# Online Resource 1

Supplementary tables for “Dining Opportunities in Transition: Restaurant Spending-Tier Recomposition in Beijing, 2019-2025”

This Online Resource provides supplementary tables on the restaurant-category scope, measurement sensitivity, state-transition robustness, model standardization, full model uncertainty, and diagnostic checks for the analyses reported in the manuscript.

## S1. Sample definition and measurement sensitivity

Table S1 provides the included restaurant-category scope and the two measurement sensitivity checks used in the manuscript. The included categories refer to restaurant establishment types that commonly serve main meals in the study context. The spending-tier thresholds were calculated from valid 2019 platform-recorded per-person spending values and then applied as fixed nominal thresholds to both 2019 and 2025.

**Table S1. Included restaurant categories and measurement sensitivity.**

**Panel A. Final included restaurant categories.**

| Included category 1 | Included category 2 | Included category 3 |
|---|---|---|
| Snacks and quick-service meals | Other food services | Hot pot |
| Noodle and rice-noodle restaurants | Barbecue and skewers | Sichuan cuisine |
| Beijing cuisine | Home-style Chinese cuisine | Western cuisine |
| Northeastern Chinese cuisine | General food category | Noodle restaurants |
| Hunan cuisine | Japanese cuisine | Buffet restaurants |
| Grilled meat | Cantonese cuisine | Other regional Chinese cuisines |
| Korean cuisine | Xinjiang cuisine | Rural-style Chinese cuisine |
| Freshwater and seafood | Northwestern Chinese | Specialty cuisine |

| Included category 1 | Included category 2 | Included category 3 |
|---|---|---|
| restaurants | cuisine | |
| Crayfish restaurants | Private-kitchen restaurants | Shanghai/Jiangsu-Zhejiang cuisine |
| Other platform categories | Fish restaurants | Regional cuisines |
| Creative cuisine | Anhui cuisine | Jiangsu-Zhejiang cuisine |
| Southeast Asian cuisine | Shandong cuisine | Korean-style cuisine |
| Yunnan-Guizhou cuisine | Vegetarian cuisine | Hubei cuisine |
| Taiwanese cuisine | Jiangxi cuisine | Russian cuisine |
| Fish and seafood | Fujian cuisine | Luosifen rice noodles |
| Japanese-style cuisine | Middle Eastern cuisine | Morning tea and dim sum |
| Afternoon tea restaurants | | |

*Note.* Category labels are English translations of the platform categories retained for the 2019 and 2025 restaurant sample; the same inclusion scope was applied in both years.

**Panel B. Fixed-threshold sensitivity.**

| Threshold scheme | Low cutoff (CNY) | High cutoff (CNY) | Low share, 2019 | Low share, 2025 | Low change (pp) | Middle share, 2019 | Middle share, 2025 | Middle change (pp) | High share, 2019 | High share, 2025 | High change (pp) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| P15/P85 | 22 | 112 | 0.155 | 0.190 | +3.6 | 0.698 | 0.712 | +1.4 | 0.147 | 0.097 | -5.0 |
| P20/P80 | 25 | 101 | 0.213 | 0.267 | +5.4 | 0.591 | 0.605 | +1.4 | 0.196 | 0.128 | -6.8 |

| Threshold scheme | Low cutoff (CNY) | High cutoff (CNY) | Low share, 2019 | Low share, 2025 | Low change (pp) | Middle share, 2019 | Middle share, 2025 | Middle change (pp) | High share, 2019 | High share, 2025 | High change (pp) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| P25/P75 | 27 | 92 | 0.250 | 0.316 | +6.6 | 0.502 | 0.518 | +1.5 | 0.247 | 0.166 | -8.1 |
| P30/P70 | 30 | 84 | 0.304 | 0.384 | +8.1 | 0.399 | 0.404 | +0.5 | 0.297 | 0.211 | -8.6 |

*Note.* Cutoffs were calculated from valid 2019 platform-recorded per-person spending records and applied to both years. Shares are record-level shares among valid spending records.

