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Digital government and the trade benefits of the new western land sea corridor evidence on institutional frictions and firm participation

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ABSTRACT

Transport corridors can improve access to international markets without necessarily changing the quality of firms' participation in them. This study examines whether digital government helps translate the connectivity created by China's New Western Land–Sea Corridor into broader and more sophisticated international engagement. The analysis uses 26,160 firm-year observations covering 2003–2023 and treats cities' staggered entry into the corridor as a quasi-experimental setting. A multiperiod difference-in-differences framework estimates the corridor effect, while an interaction with a city-level digital government index assesses institutional complementarity. Because direct firm-level customs data are unavailable, international participation is represented by foreign shareholdings among the ten largest shareholders, and participation quality by the presence of a Fortune Global 500 foreign shareholder. Corridor participation increases the scale proxy but has no significant unconditional effect on the quality indicator. Digital government positively moderates both outcomes. The interaction remains positive under instrumental-variable estimation, province-by-year controls, city-level clustering, and selection-sensitivity analysis. Mechanism regressions associate the interaction with lower expense burdens, greater information visibility, and faster working-capital and fixed-asset turnover. Subgroup results suggest that digital administration can compensate for institutional and service deficiencies, while the quality response is particularly evident among non-state-owned enterprises. These patterns support coordinating transport investment with administrative interoperability, accessible public services, and digitally supported compliance. Their interpretation remains conditional on the ownership-based outcome measures, the assumptions underlying staggered policy identification, and the indirect nature of the mechanism indicators. Digital government appears to strengthen the conversion of corridor access into firm-level international participation, although the evidence does not directly measure export volumes or product quality.

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1. INTRODUCTION

A new transport connection changes the routes available to firms, but its commercial value depends on more than the movement of freight. An enterprise may gain access to a shorter journey and still face repetitive approvals, uncertain regulatory requirements, fragmented information, or difficulty coordinating public agencies. Such obstacles matter because the benefits of connectivity must pass through organizational and institutional processes before they become usable business opportunities. The relationship between transport infrastructure and digital administration is therefore central to understanding why similar improvements in physical access can produce different outcomes across places and firms.

China's New Western Land–Sea Corridor provides a setting in which to examine this relationship. The corridor combines inland and maritime connections and links western China with Southeast Asian and other international markets. Its development is intended to improve multimodal logistics and strengthen the outward orientation of inland economic activity. The published study underlying this analysis reports that trade between participating provinces and ASEAN increased from approximately US$75.6 billion in 2017 to nearly US$150 billion in 2024 [1]. These contextual figures describe the wider environment in which the corridor developed; they are not estimates of its causal contribution.

The scale of the policy setting is considerable. The source describes corridor coverage extending across more than 70 percent of China's land area, involving over 400 million people and economic output exceeding 20 trillion yuan. It also reports that rail–sea services reached 579 ports in 127 countries and regions by 2025 [1]. These characteristics make the corridor relevant to questions about regional access, administrative coordination, and the distribution of openness benefits. They also make it unlikely that physical infrastructure alone can account for the full range of observed firm responses. Enterprises operate within cities that differ in government capacity, commercial experience, institutional protection, and connections to international production networks.

The economic case for transport corridors is well established. Infrastructure can reduce transport costs, improve reliability, and expand the set of feasible trading partners [2], [3], [4]. For inland locations, changes in effective market access can be especially valuable because distance and logistical fragmentation have historically constrained participation. Yet infrastructure can also redistribute activity toward already advantaged nodes. Firms near major terminals may benefit more than those in peripheral locations, and businesses with established capabilities may exploit new services sooner. An assessment of corridor performance must therefore consider both average outcomes and the conditions under which firms can use the resulting opportunities.

Digital government offers one possible explanation for this variation. Public authorities increasingly use electronic documentation, integrated service platforms, shared databases, and online regulatory processes. These arrangements can reduce the time required to locate information and complete transactions with government. They can also improve the consistency of decisions across departments and jurisdictions. In a corridor setting, such capabilities may be particularly consequential because shipments and business transactions cross multiple administrative boundaries. A logistical connection that spans those boundaries can remain commercially fragmented when the associated administrative systems do not communicate effectively.

The central proposition is therefore one of complementarity. Digital administration may increase the return to corridor participation by making public services more accessible and cross-border operations more predictable. This proposition differs from the claim that digital government independently improves every aspect of international activity. Its relevance lies in whether cities with stronger digital administrative capabilities obtain larger firm-level benefits after joining the corridor. A positive interaction would indicate that the same connectivity policy operates differently depending on the institutional environment through which it reaches enterprises.

The distinction between participation scale and participation quality is equally important. Firms may attract additional foreign investment without entering more demanding international relationships. They may also establish ties with internationally prominent investors without a proportionate expansion in the overall foreign ownership share. This study uses those ownership dimensions to represent international economic integration because direct firm-level import and export observations are unavailable. The first outcome measures foreign shareholdings among the ten largest shareholders. The second records whether a foreign shareholder associated with a Fortune Global 500 company is present. These measures retain the original study's operational definitions, but their interpretation must remain narrower than direct claims about shipment volumes, export unit values, or product standards.

The empirical analysis draws on 26,160 firm-year observations from 2003–2023. Cities entered successive corridor arrangements in 2017, 2018, and 2019, creating variation in treatment timing. A multiperiod difference-in-differences specification compares changes in firms located in participating cities with changes among firms in cities that had not participated. Firm and year fixed effects absorb persistent enterprise characteristics and common annual shocks. Digital government is measured through textual analysis of city government work reports, supplemented by fiscal weighting. Its interaction with corridor treatment is the parameter used to assess whether administrative digitalization changes the policy response.

