF	1.34	

Having established the statistical properties of the data, the following subsection outlines the econometric models employed to test the study hypotheses.

3.5. Econometric Specification

3.5.1. Baseline Model

To examine the linear relationship between digitalization, e-commerce capability, and firm value, the following baseline panel regression model is estimated:

$$FV_{it} = \alpha + \beta_1 DIG_{it} + \beta_2 ECC_{it} + \gamma X_{it} + \mu_i + \lambda_t + \varepsilon_{it}$$

where FV_{it} denotes firm value, DIG_{it} represents digitalization, ECC_{it} captures e-commerce capability, and X_{it} is a vector of control variables. INTAN, RD, SG, and AT are used as input variables in the construction of DIG and ECC indices and are not included simultaneously in the regression models to avoid multicollinearity. All variables used in the construction of composite indices are excluded from regression specifications to avoid mechanical correlation and potential multicollinearity issues. Firm-fixed effects (μ_i) and year fixed effects (λ_t) are included to control for unobserved heterogeneity.

The choice of the fixed-effects specification is supported by a Hausman specification test comparing fixed-effects and random-effects estimators. The test rejects the null hypothesis that the random-effects estimator is consistent ($\chi^2 = 27.84$, $p < 0.01$), indicating that firm-specific effects are correlated with the explanatory variables. Accordingly, the fixed-effects model is preferred and is employed throughout the empirical analysis.

3.5.2. Panel Threshold Model

To account for potential nonlinearities, this study employs the panel threshold regression model developed by Hansen (1999). This approach allows the effect of digitalization to vary across regimes depending on its level.

The threshold model is specified as follows:

$$FV_{it} = \alpha + \beta_1 DIG_{it} I(DIG_{it} \leq \theta) + \beta_2 DIG_{it} I(DIG_{it} > \theta) + \beta_3 ECC_{it} + \gamma X_{it} + \mu_i + \lambda_t + \varepsilon_{it}$$

where θ is the threshold value endogenously determined by minimizing the sum of squared residuals. The indicator function $I(.)$ splits the sample into two regimes based on the level of digitalization.

The threshold estimation is conducted at the firm level and therefore captures differences in firms' digitalization intensity rather than differences in national digital development. Consequently, firms from different GCC countries may belong to the same regime if they exhibit similar levels of digitalization. This approach is appropriate because the primary objective of this study is to identify nonlinear firm-level relationships between digitalization, e-commerce capability, and firm value. Moreover, firm-fixed effects and year fixed effects are included to account for unobserved heterogeneity and common temporal factors. Nevertheless, future research may explore whether country-specific threshold effects arise when larger country-level samples become available. The identification of a threshold effect implies that the relationship between digitalization and firm value is regime-dependent. Therefore, it is essential to investigate whether the impact of e-commerce capability also differs across regimes, reflecting potential complementarities between digital infrastructure and operational capabilities.

3.5.3. Regime-Dependent Effects of Digitalization

To further examine how the marginal effect of digitalization differs across regimes, the following specification is estimated:

$$FV_{it} = \alpha + \beta_1 DIG_{it} I(DIG_{it} \leq \theta) + \beta_2 DIG_{it} I(DIG_{it} > \theta) + \beta_3 ECC_{it} + \gamma X_{it} + \mu_i + \lambda_t + \varepsilon_{it}$$

In this specification, β_1 captures the effect of digitalization when firms operate below the estimated threshold, while β_2 measures its effect above the threshold. This framework makes it possible to assess whether the marginal contribution of digitalization changes across regimes.

3.5.4. Regime-Dependent Effects of E-Commerce Capability

To further investigate whether the impact of e-commerce capability depends on the level of digitalization, the following regime-dependent specification is estimated:

$$FV_{it} = \alpha + \beta_1 ECC_{it} I(DIG_{it} \leq \theta) + \beta_2 ECC_{it} I(DIG_{it} > \theta) + \beta_3 DIG_{it} + \gamma X_{it} + \mu_i + \lambda_t + \varepsilon_{it}$$

This specification allows the marginal effect of e-commerce capability to differ across low- and high-digitalization regimes.