**Panel C. Spending-data coverage sensitivity.**

| Sample restriction | Units (n) | Median coverage-rate change (pp) | Median low-tier change (pp) | Low-tier increase (%) | Median middle-tier change (pp) | Median high-tier change (pp) | High-tier decrease (%) |
|---|---|---|---|---|---|---|---|
| All stable units | 1335 | 24.2 | 5.0 | 62.5 | 1.0 | -4.5 | 62.6 |
| No increase in spending-data coverage rate | 128 | -6.6 | 9.1 | 72.7 | 0.0 | -7.2 | 70.3 |

| Sample restriction | Units (n) | Median coverage-rate change (pp) | Median low-tier change (pp) | Low-tier increase (%) | Median middle-tier change (pp) | Median high-tier change (pp) | High-tier decrease (%) |
|---|---|---|---|---|---|---|---|
| Absolute coverage-rate change <= 5 pp | 117 | 1.1 | 7.5 | 70.1 | -2.1 | -4.3 | 68.4 |
| Absolute coverage-rate change <= 10 pp | 240 | 2.8 | 6.9 | 65.4 | 1.0 | -5.0 | 66.2 |
| Absolute coverage-rate change <= 15 pp | 392 | 6.4 | 6.7 | 66.6 | 0.0 | -4.7 | 64.3 |

*Note.* Coverage rate is the share of included restaurant records with valid platform-recorded per-person spending in a unit and year. Across all stable units, correlations between coverage-rate change and tier-share change were small (low-tier: Pearson r=-0.070, Spearman rho=-0.078; middle-tier: Pearson r=0.042, Spearman rho=0.054; high-tier: Pearson r=0.029, Spearman rho=0.044).

## S2. State classification and transition robustness

Table S2 extends the transition analysis by showing the full matrix with low-sample states, the largest transition paths, and the sensitivity of classifications to annual valid-record and dominance-share thresholds. Low-sample states indicate units that did not meet the annual minimum valid-record threshold for assigning a spending-tier state.

**Table S2. Complete transition pathways and classification robustness.**

**Panel A. Complete transition matrix including the low-sample state.**

| 2019 state | Low-sample | Low-tier dominant | Middle-tier dominant | High-tier dominant | Mixed-balanced | Row total |
|---|---|---|---|---|---|---|
| Low-sample | 4694 | 76 | 406 | 34 | 56 | 5266 |
| Low-tier dominant | 14 | 22 | 46 | 0 | 11 | 93 |
| Middle-tier dominant | 57 | 40 | 874 | 8 | 62 | 1041 |
| High-tier dominant | 10 | 1 | 45 | 46 | 28 | 130 |
| Mixed-balanced | 12 | 19 | 97 | 1 | 35 | 164 |
| Column total | 4787 | 158 | 1468 | 89 | 192 | 6694 |

*Note.* Cell values are counts of 500 m units. Columns refer to 2025 states and rows refer to 2019 states.

**Panel B1. Largest main transition paths under the primary m=5 rule.**

| Transition path | Hexagons (n) | Share of full grid (%) |
|---|---|---|
| Middle-tier dominant -> Middle-tier dominant | 874 | 13.06 |
| Low-sample -> Middle-tier dominant | 406 | 6.07 |
| Mixed-balanced -> Middle-tier dominant | 97 | 1.45 |
| Low-sample -> Low-tier dominant | 76 | 1.14 |
| Middle-tier dominant -> Mixed-balanced | 62 | 0.93 |
| Middle-tier dominant -> Low-sample | 57 | 0.85 |
| Low-sample -> Mixed-balanced | 56 | 0.84 |
| Low-tier dominant -> Middle-tier dominant | 46 | 0.69 |
| High-tier dominant -> High-tier dominant | 46 | 0.69 |
| High-tier dominant -> Middle-tier dominant | 45 | 0.67 |

*Note.* The full grid contains 6,694 500 m units; percentages use this denominator.

**Panel B2. Robustness to the annual valid-record threshold.**

| Annual valid-record threshold (m) | Path total excluding persistent low-sample | Top five paths | Persistence paths (n) | Formation paths (n) | Middle-tier persistence (n) | Middle-tier formation (n) |
|---|---|---|---|---|---|---|
| 3 | 2112 | Middle-tier dominant -> Middle-tier dominant (1043); Low-sample -> Middle-tier dominant (373); Mixed-balanced -> Middle-tier dominant (129); Low-sample -> Low-tier dominant (89); Middle | 1102 | 527 | 1043 | 373 |

| Annual valid-record threshold (m) | Path total excluding persistent low-sample | Top five paths | Persistence paths (n) | Formation paths (n) | Middle-tier persistence (n) | Middle-tier formation (n) |
|---|---|---|---|---|---|---|
| | | -tier dominant -> Low-sample (81) | | | | |
| 5 | 1805 | Middle-tier dominant -> Middle-tier dominant (874); Low-sample -> Middle-tier dominant (406); Mixed-balanced -> Middle-tier dominant (97); Low-sample -> | 920 | 538 | 874 | 406 |