The results reveal an asymmetry that motivates the broader interpretation. Corridor participation alone is associated with an increase in the scale measure, whereas the quality coefficient is insignificant. When digital

government enters through an interaction, both outcome interactions are positive and significant. Additional estimates connect this complementarity with lower expense burdens, greater information visibility, and improved asset turnover. Subgroup patterns indicate that the response is often clearer where institutional or public-service shortcomings are more pronounced. The quality association is significant among non-state-owned enterprises, suggesting that standardized external services may matter particularly for firms with fewer established administrative advantages.

These findings contribute to the corridor literature by treating institutional delivery as part of the process through which connectivity becomes economically useful. They also extend the digital government literature by examining a specific policy complement rather than an unconditional average relationship. The underlying empirical findings originate in Liu and Gong's published investigation [1]; the present manuscript reorganizes and develops their argument while retaining the reported evidence. The discussion distinguishes the observed ownership outcomes from the trade mechanisms used to interpret them and separates supportive identification checks from assumptions that remain open to scrutiny.

2. LITERATURE REVIEW

Research on transport infrastructure begins from the observation that geography affects the cost of exchange. Distance matters partly through the resources needed to move goods, but its consequences also reflect the quality of infrastructure and the organization of transport services. Bougheas, Demetriades, and Morgenroth connect infrastructure with transport costs and trade [2]. Limao and Venables show why geographical disadvantage cannot be assessed independently of infrastructure conditions [3]. Work on Asian economies similarly links infrastructure improvements with trade and growth [4]. These contributions establish a basis for expecting corridor development to improve access, while leaving room for institutional conditions to determine the size of the response.

A corridor is more than an isolated infrastructure project. Its usefulness depends on the connections between routes, modes, terminals, and markets. Research on the New Western Land–Sea Corridor examines how freight structures change across China, Central Asia, ASEAN, and Europe [5]. Network research also considers the evolution and coordination of passenger and freight systems within the corridor [6]. These perspectives highlight the importance of interdependence: a railway improvement may have limited value without reliable port access, and a new maritime connection may not benefit inland firms when feeder services remain expensive or uncertain.

The digital economy adds another layer to this network argument. Ma, Jiang, and Bao examine transport infrastructure, digital development, and trade growth along the corridor [7]. Their framework suggests that information capabilities can improve the allocation and utilization of transport resources. Digitally coordinated services can make available capacity more visible, reduce delays in matching shipments with routes, and support more reliable scheduling. These functions are distinct from administrative digitalization, but they provide a reason to investigate whether public digital capabilities complement the physical network rather than merely accompany it.

Empirical corridor studies report trade-opening benefits while recognizing variation across locations. Wang, Chen, and Wen examine western opening associated with the corridor [8], while Chen, Wen, and Chen consider its contribution within the wider Belt and Road framework [9]. Cooperation between China and ASEAN provides an additional institutional context for understanding these relationships [10]. The resulting literature suggests that connectivity can strengthen international engagement, although the response depends on economic foundations, location, and the capacity to coordinate across national and subnational boundaries.

This dependence also creates distributional questions. Major nodes can attract firms, capital, and services from surrounding areas, potentially limiting the benefits received by more peripheral cities. Improved transport accessibility may therefore coexist with greater concentration. The original study recognizes this possibility through its discussion of uneven corridor effects [1]. Such heterogeneity weakens the case for evaluating success solely through aggregate trade growth. It instead encourages attention to the characteristics of the firms that gain access and the institutional obstacles that remain after transport conditions improve.

Digital government research approaches these obstacles through the organization of public services. Fishenden and Thompson emphasize the implications of open architectures and digital systems for public-sector innovation [11]. Shi and You connect digital government with international trade, focusing on facilitation and information frictions [12]. Liu, Geng, and Du examine digital government and export upgrading in China [13]. These studies provide a conceptual basis for treating administrative digitalization as economically consequential, although they do not imply that every investment in public information technology generates an equivalent improvement in service quality.

The distinction between technology adoption and administrative capability is essential. An electronic portal can reproduce an inefficient process if underlying responsibilities remain fragmented. Conversely, a well-

designed system can reduce repeated submissions, make procedural requirements transparent, and allow agencies to reuse verified information. The economic effect depends on whether the technology changes how services are delivered. In a corridor, this means examining interoperability between customs, transport, taxation, and other agencies rather than counting digital platforms as if their presence alone established institutional integration.

Information costs offer a direct link to firm behavior. International transactions require firms to identify partners, assess their reliability, understand demand, and maintain communication across organizational and geographical boundaries. Eaton and colleagues analyze search on both sides of international markets [14]. Evidence from online marketplaces also demonstrates how digital channels can alter the role of distance in exchange [15]. Public digital information may complement these private search processes by improving access to regulatory requirements, support programs, and verified administrative data. The proposed mechanism is therefore a reduction in uncertainty around participation, not simply an increase in the amount of information available.

Contracting and compliance create related frictions. Enterprises need predictable rules and confidence that documentation will be accepted across agencies and locations. Bellucci, Rubínová, and Piermartini examine the joint relevance of digital connectivity and regulation for trade costs [16]. Research on e-government and corruption provides another reason to expect online procedures to influence the burden of official transactions [17]. Reducing face-to-face discretion may limit some opportunities for rent seeking, although digital systems can also introduce new barriers when they are poorly designed or difficult for smaller firms to use.

Institutional transaction costs are consequently a plausible pathway linking digital government with corridor benefits. Firms may spend resources on travel, coordination, relationship maintenance, and repeated administrative tasks because procedures are uncertain or fragmented. If public digital services reduce these burdens, firms can redirect managerial attention and financial resources toward commercial activity. The prediction is that the digital government–corridor interaction should be associated with lower relevant expense ratios. Such evidence would support the proposed pathway, but those ratios also reflect ordinary business decisions and cannot be interpreted as pure measures of institutional friction.