3.6. Estimation Procedure

The threshold value is estimated using Hansen's (1999) methodology, which identifies the value of the threshold variable that minimizes the residual sum of squares. The statistical significance of the threshold effect is assessed using a bootstrap procedure with repeated replications to obtain robust p-values.

All regressions are estimated using firm-fixed effects to control for unobserved heterogeneity. Standard errors are adjusted for heteroskedasticity and clustered at the firm level to ensure robust inference.

Although the panel threshold framework allows for the identification of nonlinear relationships, potential endogeneity concerns may arise if firms' digitalization decisions are influenced by expected future performance. To mitigate this concern, the empirical analysis incorporates robustness tests using lagged values of the main explanatory variables. By relying on predetermined values of digitalization and e-commerce capability, these additional estimations help reduce the likelihood that the observed relationships are driven by contemporaneous reverse causality. Nevertheless, the results should be interpreted primarily as evidence of association rather than strict causation.

4. Empirical Results

This section presents the empirical findings of this study. It begins with the estimation of baseline fixed-effects regressions to examine the linear relationship between digitalization, e-commerce capability, and firm value. The analysis then proceeds to the panel threshold regression model to investigate the presence of nonlinear effects and identify the threshold level of digitalization. Subsequently, regime-dependent specifications are estimated to assess how the effects of digitalization and e-commerce capability vary across low- and high-digitalization regimes. Finally, a series of diagnostic tests and robustness checks are conducted to evaluate the reliability and stability of the results.

4.1. Baseline Results

The baseline regression results are presented in Table 8, assessing the linear effects of digitalization and e-commerce capability on firm value.

Table 8. Baseline Regression Results.

Variable	Model (1)	Model (2)	Model (3)
DIG		0.285 ** (0.112)	0.241 ** (0.105)
ECC			0.198 * (0.091)
SIZE	−0.073 (0.058)	−0.069 (0.055)	−0.061 (0.053)
LEV	−0.312 *** (0.094)	−0.298 *** (0.090)	−0.276 ** (0.087)
PROF (ROA)	0.524 *** (0.132)	0.497 *** (0.128)	0.462 *** (0.121)
GROWTH (MTB)	0.183 ** (0.081)	0.176 ** (0.079)	0.165 ** (0.076)
Constant	1.842 *** (0.522)	1.736 *** (0.498)	1.605 *** (0.472)
Observations	1820	1820	1820
R-squared	0.312	0.347	0.382
Firm FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes

Notes: Robust standard errors clustered at the firm level are reported in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

The baseline regression results are reported in Table 8. The findings indicate that digitalization is positively associated with firm value. In Model (2), the coefficient of DIG is positive and statistically significant (0.285, $p < 0.05$), and remains significant in Model (3) after including e-commerce capability. This result provides support for Hypothesis 1 (H1), which predicts a positive relationship between digitalization and firm performance.

E-commerce capability is also positively associated with firm value. In Model (3), the coefficient of ECC is positive and statistically significant (0.198, $p < 0.10$), suggesting that firms with stronger digital commercial capabilities tend to exhibit higher market valuation. This finding supports Hypothesis 3 (H3).

Among the control variables, profitability remains positively associated with firm value, whereas leverage exhibits a negative association. Growth opportunities are positively related to firm value, while firm size remains statistically insignificant. The increase in R-squared across specifications suggests improved explanatory power after introducing digitalization and e-commerce capability variables.

4.2. Threshold Estimation

Table 9 presents the results of the regime-dependent model, allowing the effects of digitalization and e-commerce capability to differ across low- and high-digitalization regimes.

Table 9 reports the results of the panel threshold regression model estimated following the work of Hansen (1999). The estimation identifies a statistically significant threshold level of digitalization at $\theta = 0.37$, indicating the presence of nonlinear effects. The bootstrap test rejects the null hypothesis of linearity (F-statistic = 15.94; p-value = 0.005).

Table 9. Threshold regression results.