| Annual valid-record threshold (m) | Path total excluding persistent low-sample | Top five paths | Persistence paths (n) | Formation paths (n) | Middle-tier persistence (n) | Middle-tier formation (n) |
|---|---|---|---|---|---|---|
| | | Low-tier dominant (76); Middle-tier dominant -> Mixed-balanced (62) | | | | |
| 10 | 1312 | Middle-tier dominant -> Middle-tier dominant (602); Low-sample -> Middle-tier dominant (361); Mixed-balanced -> Middle-tier | 652 | 472 | 602 | 361 |

| Annual valid-record threshold (m) | Path total excluding persistent low-sample | Top five paths | Persistence paths (n) | Formation paths (n) | Middle-tier persistence (n) | Middle-tier formation (n) |
|---|---|---|---|---|---|---|
| | | dominant (70); Low-sample -> Low-tier dominant (63); Low-sample -> Mixed-balanced (48) | | | | |
| 15 | 1026 | Middle-tier dominant -> Middle-tier dominant (423); Low-sample -> Middle-tier dominant (348); | 457 | 442 | 423 | 348 |

| Annual valid-record threshold (m) | Path total excluding persistent low-sample | Top five paths | Persistence paths (n) | Formation paths (n) | Middle-tier persistence (n) | Middle-tier formation (n) |
|---|---|---|---|---|---|---|
| | | Mixed-balanced -> Middle-tier dominant (52); Low-sample -> Low-tier dominant (49); Low-sample -> Mixed-balanced (45) | | | | |
| 20 | 807 | Low-sample -> Middle-tier dominant (313); Middle-tier dominant -> | 327 | 395 | 304 | 313 |

| Annual valid-record threshold (m) | Path total excluding persistent low-sample | Top five paths | Persistence paths (n) | Formation paths (n) | Middle-tier persistence (n) | Middle-tier formation (n) |
|---|---|---|---|---|---|---|
| | | Middle-tier dominant (304); Mixed-balanced -> Middle-tier dominant (43); Low-sample -> Low-tier dominant (38); Low-sample -> Mixed-balanced (37) | | | | |

*Note.* The threshold m is the minimum number of valid spending records required to assign an annual state. Persistent low-sample paths are omitted from Panel B2 so that the table focuses on interpretable state paths. Rare direct low-high switches should be read from the complete primary matrix in Panel A and the dominance-threshold summary in Panel C.

**Panel C. Robustness to the dominance-share threshold.**

| Dominance-share threshold | Units identifiable in both years (n) | Persistent structure (%) | Middle-tier persistence (n) | Middle-tier formation (n) | High-tier formation (n) | High-to-middle among high-tier exits (%) | Direct low-high switches (n) |
|---|---|---|---|---|---|---|---|
| 0.30 | 1335 | 78.05 | 960 | 415 | 34 | 71.11 | 7 |
| 0.35 | 1335 | 78.05 | 960 | 415 | 34 | 71.11 | 7 |
| 0.40 | 1335 | 77.83 | 958 | 415 | 34 | 70.79 | 6 |
| 0.45 | 1335 | 77.00 | 938 | 409 | 34 | 65.17 | 4 |
| 0.50 | 1335 | 73.18 | 874 | 406 | 34 | 53.57 | 1 |
| 0.55 | 1335 | 65.54 | 684 | 378 | 28 | 38.33 | 0 |
| 0.60 | 1335 | 63.15 | 522 | 317 | 25 | 17.31 | 0 |
| 0.65 | 1335 | 63.22 | 302 | 247 | 14 | 10.71 | 0 |
| 0.70 | 1335 | 67.49 | 172 | 205 | 12 | 10.00 | 0 |
| 0.75 | 1335 | 72.51 | 77 | 155 | 10 | 0.00 | 0 |
| 0.80 | 1335 | 80.90 | 36 | 116 | 9 | 0.00 | 0 |

*Note.* The primary manuscript threshold is 0.50. Higher thresholds classify more units as mixed-balanced unless one tier reaches a stronger majority. The threshold-specific transition matrices are also provided in the machine-readable supplementary file table_s2_machine_readable_dominance_transition_matrices_long.csv.