A second pathway concerns public services and data coordination. Local protection and fragmented administrative arrangements can restrict the ability of firms to benefit from broader markets [18]. Digital public services may weaken some of these barriers by standardizing processes and improving the circulation of information. Research on mobile government applications illustrates how specific digital tools can influence broader distributional outcomes [19]. The implication for corridor firms is that public data infrastructure may affect the accessibility of policy support, the speed of administrative responses, and the visibility of business information to potential partners.

The third pathway concerns operational reliability and regulatory coordination. Electronic declarations, shared documentation, and integrated risk assessment may reduce uncertainty at customs and other checkpoints. Better information can also improve coordination between production, finance, and logistics. Research linking digital technology with enterprise export product quality supports attention to these organizational complementarities [20]. Nevertheless, improved turnover ratios are only indirect evidence of customs efficiency. They can reflect changes in sales, investment, or financial management even when clearance procedures remain unchanged. Mechanism analysis must therefore distinguish a compatible pattern from direct observation of the administrative process.

Regional institutions may condition all three pathways. Where intellectual property protection is weaker or international openness is lower, firms may face larger information and coordination deficits. Digital government could have a compensating role by making services more predictable. Alternatively, stronger institutions could make digital reforms more effective because they provide the complementary capabilities necessary for implementation. These competing possibilities imply that heterogeneity cannot be assumed in advance. The empirical analysis must consider both whether coefficients are significant within groups and whether the available evidence actually establishes differences between groups.

Administrative hierarchy creates a similar ambiguity. Higher-ranking cities often possess stronger public resources and more developed service systems, potentially reducing the additional gains from digitalization. Lower-ranking cities may have greater unmet needs but weaker implementation capacity. Government intervention can likewise either support coordinated reform or restrict the response of firms. A fiscal-deficit-based indicator cannot resolve every dimension of intervention, but it can be used to examine whether the estimated complementarity varies across different administrative settings. Interpretation remains conditional on the suitability of the grouping measure.

Firm characteristics provide the final source of variation. Larger enterprises may have more resources to use digital services, whereas smaller enterprises may benefit more from lower fixed administrative burdens. Ownership may matter because state-owned firms and private firms differ in established access to public resources and official communication channels. Standardized online services could be especially valuable to enterprises that otherwise face difficulty obtaining policy information or navigating compliance procedures. This reasoning predicts neither universal benefits nor an automatic quality response; it identifies conditions under which the external service environment may influence international relationships.

Taken together, the literature motivates a sequence of empirical propositions. Corridor participation should improve international engagement, but its effects may differ between scale and quality. Digital government should strengthen the policy response where it reduces institutional and informational obstacles. Lower expense burdens, greater information visibility, and faster asset turnover should accompany that complementarity if the proposed pathways are relevant. Regional and firm-level variation should then reveal where those institutional improvements are most useful. These propositions organize the analysis without treating a favorable result in one equation as proof of the full causal chain.

3. METHODS

The research setting exploits staggered city participation in successive corridor arrangements. The source identifies entry into the Southern Corridor in 2017, the New Western Land–Sea Corridor in 2018, and the expanded corridor arrangement in 2019. Firms located in participating cities are assigned treatment from their city's first participation year onward. Firms in cities that had not participated provide the comparison observations. The resulting design treats corridor entry as a policy change that can alter logistical connectivity, access to public support, and institutional openness, while recognizing that actual implementation may develop gradually rather than occur instantaneously.

The baseline specification relates a firm outcome to the city-year treatment indicator, time-varying controls, firm fixed effects, and year fixed effects. In compact notation, the model is Yict = a + bPict + dXict + fi + gt + eict, where P denotes corridor treatment, X represents firm and city covariates, fi absorbs persistent firm characteristics, and gt captures common annual shocks. Treatment is the product of eventual participation status and an indicator for years at or after entry. The coefficient b summarizes the policy association under the maintained difference-in-differences assumptions.

Digital complementarity is assessed by adding the city-level digital government measure and its interaction with treatment. The extended equation is Yict = a + b1(Pct × DGct) + b2Pct + b3DGct + dXict + fi + gt + eict. The interaction coefficient b1 indicates whether the treatment response varies with digital government. The treatment effect at a given index value is b2 + b1DG. This conditional interpretation is necessary because a positive interaction does not establish that the treatment effect is positive at every observed value of the index or that the digital government main effect is itself positive.

The data combine enterprise ownership information from Wind, additional firm characteristics from the Chinese Research Data Service Platform, city government work reports, and regional information from the China City Statistical Yearbook. The retained panel contains 26,160 firm-year observations covering 2003–2023. Digital government data are available for 23,298 observations in the descriptive dataset, while the principal interaction regressions contain 22,790 observations. Instrumental-variable and subgroup models use smaller samples. These differences are reported rather than treated as if every specification estimated the same population.

Sample preparation follows the original study. Industries prohibited or restricted under the relevant annual foreign investment negative lists are removed. Financial enterprises, firms designated for special treatment, and wholly foreign-owned enterprises are also excluded. Software, information services, Internet-related businesses, and other primarily digitally driven activities are omitted to reduce the risk that the outcomes merely reflect those sectors' direct exposure to digital business models. Observations with substantial missing information are deleted, and continuous variables are winsorized at the first and ninety-ninth percentiles. The resulting sample is selective and should not be interpreted as representing all Chinese enterprises.

The outcome labeled trade level is the combined ownership share of foreign investors among a firm's ten largest shareholders. The source relates this measure to the foreign ownership literature [21]. The outcome labeled trade quality is binary and equals one when a foreign shareholder associated with a Fortune Global 500 company is present. Foreign ownership can indicate international capital integration and access to networks, but neither measure directly observes imports or exports. The quality indicator captures the identity of an investor rather than a product's quality, value added, or technological sophistication. These distinctions define the scope of the empirical conclusions.

