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Expressway Accessibility and Spatial Heterogeneity in Rural Tourism Firm Entry: Evidence from Mountainous Yunnan, China

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Abstract

Transport infrastructure can enlarge rural market access, but its tourism benefits are unlikely to be evenly distributed across space. This study examines how improvements in expressway-gateway accessibility are associated with tourism-firm entry and how this association varies across villages in mountainous Yunnan, China. We construct a balanced panel of 11,665 rural villages from 2018 to 2025, yielding 93,320 village-year observations. The database integrates annual road networks and expressway gateways, firm-registration records, pre-treatment cultural resources, pre-treatment local organisational and industrial capacity, points of interest, remote-sensing indicators and natural conditions. Network travel-time savings are analysed using village and year fixed-effects models, interaction models and spatial exposure analysis. By 2025, average travel-time savings to the nearest expressway gateway reached 78.22 min. Each 10-min reduction was positively associated with tourism-firm entry (coefficient = 0.0028, SE = 0.0006, $p < 0.001$), with stronger responses in accommodation and catering. The association was stronger in villages with richer cultural resources and greater pre-existing local capacity, whereas county-seat accessibility showed a different pattern. Spatially, the clearest firm-entry response occurred in villages experiencing direct accessibility improvements. These findings suggest that accessibility gains create spatially selective rural tourism opportunities. Transport policy should therefore be coordinated with cultural-resource development, local capacity building and cross-village corridor planning.

Introduction

Transport investment is a central instrument of rural development because it lowers travel costs and connects remote settlements to wider visitor and service markets. In tourism regions, improved roads can make villages easier to reach, enlarge potential demand and influence enterprise location choices [19, 20, 46] [47]. Yet accessibility does not automatically generate the same economic response in every village. Some places become part of tourist itineraries and attract new firms, while others remain weakly connected to tourism markets despite improved travel conditions. This uneven response is important for both research and policy. A simple sequence of road construction, visitor growth and village income leaves several intermediate processes unclear. Accessibility may open a corridor, but cultural resources give visitors a reason to stop, and local organisational capacity helps turn visits into services and firms. The key question is therefore not only whether transport matters, but under what village conditions transport improvement is translated into tourism-firm entry.

The conceptual pathway used in this study is summarised in Fig. 1. It treats transport improvement as an enabling condition rather than as a sufficient cause of rural tourism development. A newly shortened travel time can change the set of villages visible to travellers and investors. However, this change becomes economically meaningful only when it is combined with attractions, service capacity and a position within a usable travel route. This framework helps separate three questions that are often mixed together: whether access improved, which villages were able to use that improvement, and where new firms actually entered. Previous studies provide three useful foundations. Transport and tourism research has shown that infrastructure can reshape destination access, demand and regional economic conditions [7, 8, 19] [20, 25, 46]. Rural tourism research emphasises destination competitiveness, heritage, authenticity, participation

and local organisation as conditions for sustainable development [1, 4, 10] [21, 24, 37]. A related strand links rural tourism to direct sales, digital transformation, resident empowerment and local development practices [2, 3, 6] [9, 28, 30]. Spatial tourism studies further show that tourism benefits often follow routes, gateways, spillovers and landscape functions rather than spreading evenly across all nearby places [15, 31, 34] [39, 44, 45]. These strands suggest that transport accessibility, cultural capital, local capacity and spatial allocation should be analysed together.

A village-level design is especially useful for this purpose. County-level indicators can show whether a region becomes better connected, but they cannot show whether new opportunities appear in core gateway villages, nearby peripheral villages or more remote settlements. The village scale also allows the analysis to distinguish recognised cultural resources from local organisational capacity. This distinction matters because a village may have strong heritage value but weak service organisation, or it may have local enterprise capacity without a distinctive visitor attraction. Yunnan Province provides a suitable setting for this analysis. Mountainous terrain creates large differences in actual travel time, so network travel time is more informative than straight-line distance. The province also contains many traditional villages, ethnic communities, historical-cultural resources and intangible cultural heritage resources. During 2018–2025, its expressway network and gateway system changed substantially, within a broader national context of rural infrastructure development [22]. These features allow village-level analysis of how new access interacts with local tourism assets.

This study uses a balanced village-year panel covering 11,665 rural villagers committees from 2018 to 2025, with 93,320 observations. We integrate annual road networks, expressway gateway opening information, enterprise registration records, pre-treatment cultural resources, pre-treatment local capacity indicators, points of interest, remote-sensing indicators and natural conditions. The main data modules are summarised in Table 1. The analysis asks three questions: how expressway-gateway and county-seat accessibility changes relate to tourism-firm entry; whether cultural capital and local capacity condition this relationship; and whether responses concentrate in directly improved villages or extend to nearby villages. The contribution is threefold. First, the paper shifts attention from average accessibility effects to the activation of visitor corridors. Second, it examines when cultural capital becomes economically visible through firm entry. Third, it provides village-level evidence on gateway-periphery allocation in mountainous rural space.

Table 1
Sample composition and main data modules.

Data module	Spatial and temporal coverage	Records	Main use
Basic spatial database	13,532 village-level units, 2018–2025	108,256 annual records	Spatial-unit identification, POI matching, remote-sensing extraction, and spatial exposure construction
Main rural analytical sample	11,665 rural villagers committees, 2018–2025	93,320 annual records	Main model estimation, heterogeneity analysis, and robustness checks
Remote-sensing module	13,532 village-level units, 2018–2025	108,256 annual records	Nighttime lights, land-cover probabilities, elevation, and slope
Tourism-firm registration module	11,665 rural villagers committees, 2018–2025	93,320 annual records	Measurement of tourism-firm and sector-specific firm entry
Accessibility module	11,665 rural villagers committees, 2018–2025	93,320 annual records	Expressway-gateway and county-seat accessibility and time-saving measures

Note: Each village-level unit has one record per year. The full spatial database supports spatial and remote-sensing variables, while the rural sample is used for the main statistical analysis.

Materials and Methods

Study Area, Spatial Units and Sample Construction

The analysis focuses on Yunnan Province in southwest China. Because the province is mountainous, network travel time better captures real accessibility than Euclidean distance. The basic spatial unit is the administrative village. Village names, administrative identifiers, grassroots organisation types and WGS84 coordinates were integrated to create a village-level spatial database.

The full database contains 13,532 village-level units. After excluding urban communities, the main rural sample contains 11,665 rural villagers committees observed annually from 2018 to 2025. The complete village-year database contains 108,256 records and is used for spatial matching, point-of-interest extraction, remote-sensing extraction and spatial exposure construction. The rural analytical panel contains 93,320 observations and is used for the fixed-effect models, heterogeneity analysis and robustness checks. Table 1 clarifies this distinction between the full spatial database and the rural analytical panel.

Figure 2 shows the study area and the spatial distribution of expressway-gateway accessibility improvement. The map is important because the empirical setting is not a flat or evenly connected region. Villages are separated by mountains, valleys and uneven road networks. As a result, two villages that appear close in straight-line distance may face very different travel times to an expressway gateway. The

mapped pattern therefore provides a spatial check on the logic of using network travel time rather than simple distance.