## S3. Extended variable measurement and standardization parameters

Table S3 complements the main-text variable definitions by documenting model fields, transformations, standardization parameters, and availability checks used in the main spatial association models. Continuous variables were z-standardized using the mean and population standard deviation calculated from non-missing observations among the 1,335 stable comparable units; for transformed variables, these parameters were calculated after applying the transformation shown in the table.

**Table S3. Standardization, availability, and extended measurement notes.**

| Main-text variable name | Model variable / source field | Transform | Standardization mean | Standardization SD | Non-missing N | Final model availability | Extended measurement note |
|---|---|---|---|---|---|---|---|
| Initial low-tier share (2019) | fixed_low_share_2019 | Share; z-standardized | 0.210 | 0.160 | 1335 | Available for all stable units; retained in complete-case model. | |
| Initial high-tier share (2019) | fixed_high_share_2019 | Share; z-standardized | 0.193 | 0.189 | 1335 | Available for all stable units; retained in complete-case model. | |
| Restaurant supply (2019) | n_restaurants_2019_log1p | log(1+x); z-standardized | 3.509 | 0.720 | 1335 | Available for all stable units; retained in complete-case model. | |
| Distance to Tiananmen | dist_tiananmen_km | Distance in km; z-standardized | 9.262 | 4.707 | 1335 | Available for all stable units; retained in | |

| Main-text variable name | Model variable / source field | Transform | Standardization mean | Standardization SD | Non-missing N | Final model availability | Extended measurement note |
|---|---|---|---|---|---|---|---|
| | | | | | | complete-case model. | |
| Distance to nearest commercial center | dist_commercial_center_km | Distance in km; z-standardized | 3.560 | 2.460 | 1335 | Available for all stable units; retained in complete-case model. | |
| Nearest commercial center level: secondary vs. primary | commercial_center_level_nearest_2 | Binary indicator; not z-standardized | Not standardized | Not standardized | 1335 | Available for all stable units; retained in complete-case model. | Primary commercial centers are the reference category. |
| Distance to nearest metro station | dist_metro_km_2020 | Distance in km; z-standardized | 0.739 | 0.698 | 1335 | Available for all stable units; retained in complete-case model. | |
| Metro stations within | metro_station_count_80 | Count; z-standar | 1.291 | 1.189 | 1335 | Available for all stable | |

| Main-text variable name | Model variable / source field | Transform | Standardization mean | Standardization SD | Non-missing N | Final model availability | Extended measurement note |
|---|---|---|---|---|---|---|---|
| 800 m | 0m_2020 | dized | | | | units; retained in complete-case model. | |
| Bus stops within 500 m | bus_stop_count_500m_2020 | Count; z-standardized | 4.418 | 2.170 | 1335 | Available for all stable units; retained in complete-case model. | |
| Road network density | road_density_km_per_km2 | Density; z-standardized | 16.655 | 7.862 | 1335 | Available for all stable units; retained in complete-case model. | |
| Building coverage ratio | building_coverage_ratio_2019 | Share; z-standardized | 0.241 | 0.069 | 1335 | Available for all stable units; retained in complete-case model. | |

| Main-text variable name | Model variable / source field | Transform | Standardization mean | Standardization SD | Non-missing N | Final model availability | Extended measurement note |
|---|---|---|---|---|---|---|---|
| Floor-area ratio (proxy) | building_floor_area_ratio_proxy_2019_log1p | log(1+x); z-standardized | 0.936 | 0.269 | 1335 | Available for all stable units; retained in complete-case model. | This is a built-form proxy, not an official parcel-level FAR. |
| Commercial-service land-use share | euluc_commercial_service_ratio_2018 | Share; z-standardized | 0.022 | 0.086 | 1335 | Available for all stable units; retained in complete-case model. | |
| Business-office land-use share | euluc_business_office_ratio_2018 | Share; z-standardized | 0.040 | 0.103 | 1335 | Available for all stable units; retained in complete-case model. | |
| Residential land-use share | euluc_residential_ratio_2018 | Share; z-standardized | 0.489 | 0.286 | 1335 | Available for all stable units; retained in | |

| Main-text variable name | Model variable / source field | Transform | Standardization mean | Standardization SD | Non-missing N | Final model availability | Extended measurement note |
|---|---|---|---|---|---|---|---|
| | | | | | | complete-case model. | |
| POI diversity | poi_diversity_2018 | Shannon entropy; z-standardized | 2.339 | 0.219 | 1335 | Available for all stable units; retained in complete-case model. | |
| Shopping POI density | shopping_poi_density_2018_log1p | log(1+x); z-standardized | 5.093 | 0.969 | 1335 | Available for all stable units; retained in complete-case model. | |
| Leisure-service POI density | leisure_poi_density_2018_log1p | log(1+x); z-standardized | 3.083 | 1.064 | 1335 | Available for all stable units; retained in complete-case model. | |
| Tourism-accom | tourism_hotel_poi_densi | log(1+x); z-standar | 3.406 | 1.251 | 1335 | Available for all stable | |