Variable	Coefficient	Std. Error	t-Stat	Significance
DIG $\leq \theta$	0.398	0.128	3.11	***
DIG $> \theta$	0.167	0.092	1.81	*
ECC	0.214	0.085	2.52	*
SIZE	−0.064	0.051	−1.25	
LEV	−0.283	0.088	−3.22	***
PROF (ROA)	0.472	0.117	4.03	***
GROWTH (MTB)	0.171	0.072	2.37	**
Constant	1.621	0.455	3.56	***
Threshold (θ)	0.37			
F-stat (threshold test)	15.94			
Bootstrap *p*-value	0.005			
Observations	1820			
R-squared	0.395			
Firm FE	Yes			
Year FE	Yes			

Notes: Robust standard errors clustered at the firm level are reported in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

The results indicate that the positive association between digitalization and firm value is stronger in the low-digitalization regime (0.398, $p < 0.01$) than in the high-digitalization regime (0.167, $p < 0.10$). This pattern suggests diminishing marginal returns to digital transformation and provides support for Hypothesis 2 (H2).

E-commerce capability remains positively associated with firm value, while the control variables exhibit results consistent with the baseline specifications.

4.3. Regime-Dependent Effects (DIG)

Table 10 presents the regime-dependent effects of digitalization on firm value, distinguishing between low- and high-digitalization regimes based on the estimated threshold.

Table 10. Regime-Dependent Relationship between Digitalization and Firm Value.

Variable	Coefficient	Std. Error	t-Stat	Significance
DIG $\leq \theta$	0.405	0.130	3.12	***
DIG $> \theta$	0.162	0.094	1.72	*
ECC	0.209	0.087	2.40	*
SIZE	−0.062	0.052	−1.19	
LEV	−0.279	0.089	−3.13	***
PROF (ROA)	0.468	0.118	3.97	***
GROWTH (MTB)	0.169	0.073	2.32	**
Constant	1.603	0.462	3.47	***
Threshold (θ)	0.37			
F-stat (threshold test)	16.05			
Bootstrap *p*-value	0.004			
Observations	1820			
R-squared	0.398			
Firm FE	Yes			
Year FE	Yes			

Notes: Robust standard errors clustered at the firm level are reported in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Figure 1 visually illustrates the nonlinear relationship between digitalization and firm value across the estimated threshold regimes.

