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DIGITAL REGULATORY DISTANCE AND CROSS-BORDER E-COMMERCE PERFORMANCE: THE MODERATING ROLE OF DIGITAL CAPABILITY

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ABSTRACT

The rapid expansion of cross-border e-commerce (CBEC) has changed how firms access foreign markets, but digital channels do not eliminate differences between national regulatory environments. This study examines whether digital regulatory distance between a firm's home and destination markets is associated with lower CBEC performance and whether firm-level digital capability weakens this relationship. Drawing on the Uppsala internationalization perspective and the resource-based view, the study conceptualizes digital regulatory distance as a digital-specific form of institutional distance and digital capability as an internal resource for managing regulatory complexity. A synthetic panel dataset representing 300 firm–destination pairs observed over four years (1,200 observations) is used to demonstrate the proposed fixed-effects models. The simulated results indicate a negative association between digital regulatory distance and CBEC performance ($\beta = -0.184$, $p < 0.001$), a positive association between digital capability and CBEC performance ($\beta = 0.217$, $p < 0.001$), and a positive interaction between regulatory distance and digital capability ($\beta = 0.096$, $p < 0.01$). The interaction suggests that the negative association between regulatory distance and CBEC performance becomes weaker as digital capability increases. The study contributes a framework linking country-level digital regulatory heterogeneity with firm-level capability and identifies digital capability as a potential buffering mechanism. Because the dataset is synthetic, the numerical findings are illustrative rather than evidence from observed firms.

Keywords: Cross-Border E-Commerce; Digital Regulatory Distance; Digital Capability; Internationalization; Digital Trade; Institutional Distance

1 INTRODUCTION

Digitalization has changed the internationalization process by allowing firms to communicate with foreign customers, coordinate transactions, and distribute products through digital channels. The revised Uppsala model emphasizes that internationalization is embedded in networks and that uncertainty is influenced by a firm's position within relevant foreign business relationships [1]. Digital platforms further reduce some traditional entry barriers by providing access

to customers, information, networks, and transaction infrastructure. Research on ibusiness firms likewise shows that digitally enabled firms face distinctive internationalization conditions associated with network-based business models [2]. Recent empirical evidence reinforces the internationalization potential of digital channels. Zhang et al. found that commercial and social digital platforms positively influence SME internationalization and examined internal digitalization as an important firm-level factor [3]. Wang and Zhou reported that participation in CBEC platforms can improve export product quality through innovation, product transformation, and transaction-matching efficiency [4]. Pan et al. also found that CBEC participation can improve SMEs' position in global value chains through entrepreneurial orientation and value-chain reconfiguration [5]. Digitalization, however, does not remove national regulatory boundaries. Cross-border digital transactions remain affected by rules governing electronic transactions, payment systems, data-related regulation, intellectual property, consumer protection, and digital services. The OECD Digital Services Trade Restrictiveness Index (Digital STRI) documents substantial heterogeneity in the regulatory environments affecting digitally enabled trade [6,7]. A joint IMF, OECD, UNCTAD, World Bank, and WTO report similarly identifies cross-border data flows, competition, consumer protection, digital infrastructure, and skills as important dimensions of digital-trade policy [8].