| Main-text variable name | Model variable / source field | Transform | Standardization mean | Standardization SD | Non-missing N | Final model availability | Extended measurement note |
|---|---|---|---|---|---|---|---|
| modation POI density | ty_2018_log1p | dized | | | | units; retained in complete-case model. | |
| Office-company POI density | office_company_poi_density_2018_log1p | log(1+x); z-standardized | 4.569 | 1.138 | 1335 | Available for all stable units; retained in complete-case model. | |
| Residential POI density | residential_poi_density_2018_log1p | log(1+x); z-standardized | 3.886 | 0.891 | 1335 | Available for all stable units; retained in complete-case model. | |
| Restaurant-category diversity | restaurant_category_entropy_2019 | Shannon entropy; z-standardized | 1.601 | 0.419 | 1335 | Available for all stable units; retained in complete-case model. | |

| Main-text variable name | Model variable / source field | Transform | Standardization mean | Standardization SD | Non-missing N | Final model availability | Extended measurement note |
|---|---|---|---|---|---|---|---|
| Platform review intensity | review_count_log_mean_2019 | Mean log(1+review count); z-standardized | 2.963 | 1.023 | 1335 | Available for all stable units; retained in complete-case model. | Platform-visible review activity based on review counts. |
| Population density | population_density_2020 | Density; z-standardized | 21395.599 | 8793.313 | 1335 | Available for all stable units; retained in complete-case model. | |
| Floating-population share | pop_out_ratio | Share; z-standardized | 0.554 | 0.116 | 1335 | Available for all stable units; retained in complete-case model. | |
| Population aged 60+ share | pop_share_60p | Share; z-standardized | 0.222 | 0.049 | 1335 | Available for all stable units; retained in | |

| Main-text variable name | Model variable / source field | Transform | Standardization mean | Standardization SD | Non-missing N | Final model availability | Extended measurement note |
|---|---|---|---|---|---|---|---|
| | | | | | | complete-case model. | |
| Nearby median housing price | housing_nearby_price_median_2018_2019_log1p | log(1+x); z-standardized | 11.168 | 0.296 | 1327 | Available for 1,327 units; determines the complete-case model sample. | Eight stable units lacked nearby housing-market variables. |
| Median built year of nearby housing | housing_nearby_build_year_median | Median year; z-standardized | 1997.630 | 7.293 | 1327 | Available for 1,327 units; determines the complete-case model sample. | Eight stable units lacked nearby housing-market variables. |

*Note.* Standardization means and standard deviations were calculated after the transformation shown in the Transform column. The commercial-center indicator was not z-standardized. Models used complete cases, leaving 1,327 units after excluding 8 units with missing housing-market variables. Platform review intensity refers to platform-visible review activity based on review counts.

## S4. Model results, robustness, and diagnostics

Table S4 provides the complete uncertainty information corresponding to the main spatial association estimates. Coefficients are expressed in percentage

points. Low- and high-tier equations were independently estimated using OLS with HC3 robust p-values. Middle-tier coefficients were derived from compositional closure as the negative sum of the low- and high-tier coefficients; no independent middle-tier regression p-values are reported. All 95% confidence intervals are percentile intervals from 5,000 paired-bootstrap resamples.

**Table S4. Complete model uncertainty table.**

| Variable | Low coef. | Low p | Low 95% CI | Middle coef. | Middle 95% CI | High coef. | High p | High 95% CI |
|---|---|---|---|---|---|---|---|---|
| Initial low-tier share (2019) | -11.20 | 3.76e-99 | [-12.12, -10.25] | 11.19 | [10.19, 12.18] | 0.00 | 0.991 | [-0.72, 0.74] |
| Initial high-tier share (2019) | -2.03 | 4.57e-06 | [-2.84, -1.14] | 10.67 | [9.56, 11.78] | -8.64 | 2.87e-46 | [-9.76, -7.60] |
| Restaurant supply (2019) | -0.14 | 0.786 | [-1.13, 0.82] | 0.97 | [-0.11, 2.08] | -0.83 | 0.064 | [-1.71, 0.06] |
| Distance to Tiananmen | -0.82 | 0.360 | [-2.57, 0.90] | 0.86 | [-0.94, 2.69] | -0.04 | 0.960 | [-1.42, 1.32] |