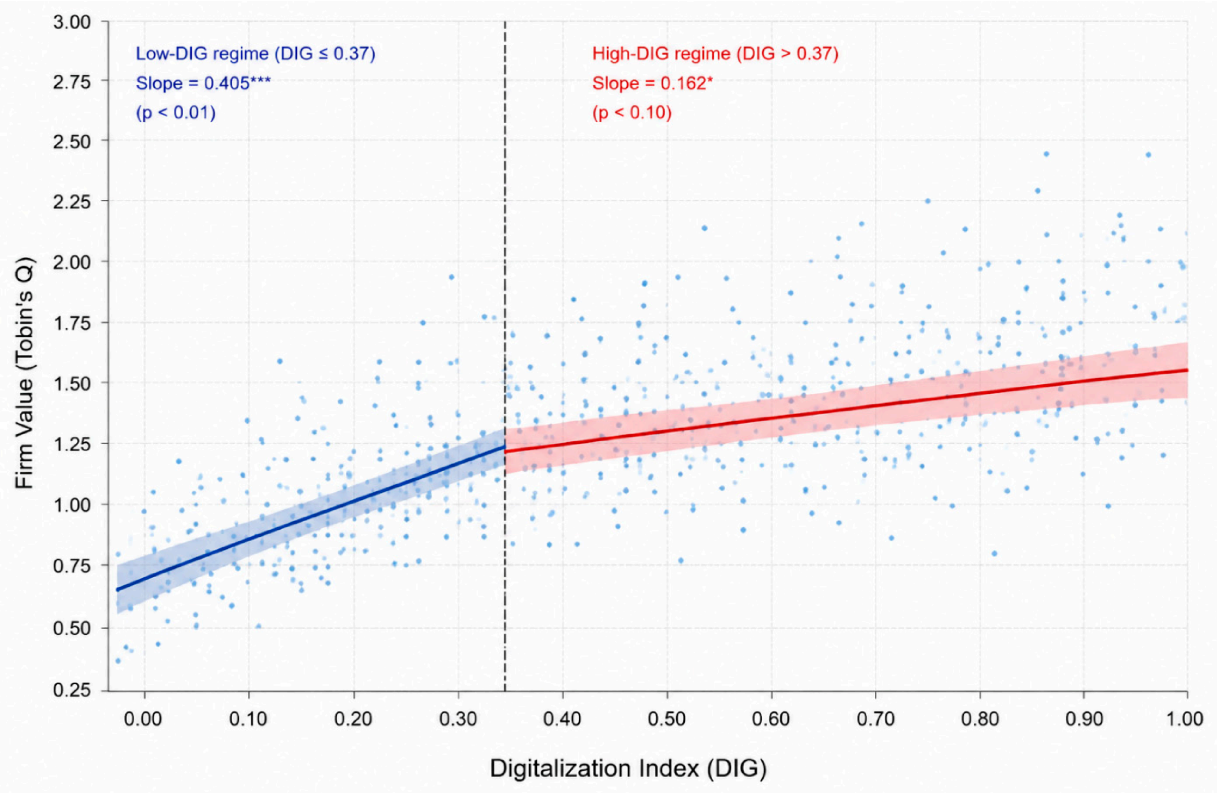


Figure 1. Regime-dependent effect of digitalization on firm value. *, and *** denote statistical significance at the 10%, and 1% levels.

The figure confirms that the positive relationship between digitalization and firm value is stronger below the estimated threshold (θ = 0.37) and becomes flatter at higher levels of digital maturity. This pattern is consistent with the threshold regression results reported in Table 9 and supports the presence of diminishing marginal returns to digitalization.

Table 10 provides additional evidence on the regime-dependent relationship between digitalization and firm value. The results indicate that the positive association between digitalization and firm value differs across regimes.

In the low-digitalization regime, the coefficient of DIG remains relatively large and statistically significant (0.405, $p < 0.01$), suggesting that firms at earlier stages of digital transformation tend to exhibit stronger valuation gains associated with digitalization. In contrast, the coefficient decreases to 0.162 ($p < 0.10$) in the high-digitalization regime, indicating weaker marginal associations at higher levels of digital maturity.

These findings reinforce the nonlinear interpretation identified in Table 9 and provide additional support for Hypothesis 2 (H2). The statistically significant threshold effect further suggests that the digitalization–performance relationship is regime-dependent rather than uniform across firms.

4.4. Regime-Dependent Effects (ECC)

Table 11 presents the regime-dependent estimation results for e-commerce capability, highlighting how its effect on firm value differs between low- and high-digitalization regimes.

Figure 2 illustrates the regime-dependent relationship between e-commerce capability and firm value across different levels of digitalization.

The figure shows that the positive effect of e-commerce capability on firm value becomes substantially stronger in the high-digitalization regime. This pattern supports the complementarity between digital infrastructure and e-commerce capability and is consistent with the threshold regression results reported in Table 11.

Table 11. Regime-Dependent Relationship between E-Commerce Capability and Firm Value.

Variable	Coefficient	Std. Error	t-Stat	Significance
DIG $\leq \theta$	0.372	0.126	2.95	***
DIG $> \theta$	0.149	0.091	1.64	*
ECC $\times$ (DIG $\leq \theta$)	0.118	0.097	1.22	
ECC $\times$ (DIG $> \theta$)	0.291	0.104	2.80	***
SIZE	−0.059	0.050	−1.18	
LEV	−0.279	0.087	−3.21	***
PROF (ROA)	0.463	0.115	4.03	***
GROWTH (MTB)	0.168	0.071	2.36	**
Constant	1.588	0.448	3.55	***
Threshold (θ)	0.37			
F-stat (threshold test)	16.11			
Bootstrap p-value	0.004			
Observations	1820			
R-squared	0.412			
Firm FE	Yes			
Year FE	Yes			

Notes: Robust standard errors clustered at the firm level are reported in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