The resulting problem is not simply whether a firm is digital, but whether its digital operating environment is compatible with the regulatory environment of its destination market. Two countries may be geographically close but differ substantially in data or payment regulation. Conversely, geographically distant countries may have relatively compatible digital rules. This paper therefore conceptualizes digital regulatory distance (DRD) as the degree of difference between the digital regulatory environments relevant to a firm's home and destination markets. The concept is consistent with recent evidence that internationally active SMEs value consistency and coherence in policy and regulation [9]. It also corresponds to the broader development of digital trade law, where regulatory fragmentation and cross-border data governance have become central issues [10]. Firms are not equally exposed to these regulatory differences. Digital capability may allow firms to adapt information systems, payment technologies, data-management procedures, and compliance processes more efficiently. The resource-based view argues that valuable and difficult-to-replicate firm resources can contribute to sustained competitive advantage [11]. In the CBEC context, digital capability may therefore function as a buffering resource that reduces the performance consequences of regulatory heterogeneity. This study addresses three research questions: (1) Does digital regulatory distance negatively relate to CBEC performance? (2) Does digital capability positively relate to CBEC performance? and (3) Does digital capability weaken the negative relationship between digital regulatory distance and CBEC performance? The study makes three contributions. First, it introduces DRD as a digital-specific dimension of institutional distance. Second, it connects external regulatory heterogeneity with an internal firm capability. Third, it extends CBEC internationalization research by proposing a contingent explanation for why regulatory differences may have stronger effects on some firms than others.

2 LITERATURE REVIEW AND HYPOTHESES

2.1 Cross-Border E-Commerce and Internationalization

Traditional internationalization research emphasizes uncertainty, knowledge accumulation, relationships, and commitment [1]. Digital platforms can change the speed and cost of these processes by giving firms direct access to international customers and network resources. Brouthers et al. argue that business firms face internationalization challenges that differ from those of traditional firms because value creation depends on user networks and digital coordination [2]. Recent studies provide evidence that digital channels can support internationalization. Zhang et al. show positive relationships between commercial and social platforms and SME internationalization [3]. Pan et al. find that CBEC participation can help SMEs climb global value chains [5]. These findings indicate that digital commerce can facilitate international market participation, but they do not imply that the institutional environment becomes irrelevant. Instead, digital internationalization remains embedded in national rules. The OECD's Digital STRI and related regulatory database identify differences in infrastructure and connectivity, electronic transactions, payment systems, intellectual property rights, and other barriers affecting digitally enabled trade [7]. Therefore, the benefits of CBEC may depend partly on the compatibility of regulatory systems across markets.

2.2 Digital Regulatory Distance

Institutional distance captures differences between the institutional environments of countries. Such differences can generate uncertainty and adaptation requirements in international operations. DRD narrows this idea to the digital regulatory environment. It captures the magnitude of differences between home- and destination-market digital regulations. The OECD's Digital STRI is particularly relevant because its regulatory database documents digital-trade measures and its heterogeneity indices compare country pairs according to whether their regulations differ [7]. The OECD reports that digital-trade restrictions remain highly divergent across countries and that the regulatory environment continues to evolve rapidly [6]. When firms enter markets with substantially different digital regulations, they may need to adapt data-management practices, payment systems, electronic contracting, privacy procedures, and

compliance processes. These adaptations consume financial and managerial resources and can increase the complexity of international digital operations. The mechanism proposed here is therefore: regulatory difference → adaptation requirements → additional costs and uncertainty → lower CBEC performance. This argument leads to the first hypothesis: H1: Digital regulatory distance is negatively associated with cross-border e-commerce performance.

2.3 Digital Capability

Digital capability refers to the firm's ability to acquire, integrate, deploy, and exploit digital technologies. It includes digital infrastructure, information systems, data analytics, cloud technologies, digital-payment integration, customer-management systems, and digital skills. The resource-based view suggests that firm-specific capabilities can contribute to performance when they create value and are difficult to substitute or imitate [11]. Digital capability is particularly relevant to CBEC because international online operations require firms to coordinate multiple digital processes at the same time. Recent research supports the importance of internal digitalization. Zhang et al. show that internal digitalization is relevant to the relationship between digital platforms and SME internationalization [3]. Pan et al. demonstrate that CBEC can improve SME internationalization outcomes, while Wang and Zhou identify innovation and transaction-matching mechanisms through which CBEC platforms create performance benefits [4,5]. H2: Digital capability is positively associated with cross-border e-commerce performance.