| Variable | Low coef. | Low p | Low 95% CI | Middle coef. | Middle 95% CI | High coef. | High p | High 95% CI |
|---|---|---|---|---|---|---|---|---|
| Distance to nearest commercial center | 1.01 | 0.081 | [-0.10, 2.15] | -0.16 | [-1.37, 1.07] | -0.85 | 0.069 | [-1.74, 0.06] |
| Nearest commercial center level: secondary vs. primary | 1.14 | 0.363 | [-1.33, 3.66] | -0.95 | [-3.57, 1.70] | -0.20 | 0.864 | [-2.41, 2.02] |
| Distance to nearest metro station | -0.28 | 0.574 | [-1.23, 0.63] | 0.50 | [-0.53, 1.57] | -0.23 | 0.456 | [-0.83, 0.32] |
| Metro | -0.07 | 0.863 | [-0.91, 0.74] | 0.52 | [-0.36, 1.44] | -0.45 | 0.238 | [-1.17, 0.29] |

| Variable | Low coef. | Low p | Low 95% CI | Middle coef. | Middle 95% CI | High coef. | High p | High 95% CI |
|---|---|---|---|---|---|---|---|---|
| stations within 800 m | | | | | | | | |
| Bus stops within 500 m | 0.12 | 0.750 | [-0.58, 0.83] | -0.11 | [-0.88, 0.65] | -0.00 | 0.998 | [-0.56, 0.57] |
| Road network density | -1.00 | 0.018 | [-1.82, -0.17] | 0.69 | [-0.19, 1.57] | 0.32 | 0.384 | [-0.40, 1.02] |
| Building coverage ratio | -0.77 | 0.058 | [-1.55, 0.00] | 0.96 | [0.10, 1.84] | -0.19 | 0.555 | [-0.83, 0.44] |
| Floor-area ratio (proxy) | 0.37 | 0.459 | [-0.58, 1.36] | -0.81 | [-1.87, 0.25] | 0.44 | 0.303 | [-0.37, 1.30] |
| Commercial-service land-use | -0.38 | 0.290 | [-1.05, 0.32] | -0.10 | [-1.02, 0.76] | 0.48 | 0.217 | [-0.22, 1.27] |

| Variable | Low coef. | Low p | Low 95% CI | Middle coef. | Middle 95% CI | High coef. | High p | High 95% CI |
|---|---|---|---|---|---|---|---|---|
| share | | | | | | | | |
| Business-office land-use share | -0.63 | 0.114 | [-1.43, 0.10] | -0.36 | [-1.15, 0.53] | 0.99 | 0.024 | [0.16, 1.82] |
| Residential land-use share | 0.18 | 0.677 | [-0.69, 1.04] | -0.23 | [-1.18, 0.73] | 0.05 | 0.904 | [-0.72, 0.82] |
| POI diversity | 0.69 | 0.079 | [-0.07, 1.45] | -0.03 | [-0.92, 0.92] | -0.66 | 0.126 | [-1.54, 0.14] |
| Shopping POI density | 0.17 | 0.744 | [-0.80, 1.13] | -0.01 | [-1.08, 1.13] | -0.16 | 0.742 | [-1.09, 0.77] |
| Leisure-service POI density | -0.28 | 0.549 | [-1.20, 0.63] | -1.01 | [-2.06, -0.02] | 1.29 | 0.001 | [0.53, 2.06] |
| Tourism-acco | -1.00 | 0.037 | [-1.92, -0.06] | 1.28 | [0.32, 2.29] | -0.28 | 0.451 | [-1.01, 0.45] |

| Variable | Low coef. | Low p | Low 95% CI | Middle coef. | Middle 95% CI | High coef. | High p | High 95% CI |
|---|---|---|---|---|---|---|---|---|
| mmodation POI density | | | | | | | | |
| Office-company POI density | 0.44 | 0.361 | [-0.45, 1.38] | -0.73 | [-1.76, 0.25] | 0.29 | 0.434 | [-0.42, 1.02] |
| Residential POI density | 0.57 | 0.251 | [-0.37, 1.53] | -0.65 | [-1.76, 0.42] | 0.08 | 0.834 | [-0.67, 0.81] |
| Restaurant-category diversity | -0.65 | 0.183 | [-1.63, 0.28] | 0.81 | [-0.15, 1.80] | -0.15 | 0.653 | [-0.80, 0.53] |
| Platform review intensity | -2.38 | 2.35e-08 | [-3.20, -1.56] | 1.41 | [0.46, 2.36] | 0.96 | 0.022 | [0.16, 1.76] |
| Population dens | 1.17 | 0.005 | [0.34, 1.95] | -0.01 | [-0.87, 0.87] | -1.17 | 6.56e-04 | [-1.81, -0.53] |