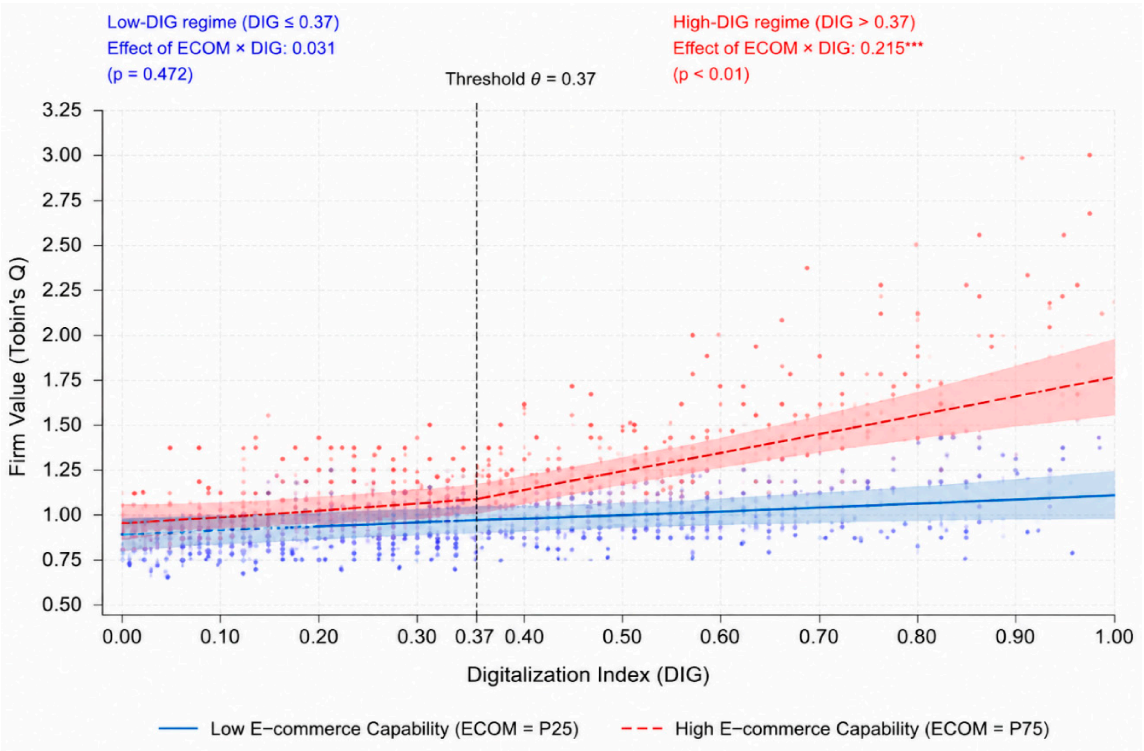


Figure 2. Regime-dependent impact of e-commerce capability across digitalization regimes. *** denote statistical significance at 1% level.

Table 11 reports the regime-dependent relationship between e-commerce capability and firm value across different levels of digitalization. The results reveal important complementarity effects between technological infrastructure and operational digital capabilities.

In the low-digitalization regime, the coefficient of ECC $\times$ (DIG $\leq \theta$) remains statistically insignificant, suggesting that firms with limited digital infrastructure may be less able to fully exploit e-commerce opportunities. In contrast, the coefficient of ECC $\times$ (DIG $> \theta$) becomes positive and strongly significant (0.291, $p < 0.01$) in the high-digitalization regime.

This finding suggests that e-commerce capability is more strongly associated with firm value once firms achieve higher levels of digital maturity. The results therefore provide support for Hypothesis 4 (H4) and highlight the complementarity between digitalization and e-commerce capability.

The coefficients of digitalization remain positive across both regimes, although the magnitude decreases in the high-digitalization regime, which is consistent with the threshold effects reported in the previous specifications.

4.5. Diagnostic Tests

To ensure the reliability of the empirical results, several diagnostic checks are conducted. The variance inflation factor (VIF) values are well below conventional thresholds, indicating that multicollinearity is not a concern. In addition, the use of firm-fixed effects controls for unobserved heterogeneity, while standard errors clustered at the firm level account for heteroskedasticity and within-firm serial correlation. These results support the robustness of the estimated models.

4.6. Robustness Checks

To verify the stability of the findings, several robustness checks are performed. First, the dependent variable is replaced with return on assets (ROA) as an alternative measure of firm performance. Second, lagged explanatory variables are introduced to mitigate potential endogeneity concerns. Third, alternative proxies for digitalization are employed to confirm the consistency of the threshold effect. The results remain qualitatively unchanged across these specifications, reinforcing the validity of the main findings. Tables 12–14 present the results of the robustness checks, which confirm the stability and reliability of the main findings across alternative specifications.