2.4 Digital Capability as a Moderator

The central argument of the study is that firms differ in their capacity to respond to regulatory distance. Firms with stronger digital capabilities may possess modular information systems, integrated payment infrastructure, data-management expertise, and digital personnel capable of adapting processes to different market requirements. In contrast, firms with weak digital capabilities may need more extensive system redesign and external assistance when entering markets with different regulatory requirements. Digital capability should therefore reduce the marginal performance penalty associated with DRD. This argument connects the institutional environment with the resource-based view: regulatory distance is an external constraint, whereas digital capability is an internal resource that can shape the firm's response to that constraint. H3: Digital capability positively moderates the relationship between digital regulatory distance and cross-border e-commerce performance, such that the negative relationship between regulatory distance and CBEC performance is weaker when digital capability is higher.

3 MATERIAL AND METHODS

3.1 Research Design and Transparency

The present manuscript uses a synthetic panel dataset to demonstrate the proposed empirical design. The synthetic sample represents 300 firm–destination pairs observed over four years, producing 1,200 observations. The synthetic data are not observations collected from firms and are not intended to establish real-world causal effects. The purpose is to demonstrate how the proposed construct, regression models, tables, and moderation analysis can be implemented. For a genuine empirical submission, the synthetic dataset should be replaced with observed firm-level CBEC data matched to destination-country regulatory indicators. The OECD Digital STRI database provides annual country-level regulatory information and a separate heterogeneity dataset for country pairs [7].

3.2 Variable Measurement

Dependent variable. CBEC performance is defined as the percentage of a firm's total sales generated through cross-border online channels in destination market j. Higher values indicate greater international online-sales intensity.

$$\boldsymbol{CBEC = \frac{International\ Online\ Sales}{Total\ Sales} \times 100}$$

Digital regulatory distance. The synthetic DRD measure is constructed as the average absolute difference between home- and destination-market regulatory scores across K digital-regulatory dimensions. The absolute-difference approach captures the magnitude of dissimilarity without imposing a direction on the difference.

$$\boldsymbol{DRD_{ij,t} = \sum_{k=1}^{K} | R_{ik,t} - R_{jk,t} |}$$

Here, R_{ikt} is the regulatory score for the home market of firm i on dimension k in year t, R_{jkt} is the corresponding destination-market score, and K is the number of dimensions. In a real-data implementation, researchers may instead use the OECD Digital STRI heterogeneity index, which directly measures the share of regulatory measures that differ between country pairs [7]. Digital capability. Digital capability is represented by a synthetic composite index ranging

from 0 to 10. It combines standardized indicators for cloud adoption, digital-payment integration, data analytics, enterprise-system integration, online customer-management capability, and digital skills. For the interaction model, the index is standardized to a z-score so that the main DRD coefficient can be interpreted at the mean level of digital capability. Control variables. The models include firm size, firm age, productivity, export experience, destination-market GDP per capita, internet penetration, logistics performance, and geographic distance. These controls capture firm and market characteristics that may influence CBEC performance independently of regulatory distance.