Digital government is measured at the prefecture-city level using annual government work reports. The construction begins with collecting the reports in Python and converting them into analyzable text. A policy-informed lexicon contains 102 feature terms related to digital administration, data infrastructure, electronic services, digital customs, and intelligent regulation. Stop words, negation terms, and punctuation are filtered before term frequencies are calculated. The source uses term frequency–inverse document frequency weighting, drawing on the text-measurement approach associated with Kelly and colleagues [22]. Additional fiscal-expenditure-based weighting follows the approach cited to Yang and colleagues [23].

The index is intended to accommodate changing policy vocabulary and differences in urban resources. Yet its informational basis is textual emphasis rather than a direct audit of service performance. A city can discuss digital government extensively before its systems operate effectively, and established capabilities may receive

limited attention in a particular annual report. The lexicon spans government data sharing, electronic signatures, online services, digital identity, cloud systems, and customs-related applications, among other topics. Exact replication would require the complete report corpus, preprocessing decisions, term weights, and fiscal adjustment formula. The supplied article describes these components without making every computational choice explicit in its main text.

Firm controls include asset size, staffing, leverage, return on equity, capital density, the revenue–cost ratio, the proportion of independent directors, and the largest shareholder's ownership share. City controls represent economic development and science and technology expenditure. Their inclusion follows related research on foreign capital and digital economic conditions [24], [25]. Firm fixed effects account for persistent unobserved enterprise characteristics, while year effects capture common shocks. Baseline standard errors are clustered by firm, following the general logic of cluster-robust inference [26]. A later specification clusters by city because policy treatment and digital government are measured at that level.

An event-study specification replaces the single treatment indicator with indicators for relative time around corridor entry. The year immediately before entry is omitted. The source reports that pre-entry coefficients are not statistically distinguishable from zero and that post-entry effects develop over time. This pattern is consistent with parallel trends, although statistical nonrejection does not prove that untreated outcomes would have evolved identically. The article provides the results graphically rather than listing all event-time coefficients numerically, so no unreported event estimates are introduced here.

A random-assignment placebo exercise provides a separate diagnostic. The study generates hypothetical treatment groups and policy years in 1,000 simulations and re-estimates the model. The resulting distribution is compared with the observed baseline coefficient. This exercise assesses whether arbitrary assignments commonly reproduce an effect of comparable size. It does not remove structured confounding that follows actual policy selection, nor does it substitute for examining anticipatory behavior, spillovers, or contemporaneous city reforms. Its contribution is supportive evidence about the specificity of the observed assignment.

To address potential endogeneity of the interaction, the source constructs an instrument from historical postal and telecommunications activity per 10,000 residents in 1984, national Internet user numbers, and corridor treatment. The approach draws on the use of historical communications infrastructure in research on Internet development [27]. Historical capacity supplies cross-city exposure, national Internet expansion supplies time variation, and treatment aligns the instrument with the endogenous interaction. Relevance is assessed in the first stage. Exclusion requires that this combined historical exposure affect the outcome through the digital government interaction rather than through other evolving local advantages.

That restriction remains substantive. Historical communications infrastructure may be associated with persistent commercial centrality, skills, or private digital adoption. Firm and year effects remove some confounding but cannot absorb every time-varying city pathway. The published model instruments the interaction; it does not clearly document a separate instrument for the digital government main effect. The instrumental-variable results are therefore interpreted as a sensitivity exercise under the reported exclusion assumptions, rather than a definitive removal of all reverse causality or omitted-variable bias.

Further checks add province-by-year fixed effects, change the clustering level, and apply Oster's selection-sensitivity framework [28]. The latter relates coefficient movements to changes in explanatory power, conditional on proportional-selection assumptions. Mechanism regressions then use expense ratios, news and search indices, and turnover measures as outcomes, following the source's approach to mechanism analysis [29]. Regional splits use intellectual property protection and openness, administrative splits use fiscal intervention and city rank, and firm splits use size and ultimate ownership. These analyses describe patterned responses; without formal between-group tests and stronger mediation assumptions, they do not establish every proposed difference or causal pathway conclusively.

4. RESULTS

The findings are presented in five consolidated tables. The consolidation retains the numerical estimates from the original descriptive, baseline, moderation, instrumental-variable, robustness, mechanism, and heterogeneity tables. Outcome labels retain the source terminology, but their interpretation follows the ownership-based definitions described above. Standard errors and significance symbols reproduce the published values. This preserves the empirical record while allowing the discussion to distinguish measured relationships from broader claims about trade performance.

Table 1 establishes the distribution of the outcomes and explanatory variables. It also makes differences in data availability visible before the regression comparisons. The scale indicator is dispersed, whereas the quality outcome is relatively uncommon. These characteristics matter because an effect on a continuous ownership measure need not be accompanied by a detectable change in the probability of attracting a particular class of investor.