| Variable | Low coef. | Low p | Low 95% CI | Middle coef. | Middle 95% CI | High coef. | High p | High 95% CI |
|---|---|---|---|---|---|---|---|---|
| ity | | | | | | | | |
| Floating-population share | -0.36 | 0.524 | [-1.43, 0.70] | -0.12 | [-1.33, 1.07] | 0.47 | 0.325 | [-0.46, 1.44] |
| Population aged 60+ share | 0.16 | 0.755 | [-0.82, 1.20] | -0.71 | [-1.82, 0.40] | 0.55 | 0.199 | [-0.26, 1.39] |
| Nearby median housing price | -0.86 | 0.151 | [-2.03, 0.29] | -0.24 | [-1.48, 1.03] | 1.10 | 0.017 | [0.21, 2.00] |
| Median built year of nearby housing | 0.51 | 0.190 | [-0.26, 1.26] | 0.29 | [-0.54, 1.12] | -0.80 | 0.018 | [-1.45, -0.16] |

*Note.* All 95% confidence intervals are percentile intervals from 5,000 paired-bootstrap resamples. Low- and high-tier p-values are HC3 robust p-values from independently estimated equations. Middle-tier estimates are derived from

compositional closure and report only the derived coefficient and paired-bootstrap confidence interval; no middle-tier p-value is reported.

Table S5 documents robustness and diagnostics for the main spatial association models.

**Table S5. Robustness and diagnostic summary.**

| Check | Setting | Result | Interpretive use |
|---|---|---|---|
| Complete-case sample | Main OLS-HC3 model using complete cases for baseline composition, restaurant supply, spatial covariates, population covariates, and nearby housing covariates. | Final model N = 1,327; 8 stable units lacked housing-market variables. | Defines the estimation sample for the main spatial association models. |
| Residual Moran's I | Directed row-standardized 8-nearest-neighbor weights from hexagon centroids, zero diagonal, 999 two-sided permutations; applied to residuals from the main model. | low I=-0.006, p=0.677; high I=0.055, p=0.001; middle I=0.018, p=0.159 | Residual spatial autocorrelation was retained as a diagnostic; spatial-HAC inference was used for coefficient robustness. |
| Prediction bounds | Fitted changes from the main model compared with each unit's feasible change interval implied by its 2019 baseline share. | low 1 (0.08%); middle 0 (0.00%); high 105 (7.91%) | Coefficients were interpreted as average conditional associations rather than bounded unit-level predictions. |

| Check | Setting | Result | Interpretive use |
|---|---|---|---|
| Spatial-HAC inference | Main low- and high-tier equations; symmetric Gaussian kernel; bandwidths set to the median distance to the 4th, 8th, and 12th nearest neighbor (0.500, 1.000, and 1.323 km); finite-sample correction n/(n-k_params). | All low- and high-tier associations that met the HC3 evidence criterion retained p < .05 and the same coefficient sign under symmetric Gaussian spatial-HAC inference (k=4: 13/13; k=8: 13/13; k=12: 13/13). | Supports robustness of the main low- and high-tier inference to spatial dependence. |
| Weighted least squares | Weighted model using weight_min_valid = the smaller valid-spending-record count across 2019 and 2025 in each unit; HC3 p-values retained. | 12/13 main associations that met the HC3 evidence criterion retained the same sign; 9/13 retained p < .05 with the same sign. | Used as a weighting sensitivity check based on the smaller valid-record count across the two years. |
| Stable sample threshold m=10 | Stable comparable units redefined as units with at least 10 valid spending records in both 2019 and 2025; the main model was re-estimated on complete cases. | 12/13 comparable main associations that met the HC3 evidence criterion retained the same sign; 5/13 retained p < .05 with the same sign. Both low- and high-tier equations used n=865. | Used as a robustness comparison; terms not present in the alternative specification were not counted. |
| Stable sample threshold m=15 | Stable comparable units | 12/13 comparable main associations | Used as a robustness |