Measurement of Accessibility, Cultural Capital, Local Capacity and Firm Entry

Expressway-gateway accessibility is measured as the shortest network travel time from each village to the nearest operating expressway interchange or toll-gate entrance in each year. Let R_t denote the passable road network in year t, G_t the set of operating expressway gateways and o_i the location of village i. The time-saving variable is defined as $SavingE_{it} = TimeE_{i,}2018 - TimeE_{it}$. Positive values mean that a village became closer to the expressway system in travel-time terms. In the regressions, this variable is divided by 10, so the coefficient refers to a 10-min saving.

County-seat accessibility is measured separately as the shortest network travel time from each village to its county seat. County-access time saving is defined as $SavingC_{it} = TimeC_{i,}2018 - TimeC_{it}$. The two measures are not interchangeable. Expressway gateways connect villages to cross-regional visitor corridors, whereas county seats represent administrative and service-centre connections. Separating them helps clarify which type of spatial connection is associated with tourism-firm entry.

The baseline year of 2018 is used as the reference point for measuring travel-time savings. This choice creates a common pre-expansion benchmark for all villages and makes later changes easier to compare. A positive saving therefore represents an improvement relative to the village's own initial accessibility, not a comparison with another village. This is useful in mountainous areas because some villages start from very remote positions, while others are already relatively close to transport facilities.

Cultural capital is measured using records that existed or were recognised before 2018, including traditional villages, ethnic-feature villages, historical-cultural villages, protected cultural relics and intangible cultural heritage. Local capacity is measured using pre-2018 records of One Village One Product, characteristic-industry villages, agricultural-product certification, demonstration cooperatives and local enterprise foundations. Count variables are transformed using $\ln(1 + x)$ and standardised, and binary indicators are standardised directly. Sub-indicators are combined with equal weights.

The main outcome is the annual number of newly registered tourism firms in each village. Firms are identified by unified social credit codes, registration dates, industry codes and business-scope text. Tourism firms include accommodation, catering, scenic-site operation, cultural-experience, leisure and related service providers. The analysis also separates accommodation, catering, cultural-tourism services and public services. Because firm-entry counts contain many zeros and are right-skewed, outcomes are transformed using the inverse hyperbolic sine, $\text{asinh}(Y_{it}) = \ln(Y_{it} + \text{sqrt}(Y_{it}^2 + 1))$ [48, 49]. This transformation retains zero observations and reduces the influence of extreme values.

POI, Remote Sensing and Natural Conditions

Point-of-interest data are measured for 2025 and summarised within 5-km buffers around village points. Facility categories include tourist attractions, accommodation, catering, cultural facilities, leisure facilities, transport services, public services and shopping. Because these data are observed at the end of the study period, they are used to describe service-facility patterns and validate the spatial plausibility of the firm-registration data, rather than as pre-treatment controls in the baseline fixed-effect model.

Remote-sensing indicators are extracted using Google Earth Engine. VIIRS nighttime lights and Dynamic World land-cover probabilities are summarised within 3-km buffers around villages for 2018–2025 [50]. Elevation and slope are derived from NASADEM. These contextual layers describe built-up intensity, land-cover background and natural constraints. They also help assess whether the spatial patterns in firm entry are plausible in relation to settlement and landscape conditions.

The POI and remote-sensing layers play a supporting role in the study design. They do not replace the firm-registration outcome, because registered firms provide the direct measure of enterprise entry used in the models. Instead, these layers help describe whether villages with new firms are located in settings that are consistent with tourism activity, settlement intensity and landscape constraints. This reduces the risk that the statistical results are interpreted without spatial context.

Fixed-Effect Models

The baseline model estimates the association between within-village changes in expressway-gateway time saving and within-village changes in firm entry: $Y_{it} = \text{beta}_E \, \text{SavingE}_{it} + \text{alpha}_i + \text{lambda}_t + \text{epsilon}_{it}$. Y_{it} is the inverse-hyperbolic-sine-transformed firm-entry outcome, SavingE_{it} is expressway-gateway time saving measured in 10-min units, alpha_i denotes village fixed effects and lambda_t denotes year fixed effects. Standard errors are clustered at the village level.

Village fixed effects remove time-invariant differences among villages, such as location, terrain background and long-standing cultural endowments. Year fixed effects absorb province-wide shocks that affect all villages in the same year. This design strengthens the comparison by focusing on changes within the same village over time. However, the estimates should still be interpreted as associations rather than definitive causal effects because unobserved time-varying local policies or investment may also affect firm entry. This modelling choice also helps the reader interpret the coefficient. The estimate does not compare an accessible village with a remote village at one point in time. Instead, it asks whether the same village tends to experience more tourism-firm entry in years when its travel time to the expressway gateway has fallen relative to 2018. This within-village interpretation is more appropriate for a setting where villages differ greatly in terrain, heritage resources and historical development paths.

The county-access model replaces SavingE_{it} with SavingC_{it}: $Y_{it} = \text{beta}_C \, \text{SavingC}_{it} + \text{alpha}_i + \text{lambda}_t + \text{epsilon}_{it}$. The comparison between beta_E and beta_C is used to distinguish two forms of spatial connection. It is not interpreted as a causal comparison between mutually exclusive transport policies because the two accessibility variables are estimated in separate models.

Heterogeneity, Spatial Exposure and Robustness

To examine whether cultural capital and local capacity condition the accessibility-firm-entry relationship, the study estimates interaction models: Y_{it} = beta $SavingE_{it}$ + psi($SavingE_{it}$ x M_i) + $alpha_i$ + $lambda_t$ + $epsilon_{it}$. M_i is the standardised pre-treatment cultural-capital index or local-capacity index. Because M_i is time invariant, its main effect is absorbed by village fixed effects. The interaction coefficient indicates whether villages with different pre-treatment conditions show different firm-entry responses to the same travel-time saving.

Spatial exposure analysis classifies villages whose travel time to the nearest expressway gateway improved by at least 10 min relative to 2018 as directly improved villages. Villages not meeting this threshold are assigned to 0–10 km, 10–30 km, 30–60 km and more than 60 km categories according to their distance to the nearest directly improved village. This design follows the logic that tourism linkages, spatial association and landscape exposure may decline with distance [34, 39, 45]. Models include village and year fixed effects, using villages more than 60 km from directly improved villages and without direct improvement as the reference group. Robustness checks use alternative accessibility-improvement thresholds of 5, 10, 20 and 30 min; 1% and 5% winsorisation of continuous time-saving variables; exclusion of 2020; exclusion of villages in the top 10% of baseline tourism-firm entry; and a placebo test using future accessibility improvement interacted with 2019. These checks examine whether the main pattern depends on a single threshold, outliers, the pandemic year or initial tourism concentration.

Together, the baseline, interaction, exposure and robustness models correspond to the empirical workflow in Fig. 1. The baseline model identifies the average within-village association. The interaction models test whether this association differs by pre-treatment cultural capital and local capacity. The exposure analysis then asks whether nearby villages share the response of directly improved villages. The robustness checks assess whether the estimated pattern is sensitive to measurement choices.