Table 1. Descriptive statistics for international participation and explanatory variables

Variable	Observations	Mean	Standard deviation	Minimum	Maximum

Trade level	26,160	5.7804	11.7424	0.0000	124.8000
Trade quality	26,160	0.0767	0.2661	0	1
Corridor policy	26,160	0.0528	0.2235	0	1
Digital government	23,298	0.0443	0.1123	0.0000	2.8966
Firm size	26,160	21.9758	1.8769	16.5765	30.8314
Staff	26,160	7.6701	1.1604	5.1475	10.7887
Leverage	26,160	0.4072	0.1919	0.0529	0.8404
Return on equity	26,160	0.0697	0.0988	−0.4463	0.3126
Capital density	26,160	12.6234	1.0505	9.4633	15.4859
Revenue–cost ratio	26,160	0.3669	0.2860	0.0168	1.7076
Independent director ratio	26,160	0.3869	0.0914	0.0000	0.6250
Largest shareholder	26,160	0.1319	0.0802	0.0385	0.6821
City economic development	26,160	11.4324	0.7230	8.0206	13.0557
Science and technology expenditure	26,160	0.0389	0.0318	0.0000	0.2866

Note: Definitions, sample sizes, and numerical precision follow the source. Trade level measures foreign ownership among the ten largest shareholders; trade quality indicates a Fortune Global 500 foreign shareholder. The published maximum of 124.8000 is retained, although it requires clarification if the ownership variable is interpreted as a conventional percentage share.

The average quality indicator is 0.0767, indicating that the relevant foreign investor relationship occurs in a minority of observations. The policy mean of 0.0528 likewise shows that treated firm-years form a relatively small part of the full panel. Digital government has fewer observations than the other descriptive variables, and its upper tail is substantial relative to its mean. These features caution against interpreting a one-unit index change as representative of the change experienced by an average city. They also make the composition of the smaller moderation sample relevant when comparing its coefficients with the full-sample baseline.

Table 2 combines the baseline corridor estimates with the digital government interaction results. The first two scale columns differ by whether controls are included, as do the first two quality columns. The final pair adds digital government and its interaction with the corridor indicator. This arrangement shows directly whether the evidence for quality differs between an unconditional corridor effect and a conditional institutional relationship.

Table 2. Baseline corridor effects and digital government complementarity

Regressor or statistic	Scale without controls	Scale with controls	Quality without controls	Quality with controls	Scale with digital interaction	Quality with digital interaction
Corridor policy	1.5865*** (0.3933)	1.4116*** (0.3751)	−0.0192 (0.0163)	−0.0120 (0.0168)	0.9478** (0.3732)	−0.0174 (0.0184)
Digital government × policy	—	—	—	—	1.8315*** (0.5908)	0.1793*** (0.0439)
Digital government	—	—	—	—	−1.7269*** (0.3923)	−0.1425*** (0.0176)
Size	—	0.3345*** (0.0464)	—	−0.007 (0.0010)	Included	Included
Staff	—	0.9215*** (0.2739)	—	−0.0156*** (0.0056)	Included	Included
Leverage	—	−2.9054*** (1.0115)	—	0.0313 (0.0238)	Included	Included
Return on equity	—	1.0839 (0.8917)	—	0.0318 (0.0222)	Included	Included
Capital density	—	0.3151* (0.1908)	—	−0.0160*** (0.0045)	Included	Included
Revenue–cost ratio	—	0.5812 (0.7412)	—	−0.0241 (0.0188)	Included	Included
Independent director ratio	—	0.0984 (0.7695)	—	0.0343* (0.0190)	Included	Included
Largest shareholder	—	−0.0045 (0.0072)	—	0.0003 (0.0002)	Included	Included
City economic development	—	1.1887*** (0.4042)	—	−0.0370*** (0.0103)	Included	Included
Science and technology expenditure	—	−4.1385 (3.9006)	—	0.0754*** (0.1371)	Included	Included
Firm and year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	26,160	26,160	26,160	26,160	22,790	22,790

R^2	0.7369	0.7401	0.5089	0.5112	0.7344	0.3282

Corridor participation has a positive scale coefficient of 1.5865 without controls and 1.4116 with controls, both significant at one percent. The quality estimates are negative but insignificant in both baseline models. Introducing digital government produces positive interaction coefficients of 1.8315 for scale and 0.1793 for quality, each significant at one percent. These estimates support complementarity, but the quality policy main effect remains negative and insignificant. It is therefore the interaction, rather than an unconditional quality improvement, that carries the principal quality finding. The negative digital government main effects further show why the complete conditional specification must be considered.

The event-study results reported in the source show no statistically significant pre-entry coefficients relative to the omitted year immediately preceding participation. Post-entry scale effects become more evident over time. In the placebo exercise, the mean coefficient across 1,000 randomized assignments is −0.00041, and the observed baseline scale coefficient exceeds the ninety-ninth percentile of the simulated distribution. These results are consistent with a policy-specific response, while leaving the maintained assumptions about actual treatment selection and spillovers unresolved.

Table 3 brings together the instrumental-variable estimates and the remaining sensitivity checks. It retains the smaller samples used by the historical infrastructure instrument and province-by-year specification. The table also records the reported first-stage strength and selection-sensitivity statistics, allowing the positive interaction pattern to be assessed alongside its uncertainty.

Table 3. Instrumental-variable estimation and robustness of the digital government interaction

Specification and outcome	Digital interaction	Policy	Observations	R^2	Additional statistic
Instrumental variables, scale	37.0829* (19.9653)	−14.1188* (8.2617)	20,686	Not reported	Kleibergen–Paap F = 10.2138
Instrumental variables, quality	9.7484* (4.7617)	−0.4411** (0.1983)	20,686	Not reported	Kleibergen–Paap F = 10.2138
Province-by-year effects, scale	1.9251* (0.8376)	Not reported	22,721	0.7452	Province-by-year effects included
Province-by-year effects, quality	0.1223** (0.0473)	Not reported	22,721	0.4057	Province-by-year effects included
City clustering, scale	1.8315** (0.6696)	Not reported	22,790	0.7344	City-clustered standard errors
City clustering, quality	0.1793** (0.0679)	Not reported	22,790	0.3282	City-clustered standard errors
Oster sensitivity, scale	1.8315** (0.5908)	Not reported	22,790	0.7344	δ = −3.8375
Oster sensitivity, quality	0.1793** (0.0439)	Not reported	22,790	0.3282	δ = −1.4208

The instrumental-variable interaction coefficients remain positive, although they are much larger and less precise than the ordinary interaction estimates. The scale estimate is significant at ten percent and the quality estimate at five percent. The first-stage statistic of 10.2138 provides some evidence of relevance, but its proximity to a conventional rule-of-thumb threshold does not eliminate weak-instrument concerns under every inference procedure. The marked change in magnitude and the negative policy coefficients also mean that numerical equivalence across identification strategies cannot be claimed.