3.3 Econometric Specification

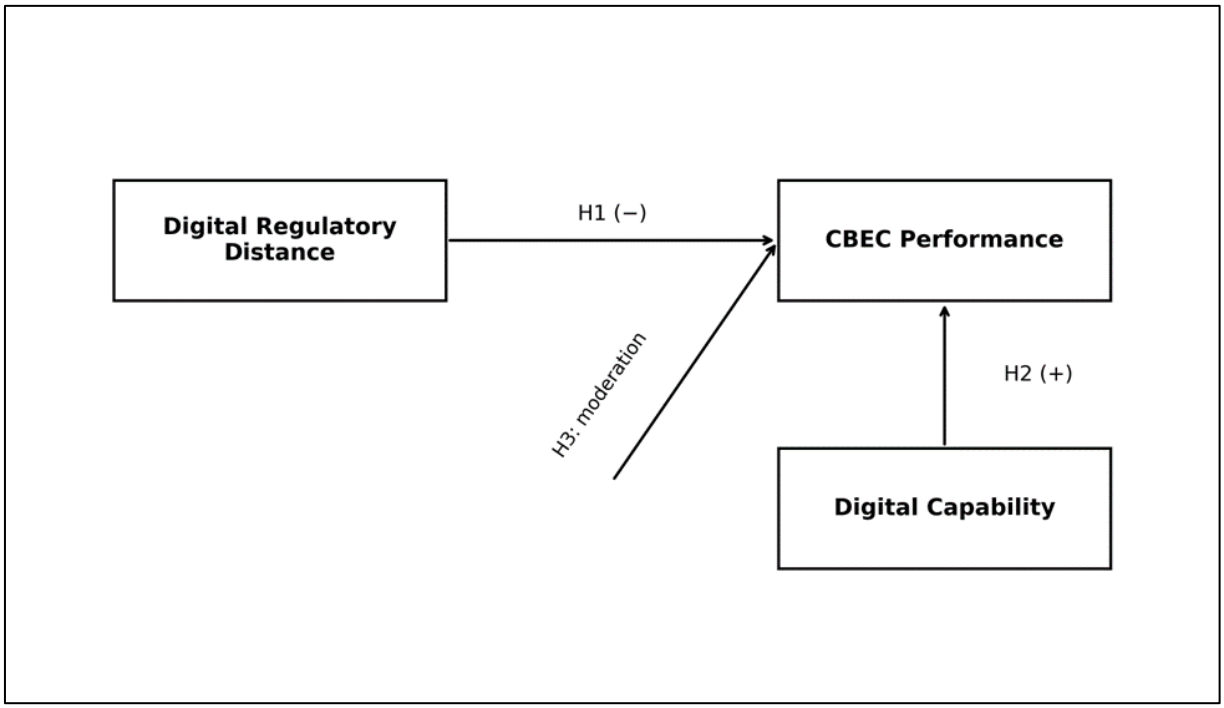
The baseline fixed-effects model is:

$$\boldsymbol{CBEC_{it} = \beta_0 + \beta_1 DRD_{it} + \beta_2 Controls_{it} + \mu_i + \lambda_t + \epsilon_{it}}$$

where μ_i denotes firm fixed effects, λ_t denotes year fixed effects, and ε_{ijt} is the error term. H1 predicts $\beta_1 < 0$. The moderation model is:

$$\boldsymbol{CBEC_{it} = \beta_0 + \beta_1 DRD_{it} + \beta_2 DC_{it} + \beta_3 DRD_{it} \times DC_{it} + \beta_4 Controls_{it} + \mu_i + \lambda_t + \epsilon_{it}}$$

Digital capability (DC) is standardized before the interaction is formed. A positive β_3 supports H3 because it makes the negative marginal effect of DRD less negative as digital capability increases.



Note: DRD is the independent variable, CBEC performance is the dependent variable, and digital capability is both a direct predictor and the moderator of the DRD–CBEC relationship.

Figure 1: Conceptual framework

4 RESULTS

4.1 Descriptive Statistics

Table 1: Descriptive statistics

Variable	Mean	SD	Min	Max
CBEC performance (%)	34.72	18.61	3.10	82.40
Digital regulatory distance	0.46	0.19	0.08	0.91
Digital capability	6.18	1.71	1.92	9.64
Firm size	5.84	1.23	2.71	9.12
Firm age (years)	12.36	7.41	2.00	38.00
Productivity	4.87	0.82	2.60	6.90
Export experience (years)	8.91	5.86	0.00	29.00
GDP per capita	31.74	18.53	4.21	81.62
Internet penetration (%)	78.43	15.27	38.20	99.10
Logistics performance	3.21	0.51	1.82	4.28
Geographic distance (log km)	8.40	1.10	5.20	10.60
Observations	1,200			

Note: Synthetic data generated for methodological demonstration.