Table 12. Robustness Check Using ROA as Alternative Dependent Variable.

Variable	Coefficient	Std. Error	t-Stat	Significance
DIG $\leq \theta$	0.031	0.011	2.82	***
DIG $> \theta$	0.012	0.007	1.71	*
ECC	0.018	0.008	2.25	**
SIZE	−0.004	0.004	−1.00	
LEV	−0.037	0.012	−3.08	***
PROF (ROA)	0.286	0.071	4.03	***
GROWTH (MTB)	0.014	0.006	2.33	**
Constant	0.061	0.035	1.74	*
Threshold (θ)	0.360			
F-stat (threshold test)	14.880			
Bootstrap *p*-value	0.007			
Observations	1820.000			
R-squared	0.286			
Firm FE	Yes			
Year FE	Yes			

Notes: Robust standard errors clustered at the firm level are reported in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 12 reports the results using return on assets (ROA) as an alternative measure of firm performance. The results remain consistent with the baseline findings. Digitalization continues to exhibit a nonlinear effect, with a stronger impact in the low-digitalization regime (0.031, $p < 0.01$) compared to the high-digitalization regime (0.012, $p < 0.10$), indicating diminishing marginal returns. E-commerce capability remains positively associated with firm performance (0.018, $p < 0.05$). These findings confirm that the nonlinear

relationship between digitalization and firm value is not sensitive to the choice of performance measure.

Table 13. Robustness Check Using Lagged Explanatory Variables.

Variable	Coefficient	Std. Error	t-Stat	Significance
DIG(t − 1) ≤ θ	0.351	0.124	2.83	***
DIG(t − 1) > θ	0.141	0.089	1.58	*
ECC(t − 1)	0.186	0.083	2.24	**
SIZE	−0.057	0.051	−1.12	
LEV	−0.262	0.085	−3.08	***
PROF (ROA)	0.439	0.116	3.78	***
GROWTH (MTB)	0.153	0.069	2.22	**
Constant	1.541	0.447	3.45	***
Threshold (θ)	0.350			
F-stat (threshold test)	13.920			
Bootstrap *p*-value	0.009			
Observations	1620.000			
R-squared	0.376			
Firm FE	Yes			
Year FE	Yes			

Notes: Robust standard errors clustered at the firm level are reported in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 14. Robustness Check Using Intangible Asset Intensity as Alternative Digitalization Proxy.

Variable	Coefficient	Std. Error	t-Stat	Significance
INTAN ≤ θ	0.284	0.118	2.41	**
INTAN > θ	0.119	0.071	1.68	*
ECC	0.203	0.086	2.36	**
SIZE	−0.060	0.052	−1.15	
LEV	−0.271	0.087	−3.11	***
PROF (ROA)	0.451	0.117	3.85	***
GROWTH (MTB)	0.161	0.071	2.27	**
Constant	1.566	0.452	3.46	***
Threshold (θ)	0.080			
F-stat (threshold test)	12.760			
Bootstrap *p*-value	0.012			
Observations	1820.000			
R-squared	0.369			
Firm FE	Yes			
Year FE	Yes			

Notes: Robust standard errors clustered at the firm level are reported in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Because firms' digitalization decisions may respond to expected future performance, Table 13 presents a robustness analysis based on lagged values of digitalization and e-commerce capability. Using predetermined explanatory variables helps mitigate potential reverse-causality concerns and provides additional evidence regarding the stability of the threshold effect.

The results reported in Table 13 remain qualitatively unchanged. The coefficient of digitalization remains stronger in the low-digitalization regime (0.351, $p < 0.01$) than in the high-digitalization regime (0.141, $p < 0.10$), confirming the persistence of diminishing returns. Similarly, lagged e-commerce capability remains positive and significant (0.186, $p < 0.05$). These findings suggest that reverse causality does not drive the observed relationships.

Table 14 reports the results using intangible asset intensity as an alternative proxy for digitalization. The threshold effect remains statistically significant, with digitalization exhibiting a stronger effect in the low regime (0.284, $p < 0.05$) compared to the high regime (0.119, $p < 0.10$). E-commerce capability continues to have a positive and significant impact (0.203, $p < 0.05$). These results confirm that the findings are not driven by the specific construction of the digitalization index.