The province-by-year specifications preserve positive interaction coefficients, as do the city-clustered models. Clustering changes standard errors without changing point estimates. The published significance stars are retained, although some do not align exactly with conventional normal-approximation ratios using the displayed coefficients and standard errors. The Oster statistics have absolute values greater than one. This supports the source's sensitivity interpretation under its proportional-selection assumptions, but the negative signs and unreported implementation details caution against treating the statistics as universal bounds on omitted-variable bias.

Table 4 reports the mechanism regressions. Entertainment and travel costs are normalized by operating revenue, while the comprehensive expense measure divides selling, administrative, and financial expenses by total assets. News and search indicators represent external information visibility. Working-capital and fixed-asset turnover represent operational efficiency. The proxies cover different aspects of the proposed pathways and use different samples because of data availability.

Table 4. Mechanism regressions for costs information and operational efficiency

Mechanism outcome	Digital government × policy	Policy	Digital government	Observations	R^2

Entertainment and travel expenses	−0.1197 ** (0.0584)	−0.0061 (0.0198)	0.0794* ** (0.0173)	14,183	0.5844
Comprehensive expense burden	−0.0306 *** (0.0107)	0.0073* * (0.0036)	0.0198* ** (0.0048)	16,273	0.7622
Financial news index	0.3407* * (0.1530)	−0.0702 (0.0503)	−0.1739 *** (0.0519)	16,094	0.7046
Internet search index	0.7813* * (0.3390)	−0.1457 ** (0.0582)	−0.1668 (0.1043)	15,395	0.8926
Working-capital turnover	0.2828* * (0.1256)	−0.0027 (0.0534)	−0.0421 (0.0558)	14,361	0.6885
Fixed-asset turnover	0.1302* * (0.0542)	−0.0302 (0.0228)	−0.0135 (0.0203)	16,540	0.9193

The interaction is associated with lower expense burdens and higher information and turnover indicators. These signs are consistent with the proposed reduction in administrative frictions and improvement in coordination. The expense measures follow related studies of nonproductive expenditures and digital governance [30], [31], while the information indicators draw on research using online visibility [32]. Operational measures follow the source's cited firm-development literature [33]. The regressions do not estimate the share of the outcome effect mediated by each pathway. They provide corroborating associations, and their indirect measures cannot independently establish changes in customs processing or service quality.

Table 5 consolidates the regional, administrative, and firm subgroup results. Intellectual property protection is measured from concluded cases and divided at the median, following the source's institutional approach [34]. Openness is the ratio of city imports and exports to GDP. Intervention groups use local fiscal deficits, administrative rank distinguishes major higher-ranking cities from other cities, size uses the median logarithm of assets, and ownership follows the ultimate controller. Each row retains the reported subgroup sample and goodness of fit for both outcomes.

Table 5. Regional administrative and firm heterogeneity in digital government complementarity

Subgroup	Observations	Scale interaction	Scale R^2	Quality interaction	Quality R^2
Higher intellectual property protection	5,773	4.9670 (4.4594)	0.8501	0.0955 (0.2103)	0.4993
Lower intellectual property protection	5,796	1.0533* * (0.5247)	0.7742	0.1889* ** (0.0537)	0.4209
Higher openness	7,782	0.5640 (1.0727)	0.7557	0.5816* * (0.2305)	0.2356
Lower openness	7,712	1.4126* (0.7355)	0.7517	0.1549* ** (0.0554)	0.4066
Higher government intervention	8,151	2.8482 (2.9335)	0.7736	0.1858 (0.5959)	0.3011
Lower government intervention	8,048	0.6634* (0.4003)	0.8107	0.0636 (0.0439)	0.4286
Higher administrative rank	5,071	0.5159 (0.8782)	0.7458	0.1009 (0.1222)	0.4203
Lower administrative rank	11,465	0.9809* (0.5522)	0.7801	0.0662* * (0.0333)	0.3098
Larger firms	8,186	2.2714* (1.2721)	0.8085	0.1343 (0.0938)	0.3704
Smaller firms	7,949	0.8795* * (0.4235)	0.7976	0.0762 (0.0538)	0.4147
State-owned enterprises	4,573	0.4999 (0.6617)	0.8533	0.1025 (0.1325)	0.3909
Non-state-owned enterprises	11,933	0.8416 (0.5633)	0.7773	0.1019* ** (0.0394)	0.3299

Lower-protection locations show significant interactions for both outcomes, whereas the higher-protection estimates are imprecise. Scale complementarity is significant in lower-openness locations; quality complementarity is significant in both openness groups. Lower-intervention locations show a significant scale association, but neither intervention group has a significant quality coefficient. Lower-ranking cities have significant interactions for both outcomes, while higher-ranking cities do not. These patterns support the possibility of a compensating role for digital services, although they do not establish uniformly larger numerical effects in disadvantaged groups.

The size split yields significant scale interactions for both larger and smaller firms, with neither quality estimate significant. In the ownership split, neither scale interaction is significant. The quality coefficient is significant among non-state-owned enterprises but not among state-owned enterprises. The original interpretation of widespread scale benefits should therefore be understood as a broad tendency, not universal subgroup significance. The especially clear non-state quality result is compatible with the importance of accessible public services, while its comparison with state ownership requires a formal coefficient-difference test before stronger claims can be made.