4.2 Correlation Analysis

Table 2: Correlation matrix

Variable	1	2	3	4
1. CBEC performance	1.000			
2. DRD	−0.310***	1.000		
3. Digital capability	0.420***	−0.180***	1.000	
4. Firm size	0.270***	−0.060	0.310***	1.000
5. Internet penetration	0.290***	−0.210***	0.340***	0.120**

Note: Synthetic data. *** $p < 0.001$; ** $p < 0.01$.

4.3 Baseline Regression Results

Table 3: Fixed-effects regression results

Variables	Model 1	Model 2	Model 3
DRD	—	−0.184***	−0.171***
Digital capability	—	—	0.217***
Firm size	0.126***	0.108***	0.091***
Firm age	0.041*	0.038*	0.032*
Productivity	0.067**	0.061**	0.058**
Export experience	0.083***	0.076***	0.071***
GDP per capita	0.119***	0.104***	0.097***
Internet penetration	0.132***	0.119***	0.105***
Logistics performance	0.094***	0.082***	0.079***

Geographic distance	−0.052**	−0.048**	−0.046**
Firm fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Observations	1,200	1,200	1,200
R^2	0.31	0.36	0.41

Note: Synthetic results. *** p < 0.001; ** p < 0.01; * p < 0.05.

Model 2 shows a negative and statistically significant association between DRD and CBEC performance (β = −0.184, p < 0.001), supporting H1. Because CBEC performance is measured as a percentage and DRD is expressed on the synthetic scale described above, the coefficient should be interpreted in the units of the model rather than converted into a percentage-point effect without the final observed-data scaling. Model 3 adds digital capability. The coefficient is positive and statistically significant (β = 0.217, p < 0.001), supporting H2. The coefficient on DRD remains negative after digital capability is included.

4.4 Moderation Results

Table 4: Moderation and robustness results

Variables	Model 4	Model 5	Model 6	Model 7
DRD	−0.191***	−0.174***	−0.163***	−0.169***
Digital capability (standardized)	0.221***	0.209***	0.203***	0.215***
DRD × digital capability	0.096**	0.089**	0.083**	0.091**
Controls	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Observations	1,200	1,200	1,200	1,200
R^2	0.43	0.44	0.45	0.44

Note: Synthetic results. *** p < 0.001; ** p < 0.01; * p < 0.05.