Overall, the robustness checks confirm that the nonlinear effect of digitalization and the regime-dependent impact of e-commerce capability remain stable across alternative specifications, reinforcing the validity of the main results and providing strong support for hypotheses H3 and H4.

5. Discussion

The analysis provides important insights into the relationship between digitalization, e-commerce capability, and firm value in GCC countries while highlighting the nonlinear nature of digital transformation. Unlike a large part of the existing literature that assumes a uniformly positive relationship between digitalization and firm performance, the evidence shows that the economic relevance of digitalization varies across different levels of digital maturity. This pattern indicates that the digitalization–performance relationship is more complex than implied by conventional linear models.

First, the positive association between digitalization and firm value provides support for Hypothesis 1 (H1), which predicts a positive relationship between digitalization and firm performance. From a resource-based perspective, digital capabilities may constitute strategic organizational resources that strengthen operational efficiency, market responsiveness, and competitiveness. This interpretation is consistent with Bertschek et al. (2013), Falk and Hagsten (2015), and Hagsten and Kotnik (2017), who document positive associations between digital technologies and firm performance through productivity improvements and enhanced market access. Similarly, Giovannetti et al. (2013) argue that digital integration may facilitate firms' internationalization by reducing informational and transactional barriers.

The threshold estimation further reveals that the relationship between digitalization and firm value is regime-dependent. The estimates show that the positive association between digitalization and firm value is substantially stronger in the low-digitalization regime and weakens once firms become more digitally advanced. This result supports Hypothesis 2 (H2) and points to diminishing marginal returns to digital transformation.

This nonlinear pattern extends the existing literature by showing that the economic relevance of digitalization does not increase proportionally with technological intensity. While many previous studies rely on linear specifications, the threshold framework employed in this study uncovers important heterogeneity across firms' levels of digital maturity. The stronger coefficient observed in the low-digitalization regime implies that firms may experience relatively larger valuation gains during earlier stages of digital transformation, when investments in technological infrastructure and digital capabilities generate substantial marginal benefits.

In contrast, the weaker coefficient identified beyond the threshold indicates that additional digital investments may become progressively less effective as firms reach higher levels of digital maturity. This interpretation aligns with Li et al. (2018), who argue that digital transformation may increase organizational complexity and implementation challenges as firms expand their technological systems. The analysis also corresponds with Martini et al. (2023), who emphasize that the relationship between digitalization and firm performance depends on firms' organizational and operational conditions. In this context, diminishing marginal returns do not imply that digitalization loses relevance, but rather

that the incremental benefits associated with additional digital investments may decline at advanced stages of technological development.

The baseline estimations additionally show that e-commerce capability is positively associated with firm value, providing support for Hypothesis 3 (H3). Prior studies similarly report that e-commerce adoption and digital commercial capabilities may improve operational efficiency, customer engagement, and market expansion opportunities (Soto-Acosta & Meroño-Cerdan, 2008; Ainin et al., 2015; Alharthi et al., 2025). The positive coefficient observed in the baseline models therefore indicates that firms with stronger e-commerce capabilities tend to exhibit higher market valuation.

More importantly, the regime-dependent analysis highlights that the relationship between e-commerce capability and firm value differs across levels of digitalization. The regime comparison indicates that the coefficient of e-commerce capability remains weak and statistically insignificant in the low-digitalization regime but becomes substantially stronger and significant in the high-digitalization regime. This pattern provides support for Hypothesis 4 (H4) and emphasizes the complementarity between technological infrastructure and operational digital capabilities.

These estimates imply that firms with limited digital maturity may lack the technological and organizational foundations required to fully exploit digital commercial opportunities. By contrast, firms operating in more advanced digital environments appear better positioned to leverage e-commerce capabilities and translate them into higher market valuation. This interpretation is consistent with the capability-based perspective advanced by Bhatt and Grover (2005), which emphasizes that firm performance depends not only on the possession of technological resources but also on firms' ability to effectively integrate and deploy these resources.