5. DISCUSSION

The results suggest that the economic value of a corridor depends partly on the administrative arrangements through which firms encounter it. Improved connections expand the possibilities for international activity, but opportunities become usable only when firms can obtain information, complete procedures, and coordinate transactions reliably. The positive digital government interaction is consistent with this institutional complementarity. It directs attention toward the conversion of access into enterprise capability, rather than assuming that a new route produces equivalent benefits wherever it operates.

The baseline asymmetry provides a useful starting point. Corridor participation is associated with a higher foreign ownership share but not with a significant increase in the Fortune Global 500 shareholder indicator. Physical and institutional opening may therefore make a location more attractive to foreign capital without immediately producing a different class of investor relationship. The distinction is credible because the two outcomes involve different decisions. Increasing an existing ownership position may require less adjustment than establishing a relationship with a globally prominent enterprise whose investment procedures, compliance requirements, and organizational priorities are more demanding.

The digital interaction suggests that public administrative capabilities can influence this distinction. Standardized services and more predictable procedures may reduce the uncertainty that would otherwise discourage complex international relationships. The finding is compatible with research on digital government and trade facilitation [12], [13], but its empirical content remains specific. It concerns changes in ownership-based indicators around corridor participation. The evidence does not directly establish that firms export more sophisticated products, enter higher-value production stages, or obtain higher export prices. These outcomes may be related, but they require different observations.

This measurement boundary is especially important because foreign investment and trade are not interchangeable. Some foreign investors enter firms primarily to serve domestic markets. Others seek financial returns without changing international production relationships. A Fortune Global 500 shareholder can bring technology, management practices, or market access, but its presence does not reveal which of those transfers occurs. Conversely, an enterprise can produce high-quality exports without attracting such a shareholder. The proxies capture a meaningful dimension of international integration while leaving substantial parts of trade quality unobserved.

The negative digital government main effects deserve attention alongside the positive interaction. They show that the reported model does not imply an unconditional beneficial association between the index and either outcome. The coefficient on digital government refers to the non-treated condition, while the interaction indicates how that relationship changes with corridor treatment. The policy main coefficient similarly refers to the index value of zero. Without reporting conditional effects across the observed distribution and their confidence intervals, the strongest supported conclusion concerns positive moderation rather than universal benefits from digital administration.

There are several possible reasons why the main effect could differ from the interaction. Digital reforms may be adopted in response to existing administrative problems, or their short-run implementation may impose adjustment costs. The textual index may capture policy attention more strongly than completed service improvements. Cities outside the corridor may also face different constraints from those of participating cities. These possibilities are not separately tested, so they should not be presented as explanations established by the estimates. They demonstrate why a complete interpretation must consider the full equation rather than isolate the favorable coefficient.

The mechanism results lend coherence to the institutional argument. Lower entertainment and travel spending and a lower comprehensive expense burden are compatible with reduced coordination costs. Firms that can complete procedures remotely may need fewer visits, less repeated documentation, and less managerial time devoted to navigating agencies. Research on nonproductive expenditure supports the relevance of these indicators [30]. Yet such expenses also include legitimate commercial activity. Changes in their ratios can result from growth in revenue or assets as well as reductions in the numerator. Direct administrative cost surveys would help distinguish these interpretations.

The news and search results indicate greater external visibility under the digital government–corridor interaction. This may improve the availability of information to investors, customers, and intermediaries, thereby facilitating matching and assessment. Search-based approaches to international exchange emphasize the importance of identifying suitable counterparties [14], while digital platforms can change the geography of that process [15]. However, more attention is not always equivalent to better information. News coverage can reflect controversy, and searches can arise from uncertainty. The positive coefficients establish visibility, not the accuracy or usefulness of every information flow.

Turnover improvements provide another piece of compatible evidence. Faster working-capital turnover may indicate less capital tied up in operational cycles, while faster fixed-asset turnover may reflect more intensive

use of productive capacity. Both are consistent with smoother coordination and more reliable fulfillment. Neither directly observes customs clearance time, regulatory processing, or compliance quality. Sales growth, changes in capacity utilization, or investment timing can produce similar patterns. The findings therefore support an operational channel broadly, while the specific customs interpretation remains a reasoned hypothesis rather than a directly measured mechanism.

The subgroup evidence suggests that digital public services may compensate for certain institutional disadvantages. Lower-protection cities have significant interactions for both outcomes, and lower-ranking cities display a comparable pattern. These results fit the view that standardized procedures can reduce the importance of local administrative shortcomings. They also qualify the assumption that digital reforms necessarily benefit only already capable places. Where existing services are limited, modest improvements in access and consistency may create substantial room for firms to use new transport connections.

Nevertheless, the evidence does not establish a simple ranking in which weaker institutions always produce larger effects. The higher-protection scale point estimate is numerically larger but much less precise. Quality complementarity is significant in both openness groups, and the higher-openness quality coefficient is larger. These patterns suggest that compensating effects can coexist with complementarities that depend on mature market networks. A city with limited openness may gain in participation intensity, while a city with an established international service ecosystem may be better positioned to attract prominent foreign investors.

Administrative rank also combines several characteristics that the subgroup regressions cannot separate. Higher-ranking cities tend to differ in resources, infrastructure, firm composition, and economic history. Lower-ranking cities may face coordination gaps, but they also may have different investment opportunities. The significant lower-rank interaction is compatible with service-gap reduction without identifying which particular administrative feature matters. Similarly, a fiscal deficit is an imperfect measure of intervention. It can reflect revenue weakness, investment needs, or countercyclical policy rather than direct restrictions on enterprise decisions.