Results

Expressway-Gateway Accessibility Expanded Rapidly, Whereas County Access Changed Modestly

Table 2 and Fig. 3 show a rapid expansion of expressway-gateway accessibility in rural Yunnan during 2018–2025. Relative to 2018, average time savings reached 0.87 min in 2019, 16.03 min in 2020, 26.77 min in 2021, 39.78 min in 2022, 52.73 min in 2023, 65.48 min in 2024 and 78.22 min in 2025. The share of villages with at least 10 min of expressway-gateway improvement rose from 7.07% in 2019 to 51.62% in 2022 and 96.91% in 2025. These descriptive results establish that the study period contained a substantial accessibility shock for most rural villages.

Table 2
Village accessibility changes, 2018–2025.

Year	County mean time saving (min)	County villages improved > = 10 min (%)	Expressway-gateway mean time saving (min)	Expressway-gateway villages improved > = 10 min (%)	Villages
2018	0.00	0.00	0.00	0.00	11,665
2019	1.79	1.01	0.87	7.07	11,665
2020	2.47	2.02	16.03	22.15	11,665
2021	2.05	2.29	26.77	38.21	11,665
2022	2.35	2.53	39.78	51.62	11,665
2023	2.48	3.17	52.73	66.95	11,665
2024	2.61	3.65	65.48	81.93	11,665
2025	2.73	4.14	78.22	96.91	11,665

Note: Time savings are measured relative to 2018. Positive values indicate shorter travel time. Each year includes 11,665 rural villages.

County-seat accessibility changed much less. Average county-seat time saving increased from 1.79 min in 2019 to only 2.73 min in 2025, and the share of villages with at least 10 min of county-access improvement reached only 4.14% by 2025. The dominant transport change during the study period was therefore not a broad reduction in travel time to county centres. It was the selective connection of villages to the expressway-gateway system.

Expressway-Gateway Accessibility Is Positively Associated with Tourism-Firm Entry

Table 3 reports the fixed-effect estimates. A 10-min reduction in travel time to the nearest expressway gateway is positively associated with tourism-firm entry (coefficient = 0.0028, SE = 0.0006, $p < 0.001$). The model contains 93,320 village-year observations and controls for village and year fixed effects. Because the outcome is inverse-hyperbolic-sine transformed, the coefficient should be read as the direction and relative strength of association, not as a direct change in raw firm counts. The estimate is small in absolute terms, but it is meaningful at the village-year scale because many observations have zero new firms.

Table 3
Separate estimates for expressway-gateway and county-seat accessibility.

Outcome variable	Expressway-gateway coefficient	SE	p value	County-seat coefficient	SE	p value	Observations
Tourism-firm entry	0.0028	0.0006	< 0.001	-0.0363	0.0060	< 0.001	93,320
Accommodation-firm entry	0.0017	0.0003	< 0.001	-0.0119	0.0035	< 0.001	93,320
Catering-firm entry	0.0037	0.0006	< 0.001	-0.0287	0.0054	< 0.001	93,320
Cultural-tourism service entry	-0.0008	0.0003	0.011	-0.0080	0.0032	0.011	93,320
Public-service firm entry	0.0038	0.0005	< 0.001	0.0037	0.0044	0.403	93,320

Note: Treatment variables are measured per 10-min time saving. Outcomes are inverse-hyperbolic-sine-transformed counts of new firm entry. All models include village and year fixed effects, with standard errors clustered at the village level.

Figure 4 and Table 3 further show that the positive association is concentrated in basic visitor-reception services. The coefficients are 0.0017 for accommodation firms and 0.0037 for catering firms, both significant at the 1% level. Public-service firms also show a positive coefficient of 0.0038 ($p < 0.001$), although such firms serve both visitors and local residents. Cultural-tourism service firms show a negative coefficient (-0.0008, $p = 0.011$), indicating that accessibility improvement is more clearly related to accommodation and catering entry than to specialised cultural-tourism services.

County-seat accessibility shows a different pattern. Coefficients for tourism, accommodation, catering and cultural-tourism services are negative and statistically significant, whereas the public-service coefficient is positive but insignificant. One plausible interpretation is that county seats concentrate accommodation, catering, transport transfer and public services. Visitors may therefore stay or consume in county centres while making shorter visits to surrounding villages. This interpretation is consistent with the sectoral comparison in Table 3 and Fig. 4. Because the two accessibility variables are estimated separately, the results identify different association patterns rather than independent causal effects.

Cultural Capital and Local Capacity Condition the Firm-Entry Response

Table 4 and Fig. 5 show that cultural resources condition the firm-entry response. The interaction between cultural capital and expressway-gateway time saving is positive and significant (psi = 0.0096, SE = 0.0034, $p = 0.005$). At the sample mean of cultural capital, a 10-min expressway-gateway time saving is associated with a coefficient of 0.0024 (SE = 0.0006, $p < 0.001$). Because the cultural-capital index is standardised, a one-standard-deviation increase in cultural capital raises the association between accessibility improvement and firm entry by 0.0096.

Table 4
Interaction estimates for cultural capital and local capacity.

Model	Variable	Coefficient	SE	p value	Observations
Cultural-capital model	Expressway-gateway time saving	0.0024	0.0006	< 0.001	93,320
Cultural-capital model	Cultural capital x expressway-gateway time saving	0.0096	0.0034	0.005	93,320
Local-capacity model	Expressway-gateway time saving	-0.0001	0.0006	0.874	93,320
Local-capacity model	Local capacity x expressway-gateway time saving	0.0073	0.0012	< 0.001	93,320

Note: Expressway-gateway time saving is measured per 10 min. Cultural capital and local capacity are standardized pre-treatment indices; their main effects are absorbed by village fixed effects.

The local-capacity model shows a similar conditional pattern. The interaction between local capacity and expressway-gateway time saving is positive and significant (psi = 0.0073, SE = 0.0012, p < 0.001). At the sample mean of local capacity, the baseline time-saving coefficient is close to zero and insignificant (-0.0001, SE = 0.0006, p = 0.874). These results indicate that improved access is not enough by itself. Firm entry is stronger where villages already have cultural assets, organisational foundations or industry-related capacity. The marginal patterns shown in Fig. 5 make this conditional relationship easier to see than the coefficients alone.

Firm Entry Concentrates in Directly Improved Villages

Table 5 and Fig. 6 summarise the spatial exposure results. By 2025, 11,304 villages, or 96.91% of the rural sample, had at least 10 min of direct expressway-gateway time saving. Villages in the 0–10 km, 10–30 km, 30–60 km and more than 60 km peripheral categories accounted for 1.71%, 1.20%, 0.13% and 0.05%, respectively.

Table 5
Village spatial types in 2025 and spatial-exposure estimates.

Spatial type or exposure variable	Villages	Share (%)	Coefficient	SE	p value
Directly improved villages	11,304	96.91	0.0284	0.0110	0.010
0–10 km periphery	200	1.71	0.0047	0.0085	0.582
10–30 km periphery	140	1.20	0.0031	0.0092	0.735
30–60 km periphery	15	0.13	0.0027	0.0107	0.800
More than 60 km	6	0.05	Reference	-	-
Total	11,665	100	-	-	-

Note: Villages more than 60 km away and without direct accessibility improvement form the reference group. Estimates are from village-year fixed-effect models.