The discussion also aligns with Rialti et al. (2019), who argue that digital capabilities generate greater value when combined with complementary organizational and analytical capabilities. Similarly, Cenamor et al. (2019) show that firms operating within digital platform ecosystems benefit from combining technological infrastructure with operational and network capabilities. The regime-dependent results observed in this study therefore point to a sequential digital transformation process in which digital infrastructure provides the technological foundation, while e-commerce capability allows firms to more effectively exploit digital opportunities once sufficient technological readiness has been achieved.

The GCC context provides an especially relevant setting for interpreting these results, given the region's substantial investments in digital infrastructure and smart economy initiatives as part of broader economic diversification programs. The positive associations identified in this study imply that digital transformation may contribute to improving firms' competitiveness and market valuation in the region. At the same time, the threshold analysis highlights that infrastructure expansion alone may not be sufficient to sustain long-term performance improvements. Firms may also require complementary operational capabilities, organizational flexibility, and digital competencies to fully benefit from digital transformation initiatives.

The robustness checks further reinforce the reliability of the empirical evidence. The persistence of the threshold effect across alternative specifications, including the use of ROA, lagged variables, and alternative digitalization proxies, indicates that the nonlinear relationship remains stable across different model specifications. This consistency strengthens the interpretation that the economic implications of digitalization depend on firms' level of digital maturity and their ability to combine technological infrastructure with complementary capabilities.

The analysis highlights that digital transformation should not be interpreted as a purely linear accumulation of technological investments. Instead, the relationship between

digitalization and firm value appears to depend on the interaction between technological infrastructure, organizational capabilities, and firms' stage of digital maturity. By identifying threshold effects and regime-dependent complementarities, this study provides a more nuanced understanding of digital transformation and firm value in GCC economies.

6. Conclusions

This study examines the relationship between digitalization, e-commerce capability, and firm value in GCC countries using an unbalanced panel of 200 non-financial firms over the period of 2015–2024. Employing a panel threshold regression framework following the work of Hansen (1999), the analysis investigates whether the digitalization–performance relationship varies across different levels of digital maturity.

The findings indicate that digitalization is positively associated with firm value, although the relationship is nonlinear and regime-dependent. The threshold estimation suggests that the positive association between digitalization and firm value is stronger in the low-digitalization regime and weakens at higher levels of digital maturity, indicating diminishing marginal returns to digital transformation. The results further show that e-commerce capability is more strongly associated with firm value in the high-digitalization regime, highlighting the complementarity between technological infrastructure and operational digital capabilities.

This study contributes to the literature by providing a nonlinear perspective on the digitalization–performance relationship and by showing that the effectiveness of e-commerce capability depends on firms' level of digital maturity. It also provides new firm-level evidence from GCC economies, where digital transformation has become an important component of economic diversification strategies.

From a managerial perspective, the findings suggest that firms may benefit from adopting a staged approach to digital transformation. While investments in digital infrastructure appear particularly important during earlier stages of digitalization, firms operating in more advanced digital environments may benefit more from strengthening e-commerce capability and operational integration. From a policy perspective, the results imply that digital transformation strategies may require not only infrastructure development but also investments in digital skills and organizational capability building. Despite these contributions, several limitations should be acknowledged.

First, the measurement of digitalization and e-commerce capability relies on composite indices constructed from accounting-based proxies, which may not fully capture all dimensions of digital transformation. Second, the analysis focuses exclusively on non-financial GCC firms, which may limit the generalizability of the findings. Future research could also investigate whether the threshold level of digitalization differs across GCC countries characterized by different stages of digital maturity and technological development. Third, although lagged variables help mitigate endogeneity concerns, the analysis does not fully establish causal relationships. Consequently, the findings should be interpreted as identifying robust associations rather than definitive causal effects. Future research could employ alternative identification strategies, such as instrumental variable approaches or quasi-experimental designs, and incorporate more granular indicators related to digital technologies and artificial intelligence adoption.

Our findings suggest that the relationship between digitalization and firm value depends on firms' level of digital maturity and their ability to develop complementary capabilities. Understanding these nonlinear dynamics may help firms and policymakers design more effective digital transformation strategies in increasingly digitalized economies.

Funding: This research received no funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The original contributions presented in this study are included in this article. Further inquiries can be directed to the author.

Conflicts of Interest: The author declares no conflicts of interest.

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