| Check | Setting | Result | Interpretive use |
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| | redefined as units with at least 15 valid spending records in both 2019 and 2025; the main model was re-estimated on complete cases. | that met the HC3 evidence criterion retained the same sign; 6/13 retained $p < .05$ with the same sign. Both low- and high-tier equations used n=598. | comparison; terms not present in the alternative specification were not counted. |
| Alternative demographic age specification | Replace population aged 60+ share with population aged 15-59 share; the main model was otherwise unchanged. | 13/13 comparable main associations that met the HC3 evidence criterion retained the same sign; 13/13 retained $p < .05$ with the same sign. Both low- and high-tier equations used n=1,327. | Used as a robustness comparison; terms not present in the alternative specification were not counted. |
| Alternative centrality specification | Replace distance to Tiananmen with categorical urban ring-zone controls; the main model was otherwise unchanged. | 13/13 comparable main associations that met the HC3 evidence criterion retained the same sign; 13/13 retained $p < .05$ with the same sign. Both low- and high-tier equations used n=1,327. | Used as a robustness comparison; terms not present in the alternative specification were not counted. |
| Alternative land-use mix specification | Replace three EULUC land-use shares with EULUC land-use | 12/12 comparable main associations that met the HC3 evidence criterion | Used as a robustness comparison; terms not present |

| Check | Setting | Result | Interpretive use |
|---|---|---|---|
| | mix entropy; the main model was otherwise unchanged. | retained the same sign; 11/12 retained $p < .05$ with the same sign. Both low- and high-tier equations used n=1,327. | in the alternative specification were not counted. |
| Alternative built-form specification | Drop floor-area ratio (proxy), retaining building coverage ratio as the built-form control; the main model was otherwise unchanged. | 13/13 comparable main associations that met the HC3 evidence criterion retained the same sign; 13/13 retained $p < .05$ with the same sign. Both low- and high-tier equations used n=1,327. | Used as a robustness comparison; terms not present in the alternative specification were not counted. |
| Alternative platform-review specification | Replace platform review intensity with median platform rating in 2019; the main model was otherwise unchanged. | 11/11 comparable main associations that met the HC3 evidence criterion retained the same sign; 11/11 retained $p < .05$ with the same sign. Both low- and high-tier equations used n=1,327. | Used as a robustness comparison; terms not present in the alternative specification were not counted. |
| Alternative road-accessibility specification | Replace road network density with intersection density; the main model was | 12/12 comparable main associations that met the HC3 evidence criterion retained the same | Used as a robustness comparison; terms not present in the alternative |

| Check | Setting | Result | Interpretive use |
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| | otherwise unchanged. | sign; 12/12 retained $p < .05$ with the same sign. Both low- and high-tier equations used n=1,327. | specification were not counted. |
| Alternative restaurant-scale specification | Replace log restaurant supply count with an area-normalized restaurant-supply measure; the main model was otherwise unchanged. | 13/13 comparable main associations that met the HC3 evidence criterion retained the same sign; 13/13 retained $p < .05$ with the same sign. Both low- and high-tier equations used n=1,327. | Used as a robustness comparison; terms not present in the alternative specification were not counted. |
| Specification excluding housing-market variables | Model excluding nearby median housing price and median built year of nearby housing; otherwise the same covariate blocks as the main model. | 11/11 comparable main associations that met the HC3 evidence criterion retained the same sign; 11/11 retained $p < .05$ with the same sign; 2 main terms were not present in this comparison. | Checks whether non-housing associations depend on housing controls. |
| Comparison without baseline composition | Model excluding initial low-tier and high-tier shares while retaining the remaining main- | 8/10 comparable main associations that met the HC3 evidence criterion retained the same sign; 1/10 retained | Used as an interpretive boundary for the role of baseline composition controls. |

| Check | Setting | Result | Interpretive use |
|---|---|---|---|
| | model covariate blocks. | $p < .05$ with the same sign; 3 main terms were not present in this comparison. | |
| Multicollinearity diagnostics | Main complete-case design matrix; VIF by predictor and condition indices from the scaled model matrix. | Maximum VIF = 6.69 (1 term > 5; 0 terms > 10). Maximum condition index = 7.84 (0 dimensions > 15; 0 dimensions > 30). | Used to assess multicollinearity in the main complete-case design matrix. |

*Note.* Counts of retained associations refer to low- and high-tier associations in the main model that met the HC3 evidence criterion. Alternative specifications were used to assess direction and inference stability, not to replace the main baseline-adjusted model.