The direct-improvement coefficient is positive and significant (0.0284, SE = 0.0110, p = 0.010). Coefficients for the 0–10 km, 10–30 km and 30–60 km peripheral categories are positive but statistically insignificant. The clearest firm-entry response therefore appears in villages whose own travel time to an expressway gateway shortened substantially. Nearby villages do not appear to benefit automatically unless they are functionally connected to the improved corridor. This pattern is visible in the exposure estimates in Table 5 and in the spatial grouping shown in Fig. 6.

Robustness Checks

Table 6 and Fig. 7 report the robustness checks. The baseline association remains positive after 1% and 5% winsorisation of the continuous expressway-gateway time-saving variable. The corresponding coefficients are 0.0028 (SE = 0.0006, p < 0.001) and 0.0023 (SE = 0.0009, p = 0.008). Excluding 2020 gives a coefficient of 0.0030 (SE = 0.0006, p < 0.001), and excluding villages in the top 10% of baseline tourism-firm entry gives a coefficient of 0.0026 (SE = 0.0006, p < 0.001).

Table 6
Robustness and placebo tests.

Test type	Variable or sample adjustment	Coefficient	SE	p value	Observations
Threshold treatment	Time saving to expressway gateway > = 5 min	0.0188	0.0070	0.008	93,320
Threshold treatment	Time saving to expressway gateway > = 10 min	0.0168	0.0072	0.020	93,320
Threshold treatment	Time saving to expressway gateway > = 20 min	0.0133	0.0062	0.033	93,320
Threshold treatment	Time saving to expressway gateway > = 30 min	0.0093	0.0059	0.112	93,320
Continuous treatment	1% winsorized time saving	0.0028	0.0006	< 0.001	93,320
Continuous treatment	5% winsorized time saving	0.0023	0.0009	0.008	93,320
Sample adjustment	Drop 2020	0.0030	0.0006	< 0.001	81,655
Sample adjustment	Drop villages in top 10% baseline tourism entry	0.0026	0.0006	< 0.001	83,536
Placebo test	Future time saving x 2019	-0.0014	0.0008	0.080	23,330

Note: Continuous treatment variables are measured per 10-min saving relative to 2018. Threshold variables indicate whether a village reaches the specified time-saving cutoff.

Alternative threshold definitions also produce positive estimates. Thresholds of at least 5, 10, 20 and 30 min yield coefficients of 0.0188, 0.0168, 0.0133 and 0.0093, respectively. The first three are significant at the 5% level, while the 30-min threshold remains positive but does not reach conventional significance. A placebo test using future time saving interacted with 2019 gives a coefficient of -0.0014 (SE = 0.0008, p = 0.080), providing no clear evidence that future accessibility changes significantly predict pre-treatment firm entry at the 5% level. The consistency across Table 6 and Fig. 7 supports the view that the main result is not driven by a single coding choice.

Discussion

Expressway-Gateway Connection and County-Seat Connection Indicate Different Tourism Geographies

The findings show that expressway-gateway time saving is positively associated with new tourism-firm registration, especially accommodation and catering. This result is consistent with research showing that

transport infrastructure can reduce travel costs, shape destination access and influence community support for tourism [16, 19, 20]. It is also consistent with recent evidence on infrastructure investment and tourism development in China [25, 46]. The present study refines that view by showing that the type of accessibility matters. Expressway gateways connect villages to visitor corridors, whereas county seats often function as administrative, service and transfer centres.

The results should be interpreted as changes in registered firm entry rather than direct evidence of tourist spending, household income or employment growth. Tourism outcomes differ across indicators, and enterprise registration does not guarantee survival or local ownership [23, 32, 36]. Still, firm entry is a meaningful early indicator of how private actors perceive local tourism opportunities.

Cultural Capital Becomes Economically Visible under Improved Access

Villages with richer pre-treatment cultural resources show stronger firm-entry responses to the same expressway-gateway time saving. This result aligns with rural tourism studies that identify heritage, authenticity, intangible culture and local identity as foundations of destination attractiveness [4, 5, 10] [12, 27, 43]. The contribution here is to show that cultural resources are not simply static background assets. Their economic visibility depends partly on whether visitors and firms can reach and recognise them through transport corridors.

Transport improvement does not create cultural capital. Instead, it changes the conditions under which cultural capital can be visited, narrated, packaged and converted into local tourism services. This interpretation is consistent with recent studies on heritage-led local development, cultural consumption policy and intangible-cultural-heritage protection [4, 26, 27]. It also explains why improved access may generate stronger firm entry in culturally endowed villages than in otherwise similar villages with fewer recognised cultural assets.

This mechanism also clarifies why the study focuses on pre-treatment cultural resources. If cultural indicators were measured after accessibility improvement, they could partly reflect tourism development itself. Using pre-2018 records reduces this problem and makes the moderation analysis easier to interpret. The results therefore point to the activation of existing resources rather than the creation of new cultural assets by transport investment.

Local Capacity Converts Accessibility into Enterprise Entry

The local-capacity interaction shows that villages with stronger pre-treatment product, organisation, certification, cooperative and enterprise foundations experience stronger firm-entry responses. This result is consistent with work that links rural tourism development to local development practices, resident participation, empowerment and direct sales [2, 6, 9] [21, 30, 41]. It also relates to studies on agritourism innovation, resilience, digital marketing and sustainable livelihood pathways [11, 17, 28] [29, 32, 40].

The implication is that accessibility improvement and local capacity are complementary. Travel-time savings expose villages to visitor markets, but local capacity helps organise products, services,

coordination and business entry. Without such capacity, visitors may pass through or make short visits without generating local enterprise formation. With such capacity, villages are better positioned to translate accessibility into accommodation, catering and related service supply.

This complementarity is important for policy design. A road project may change physical access quickly, but organisational capacity usually develops more slowly. Villages need people and institutions that can identify products, coordinate households, negotiate with outside firms and maintain service quality. If this local capacity is weak, transport investment may mainly benefit nearby towns or external operators. If it is stronger, improved access is more likely to support locally embedded firms.

Gateway-Periphery Allocation Is Selective rather than Automatic

The spatial exposure results show that firm entry concentrates in directly improved villages and does not diffuse automatically to nearby peripheral villages. This finding extends spatial-spillover and route-based tourism research by shifting attention to village-level allocation [15, 31, 34] [44, 45]. At this scale, proximity to an improved gateway village is not equivalent to incorporation into a functional tourism corridor.

Peripheral villages may need branch-road connectivity, cross-village itineraries, product complementarity and coordinated marketing to share benefits from gateway improvements. Route-based studies show that tourism corridors can support rural areas, but only when access points, attractions, products and governance are linked in practice [10, 31, 39]. Otherwise, gateways may concentrate firms around the best-connected villages while leaving surrounding settlements weakly integrated into tourism supply chains.

The exposure results also caution against treating distance buffers as evidence of spillovers by themselves. A peripheral village may be geographically close to an improved village but disconnected from tourist movement, service supply or route planning. Conversely, a village farther away may participate in a corridor if it has a distinctive attraction and reliable connecting roads. For this reason, future studies should combine distance-based exposure with itinerary data, visitor-flow records or firm-supply-chain information.

From Firm Entry to Broader Rural Development

Newly registered firms indicate entrepreneurial response, but they do not automatically prove sustained operation, local ownership, employment growth, household income gains or diversified rural development. Rural tourism can support local development when firms are linked to local procurement, agricultural products, cultural production and resident employment [18, 24, 37] [38, 40]. The sectoral results show that early responses are concentrated in accommodation and catering rather than in more specialised cultural-tourism services.