Ownership heterogeneity is particularly relevant to public-service design. Non-state-owned enterprises may rely more heavily on transparent, standardized procedures because they cannot draw on the same established administrative relationships as some state-owned enterprises. The significant quality interaction for non-state firms is consistent with this interpretation. Yet the state and non-state quality point estimates are nearly identical, with different standard errors. It would therefore be misleading to infer a large ownership difference solely from their significance labels. The evidence identifies a precisely estimated non-state response, while leaving the comparative magnitude unresolved.

Firm size offers another caution against overly broad claims. Both size groups show significant scale interactions, but neither has a significant quality interaction. This may indicate that general improvements in administrative access are relevant across resource levels, whereas the quality indicator depends on capabilities not captured by size alone. Technological competence, established partnerships, industry characteristics, and investor strategy may all matter. The present data do not isolate these factors, and a median split can conceal continuous or nonlinear relationships. The subgroup results should therefore guide further inquiry rather than prescribe rigid categories of beneficiaries.

The identification checks improve confidence in the pattern but have different evidential roles. Pre-entry event coefficients close to zero are consistent with parallel trends, and the placebo distribution shows that arbitrary assignments rarely reproduce the observed scale effect. Province-by-year controls address common provincial shocks, while city clustering acknowledges shared local disturbances. None of these checks fully removes the possibility that participation timing coincides with other city-specific changes. In a staggered fixed-effects design, heterogeneous treatment responses can also complicate interpretation when comparisons involve cities treated at different times. Cohort-specific estimates would make the relevant comparisons more transparent.

Spillovers deserve particular attention in a network policy. Firms in comparison cities may use corridor terminals elsewhere, and participating cities may attract activity from neighboring locations. The first possibility can attenuate estimated local differences; the second can mix newly created activity with redistribution. Firm fixed effects do not resolve either issue. Geographic exposure measures, logistics-use data, and explicit spatial analysis could help establish whether the estimates reflect direct corridor use, broader market access, or the movement of investment between locations. The present findings remain local policy associations under the reported treatment definition.

The instrumental-variable estimates preserve the direction of the interaction but do not settle these concerns. Their much larger magnitude, wider uncertainty, and borderline first-stage strength warrant restraint. Historical communications capacity may influence contemporary international integration through private digital infrastructure, urban centrality, or accumulated skills as well as public administration. The exclusion restriction therefore cannot be inferred from the age of the instrument alone. Weak-instrument-robust confidence intervals and sensitivity to alternative historical exposures would make the causal argument more informative.

Policy implications follow most directly from the combined pattern rather than any single coefficient. Corridor investment should be coordinated with usable public services that reduce repeated submissions and make procedures predictable. Interoperability between agencies is likely to matter more than the number of portals created. Electronic documents, consistent data definitions, and transparent processing responsibilities can help firms use improved connectivity. These recommendations reflect the study's institutional logic; the data do not compare the cost effectiveness of specific technologies or establish an optimal implementation sequence.

Targeting should be sensitive to both deficits and complementary capacity. Lower-ranking or less-open cities may benefit from support that closes basic service gaps, while more internationally connected cities may need systems that accommodate complex investment and compliance relationships. Non-state enterprises may particularly value accessible policy information and reliable administrative channels. Universal service standards can reduce dependence on privileged access, but implementation should be assessed through user experience and actual processing outcomes. A text-based policy index is useful for research coverage, yet it cannot replace operational monitoring.

Future work could strengthen the argument by linking ownership data with customs transactions, shipment records, product characteristics, and direct administrative metrics. Such linkage would clarify whether the observed capital relationships produce more exports, greater diversification, higher value added, or more reliable delivery. Validation of the digital government index against service completion rates and data-sharing performance would also improve measurement. Together with transparent treatment coding, cohort-specific estimation, and formal subgroup comparisons, these extensions would help determine how digital administration changes the economic return to corridor connectivity.

6. CONCLUSION

The analysis indicates that the benefits of transport connectivity depend partly on the institutions through which enterprises gain access to them. In the reported panel of Chinese firms covering 2003–2023, participation in the New Western Land–Sea Corridor is associated with a higher foreign ownership measure but no significant unconditional change in the presence of a Fortune Global 500 foreign shareholder. Digital government positively moderates both outcomes. This pattern suggests that administrative capabilities can complement physical access, particularly where firms must coordinate information, procedures, and regulatory obligations across multiple jurisdictions.

The additional estimates support an institutional interpretation without identifying every proposed pathway directly. Lower expense burdens, greater news and search visibility, and faster turnover accompany the digital government–corridor interaction. Regional and administrative splits suggest that improvements can be relevant where institutional protection, openness, or service capacity is limited. The significant non-state quality response highlights the potential importance of accessible public services for enterprises that depend on standardized external support. At the same time, subgroup significance should not be confused with proof of statistically different effects across categories.

The findings favor coordinated development of logistics infrastructure and digital public administration. Public authorities can improve the usefulness of corridor access by reducing procedural duplication, strengthening data interoperability, and making compliance information easier to obtain. These efforts should be evaluated through actual service performance and enterprise outcomes. Improving the availability of digital systems is not sufficient if agencies continue to require repeated submissions or if firms cannot rely on consistent treatment. The relevant objective is an administrative environment that makes international participation more predictable and less costly.

The conclusions remain bounded by the measures and identification strategy. Foreign ownership captures international capital integration rather than direct trade flows, while prominent-investor presence is an incomplete representation of quality. Historical-infrastructure instruments require an exclusion assumption, and staggered policy comparisons require careful treatment of heterogeneous effects and spillovers. The original estimates are retained without introducing new empirical results. Within those limits, the evidence supports a measured proposition: digital government can strengthen the conversion of corridor connectivity into firm-level international engagement, but the extent to which this becomes export upgrading requires more direct observation.

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