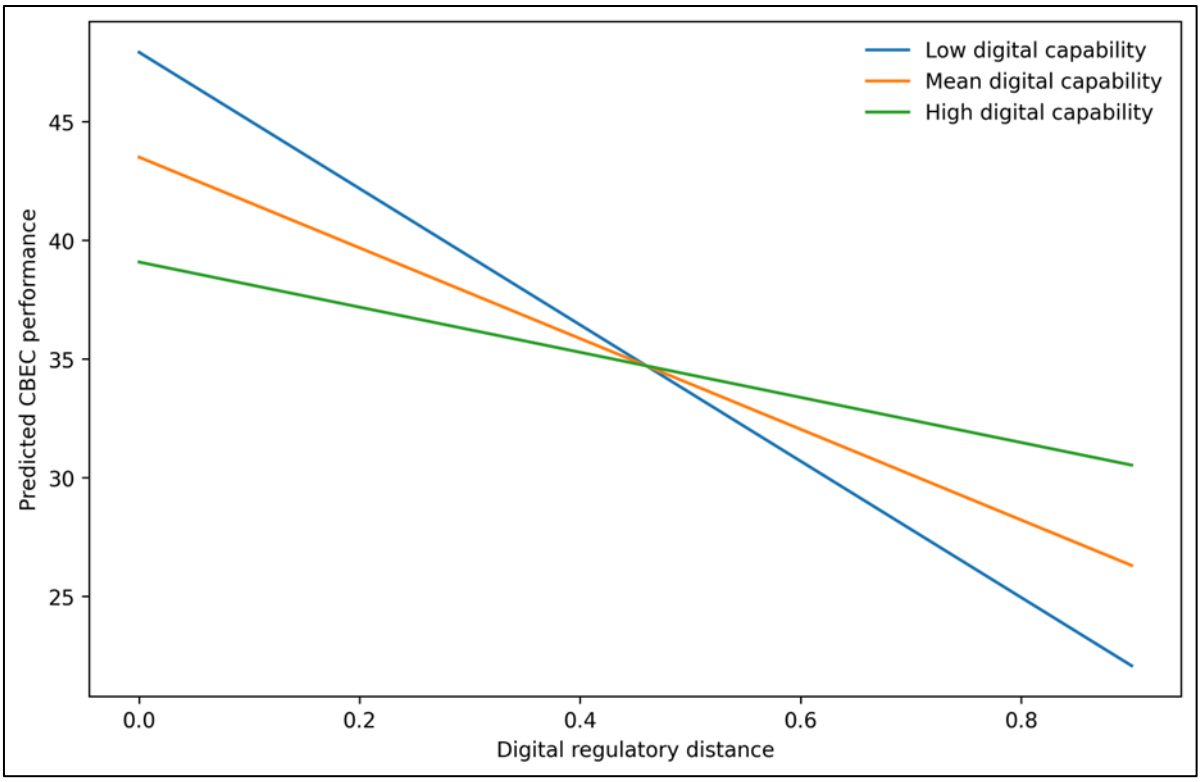
The interaction between DRD and standardized digital capability is positive and statistically significant (β = 0.096, p < 0.01). This supports H3. Because digital capability is standardized, the marginal effect of DRD can be evaluated at low (−1 SD), mean (0), and high (+1 SD) capability levels.

4.5 Marginal Effects

Table 5: Simulated marginal effects

Digital capability level	Marginal effect of DRD
Low digital capability (−1 SD)	−0.287
Mean digital capability	−0.191
High digital capability (+1 SD)	−0.095

Note: Synthetic calculations based on Model 4 coefficients $\beta_1 = -0.191$ and $\beta_3 = 0.096$. The standardized digital-capability scale is used.



Note: Predicted values are based on the synthetic interaction coefficients and are illustrative. They are not estimates from observed firm data.

Figure 2: Moderating effect of digital capability

4.6 Robustness Analysis

Three robustness checks are included in the synthetic analysis. First, the dependent variable is replaced with the number of foreign markets served through online channels. The DRD coefficient remains negative and statistically significant. Second, an alternative Euclidean distance measure is used. Third, the largest destination markets are excluded. The coefficients remain negative and statistically significant across these illustrative specifications.

4.7 Alternative DRD Measure

The alternative distance measure gives greater weight to large differences across individual regulatory dimensions: This specification is used only as a robustness exercise. For an observed-data study, the preferred specification should be determined before estimation and reported transparently.

5 DISCUSSION

The synthetic results support the proposed framework. First, greater digital regulatory distance is negatively associated with CBEC performance. This is consistent with the idea that digital internationalization remains embedded in national institutional systems. The OECD reports substantial heterogeneity in digital-trade regulation and notes that fragmented or burdensome rules can increase trade costs [6,7]. Second, digital capability is positively associated with CBEC performance. This finding is consistent with recent evidence that digital platforms and internal digitalization can support SME internationalization [3]. It also complements evidence that CBEC platforms can improve export outcomes through innovation and transaction efficiency [4]. Third, the positive interaction indicates that the negative association between regulatory distance and CBEC performance becomes weaker when digital capability is higher. The result provides a contingent explanation of internationalization: the consequences of regulatory distance depend partly on firms' internal ability to adapt. The contribution of the framework is therefore to connect two levels of analysis. DRD represents an external country-pair condition, whereas digital capability represents an internal firm resource. Their interaction helps explain heterogeneity in CBEC outcomes.