Policy should therefore combine transport planning with cultural-resource interpretation, product development, cooperative organisation, business training and cross-village corridor governance. For culturally rich villages with weak local capacity, accessibility improvement should be paired with support for product design and local enterprise organisation [13, 14, 18]. Community-based tourism models may be especially relevant where villages need to retain local benefits while expanding visitor services [33]. For

peripheral villages near gateways, planners should not assume automatic spillovers. They should build functional route connections, consider zoning and infrastructure constraints, and monitor whether benefits remain local and diversified [35, 42, 47].

Conclusions

This study examined how expressway-gateway accessibility improvement relates to rural tourism-firm entry using 93,320 village-year observations for 11,665 rural villages in Yunnan from 2018 to 2025. By 2025, villages saved an average of 78.22 min in travel time to the nearest expressway gateway relative to 2018, and 96.91% achieved at least 10 min of improvement. A 10-min expressway-gateway time saving is positively associated with tourism-firm entry, especially accommodation and catering, while county-seat accessibility follows a different pattern.

The central conclusion is that transport improvement activates rural tourism selectively. Villages with richer cultural capital and stronger pre-existing local capacity show stronger firm-entry responses to the same accessibility gain. Spatially, firm entry is concentrated in directly improved villages rather than diffusing evenly to nearby peripheries. Transport planning for rural tourism should therefore be coordinated with cultural-capital activation, local capacity building and gateway-periphery corridor governance. Future research can extend this analysis by linking firm registration to firm survival, ownership, employment, visitor flows, local income and industrial diversification.

Declarations

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Data Availability Statement

The data used in this study were obtained from publicly available sources, including road-network and expressway-gateway data, firm-registration records, cultural-resource and local-capacity data, points of interest, and remote-sensing and environmental datasets. Remote-sensing indicators were derived from publicly accessible datasets through Google Earth Engine. Detailed descriptions of the data sources, variables, processing procedures, and corresponding references are provided in the Materials and Methods section of the manuscript. No new proprietary datasets were generated for this study.

Conflict of Interest

The authors declare no conflict of interest.

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Figures

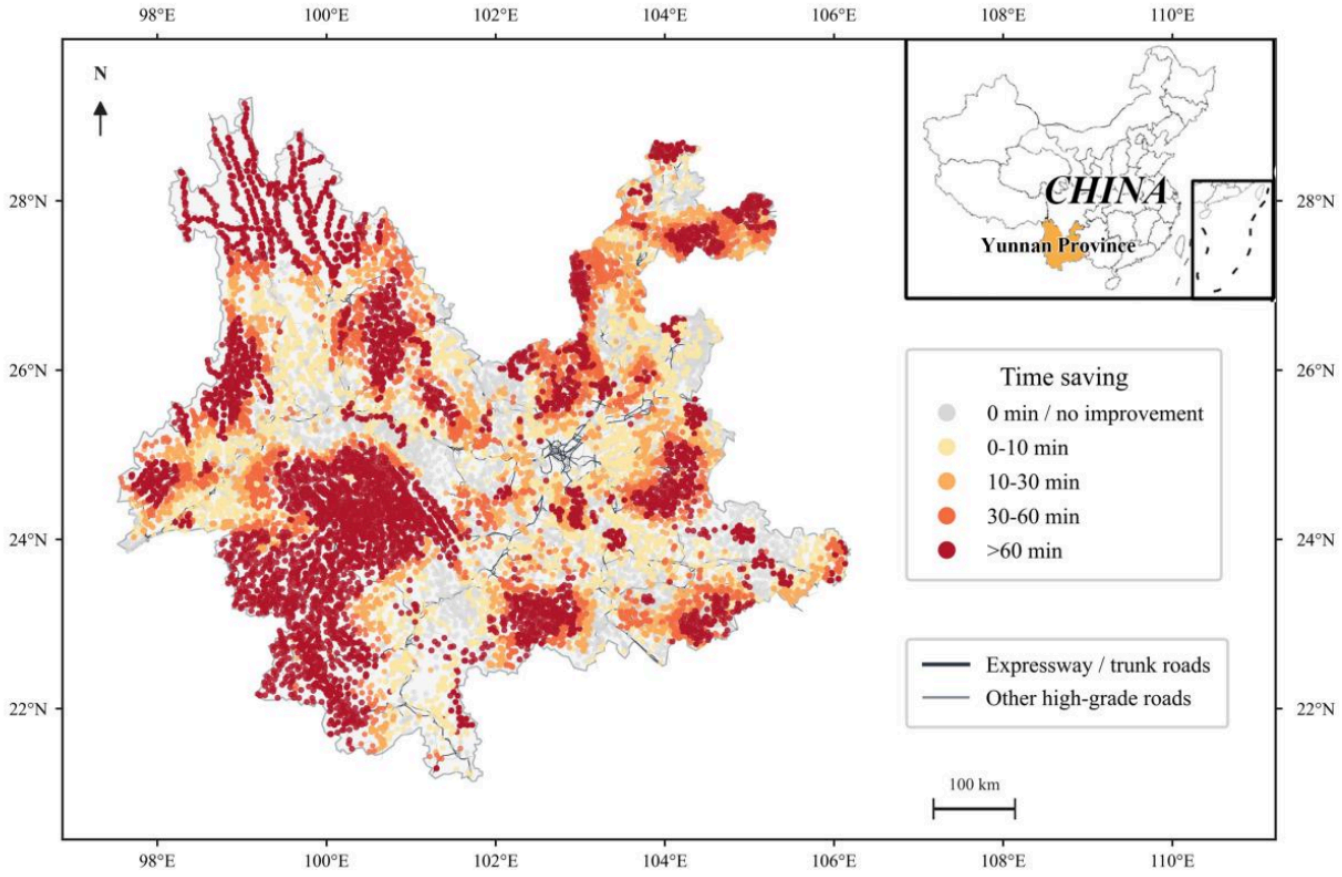


Figure 1

Research framework and empirical workflow. Multi-source data on roads and expressway entrances, firm registrations, cultural resources, local capacity, POIs, and remote sensing are integrated into a balanced panel of 11,665 rural villages in Yunnan from 2018 to 2025, comprising 93,320 village-year observations. The framework measures changes in access to expressway entrances and county seats, constructs baseline endowments, firm-entry outcomes, and spatial exposure, and applies fixed-effects estimation, heterogeneity analysis, spatial analysis, and robustness tests. The findings assess the relationships between accessibility improvements and tourism-firm entry, sectoral differences, the moderating roles of cultural resources and local capacity, and direct versus peripheral responses.

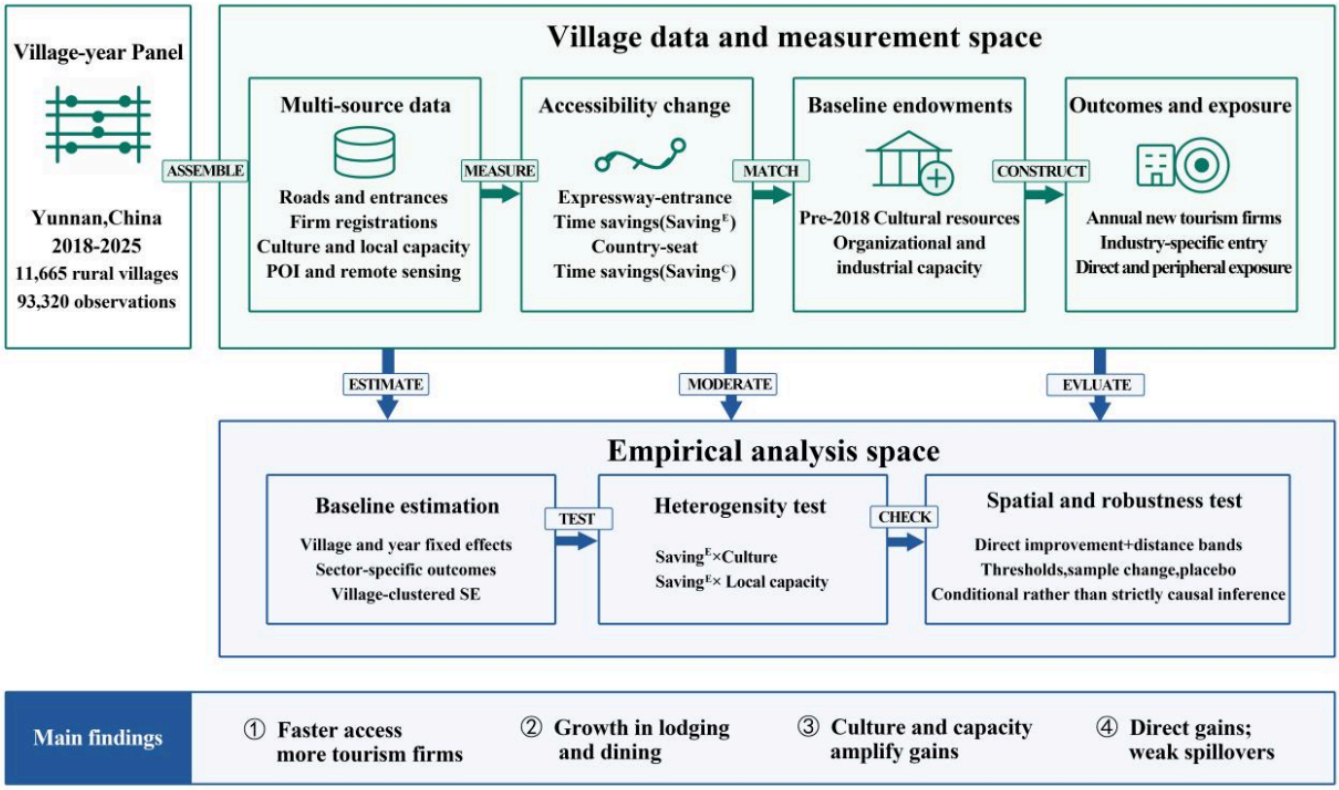


Figure 2

Study area and spatial distribution of expressway-gateway accessibility improvement. The map shows rural village locations, expressway and high-grade road networks, and time saving to the nearest expressway gateway in 2025 relative to 2018. Village points are classified into no improvement, 0-10 min, 10-30 min, 30-60 min, and more than 60 min of time saving. The spatial pattern highlights uneven accessibility gains across mountainous areas of Yunnan.

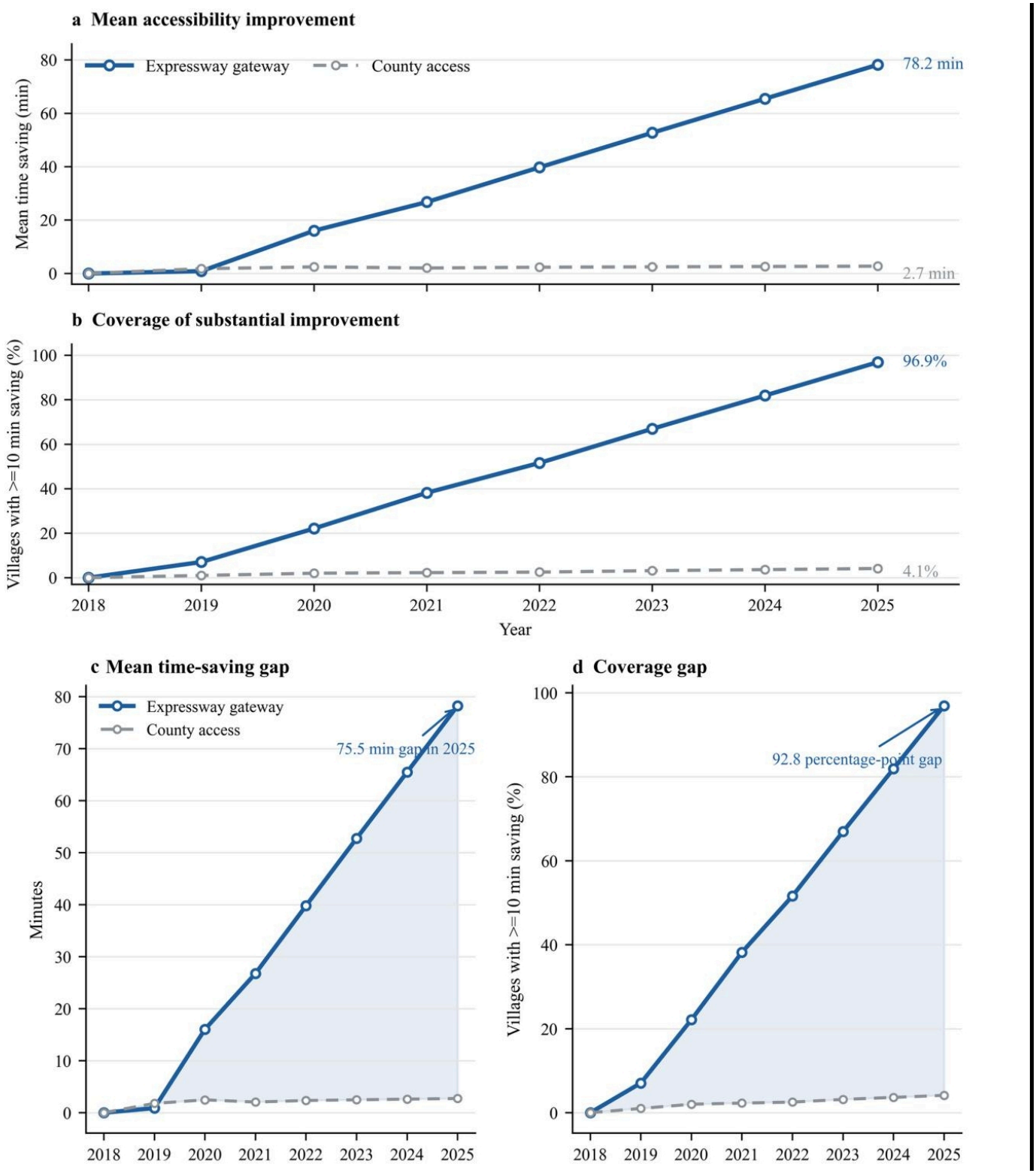


Figure 3

Temporal expansion and divergence of accessibility improvement, 2018-2025. (a) Mean time saving and the share of villages with at least 10 min improvement are shown for expressway-gateway accessibility and county accessibility. (b) The gap between expressway-gateway and county accessibility expands steadily over the study period, indicating that the main spatial shock comes from the opening and connection of expressway gateways rather than from general county-seat access.