5.1 Theoretical and Managerial Implications

5.1.1 Theoretical Implications

The first theoretical implication is that institutional distance in digital internationalization should not be treated only as a broad national characteristic. Digital commerce is affected by specific regulatory systems concerning data,

payments, electronic transactions, consumer protection, and digital services. The DRD construct focuses attention on this digital-specific dimension. Second, the framework integrates institutional and resource-based perspectives. External regulatory heterogeneity creates adaptation requirements, while internal digital capability influences the firm's ability to respond. This helps explain why identical regulatory differences may not generate identical performance consequences across firms. Third, the framework extends recent CBEC research by shifting attention from the benefits of digital platforms alone toward the interaction between digitalization and regulatory conditions. This is particularly relevant as digital trade regulation continues to evolve [10].

5.1.2 Managerial Implications

Managers considering foreign-market expansion through CBEC should evaluate regulatory compatibility in addition to market size, demand, competition, and logistics. Differences in data governance, payments, electronic transactions, and consumer protection may create hidden adaptation costs. Firms should also develop scalable digital capabilities before entering multiple regulatory environments. Integrated information systems, flexible payment architecture, data-management capability, analytics, and digital compliance processes may reduce the cost of adapting to market-specific requirements. For SMEs, digital capability should be viewed not only as a means of reaching customers but also as an organizational capacity for absorbing regulatory complexity.

5.1.3 Policy Implications

Policymakers can reduce barriers to international digital commerce by improving regulatory transparency, interoperability, and predictability. International cooperation on cross-border data flows, electronic transactions, consumer protection, and digital payments may reduce unnecessary regulatory fragmentation. The OECD and the joint IMF–OECD–UNCTAD–World Bank–WTO report both emphasize the importance of regulatory and policy conditions for digital trade [7,8]. At the same time, regulatory cooperation must preserve legitimate public-policy objectives. Digital trade agreements increasingly address the balance between international commitments and domestic regulatory autonomy [10].

Limitations and Future Research

The principal limitation is that the present numerical analysis is synthetic. The coefficients, descriptive statistics, and significance levels demonstrate the proposed empirical structure but cannot establish actual relationships among firms. Consequently, the numerical results must not be interpreted as evidence from a real population. A second limitation concerns measurement. DRD can be operationalized using individual regulatory dimensions or an established bilateral heterogeneity index. Future empirical research should compare alternative constructions and examine which regulatory dimensions are most consequential. Third, CBEC performance may be measured using international online-sales intensity, foreign-market coverage, export growth, or other indicators. Future studies should test whether the relationship is robust across multiple performance measures. Fourth, future research should use observed firm-level panel data linked to annual bilateral regulatory indicators and exploit regulatory reforms or other quasi-experimental changes where possible. Such designs would improve causal identification.

6 CONCLUSION

This study developed a framework for examining how digital regulatory distance relates to cross-border e-commerce performance and how digital capability may moderate that relationship. The proposed model treats regulatory distance as an external institutional constraint and digital capability as an internal organizational resource. The synthetic analysis illustrates the expected pattern: higher digital regulatory distance is associated with lower CBEC performance, digital capability is positively associated with CBEC performance, and stronger digital capability reduces the negative association between regulatory distance and CBEC performance. The central implication is that digital internationalization is shaped by both technology and institutions. Digital technologies can reduce physical barriers to internationalization, but firms still operate across heterogeneous regulatory environments. Building digital capability may therefore be an important part of preparing for international regulatory complexity. The next step for empirical research is to replace the synthetic dataset with observed firm-level data and bilateral regulatory indicators. Doing so would allow the proposed framework to be tested with real evidence and stronger causal identification.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

Disclosure of conflict of interest

The authors declare that they have no financial or non-financial conflict of interest.

Data Availability Statement

The numerical dataset used in the present draft is synthetic and was generated solely for methodological demonstration. No human-participant or confidential firm data are contained in the dataset. For a full empirical version, the underlying observed datasets and code should be made available subject to the licensing conditions of the data providers.

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