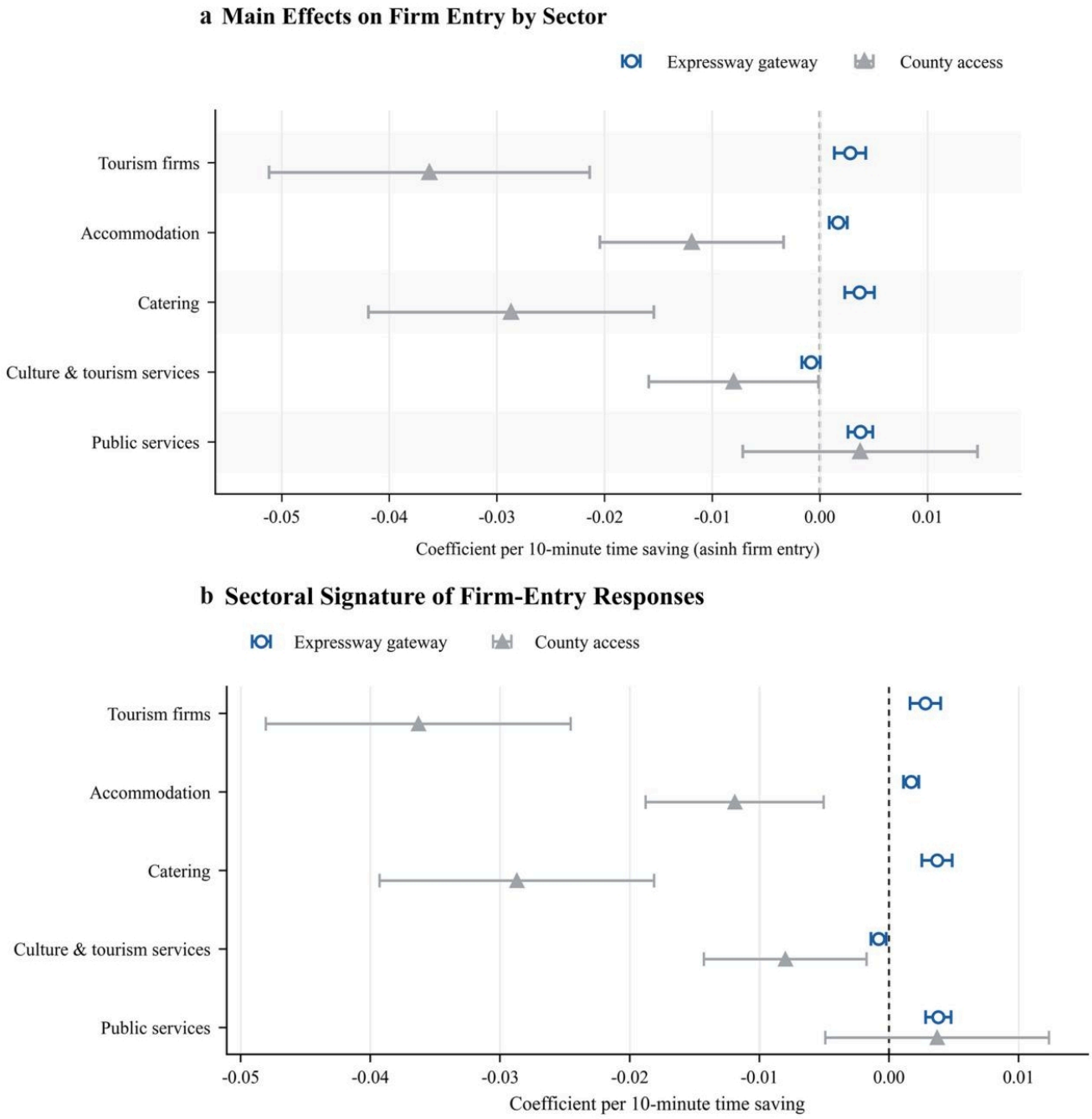


Figure 4

Main effects and sectoral signature of tourism-enterprise responses. (a) Estimated effects of expressway-gateway time saving and county-access time saving on tourism-firm entry and sector-specific outcomes. (b) Sectoral response signature comparing expressway-gateway coefficients with county-access coefficients. Points denote estimated coefficients per 10-minute time saving and bars denote 95% confidence intervals. Outcome variables are inverse-hyperbolic-sine transformed.

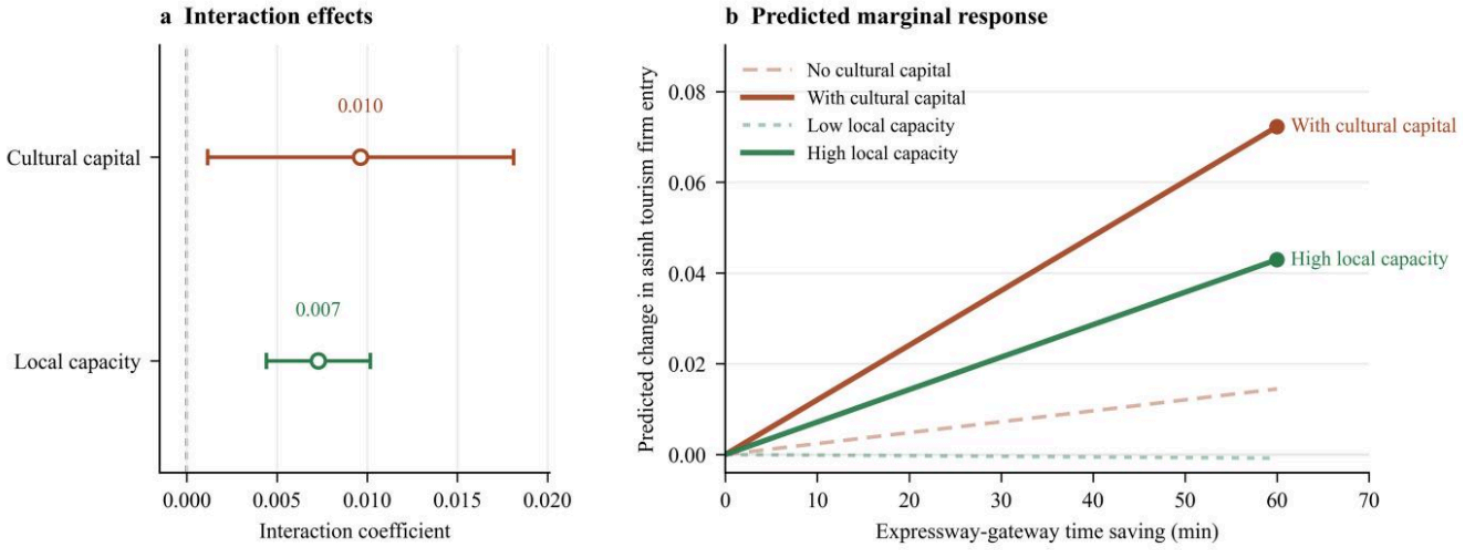


Figure 5

Cultural capital, local capacity, and conditional activation. (a) Interaction effects between expressway-gateway time saving and village-level cultural capital or local capacity. (b) Predicted marginal responses under different cultural-capital and local-capacity conditions. The figure shows that the same accessibility improvement produces stronger tourism-firm entry where villages already hold cultural resources or stronger local organizational and industrial capacity.

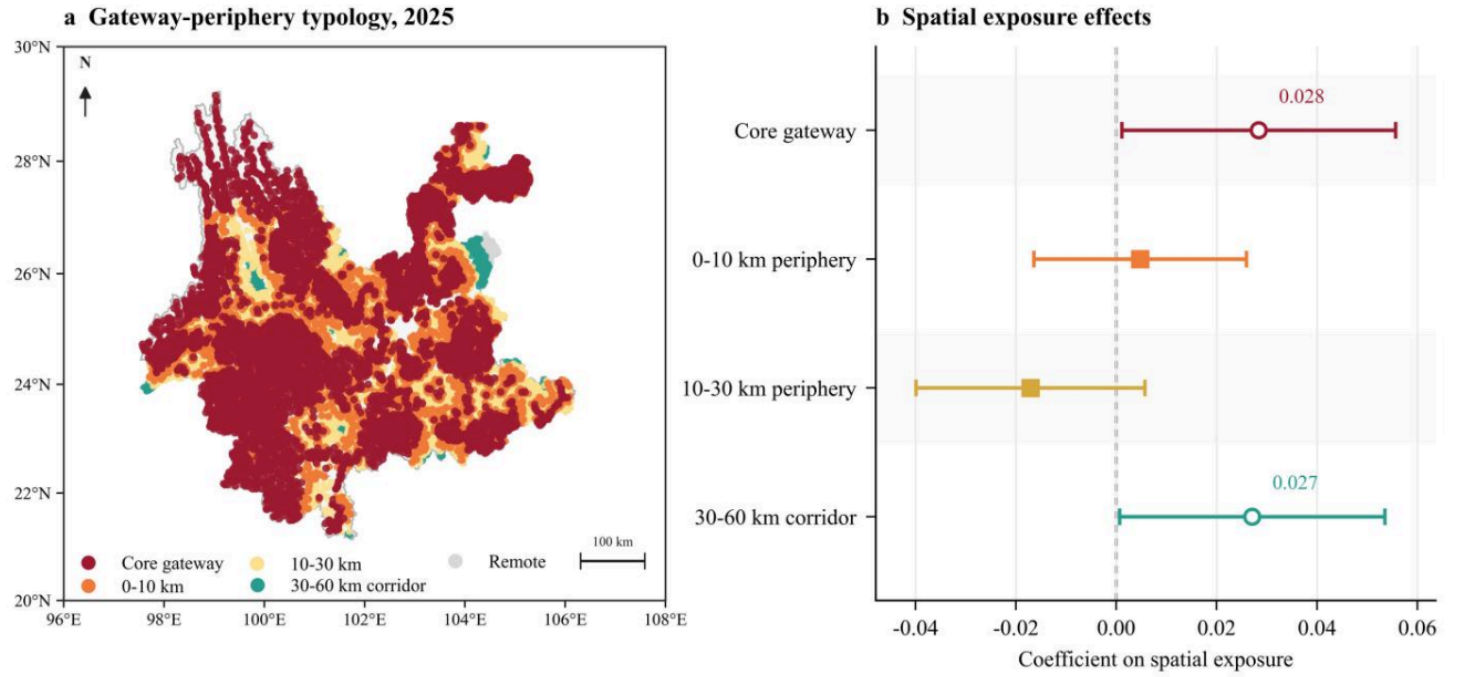


Figure 6

Gateway-periphery spatial allocation and exposure effects. (a) Gateway-periphery typology of rural villages in 2022, including core gateway villages, 0-10 km periphery, 10-30 km periphery, 30-60 km corridor, and

remote villages. (b) Estimated spatial exposure effects on tourism-firm entry. Points denote coefficients and bars denote 95% confidence intervals from village-year fixed-effect models.

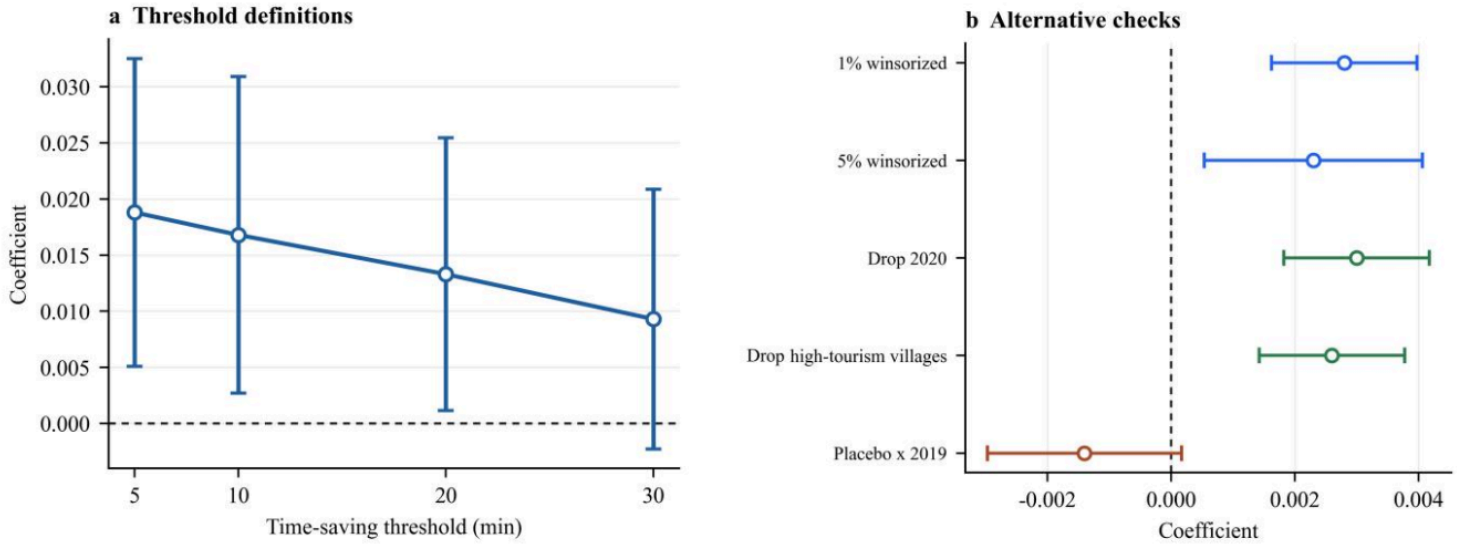


Figure 7

Robustness across treatment definitions and sample restrictions. (a) Estimated effects under alternative threshold definitions of accessibility improvement. (b) Continuous-treatment robustness checks, sample restrictions, and placebo specification. Points denote coefficients and bars denote 95% confidence intervals. The pattern indicates that the positive association between expressway-gateway accessibility improvement and tourism-firm entry is not driven by a single treatment threshold, outlier handling, or baseline tourism concentration.