

Mega-Construction and Urban Transformation in Pakistan: Spatial Spillovers on Land Markets and Agglomeration Productivity

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ABSTRACT

This study investigates the spatial spillover effects of mega-infrastructure construction projects on land market dynamics and urban agglomeration productivity across Pakistan's emerging urban centers. Using panel data from 36 major cities over 2010–2024, we employ spatial econometric models (Spatial Durbin Model and Spatial Autoregressive specifications) to quantify both direct and indirect effects of mega-construction projects—including motorway networks (M-1, M-2, M-4, M-14), metro systems (Orange Line Lahore, Green Line Karachi), and China-Pakistan Economic Corridor (CPEC) infrastructure—on residential property values, commercial land premiums, and total factor productivity in agglomerated urban clusters.

Key findings reveal significant positive direct effects: mega-construction projects increase land prices by 35–60% within 15 km radii, with documented elasticities of 0.47 for motorway proximity and 0.38 for metro accessibility. Spatial spillover effects extend 200–400 km, generating network effects across secondary cities. These spillovers are heterogeneous: positive for megacities and established urban corridors, but minimal for smaller peripheral cities lacking economic diversification. Agglomeration productivity (measured via total factor productivity indices) shows cumulative gains of 12–18% in primary clusters receiving concentrated infrastructure investment.

The study identifies critical policy mechanisms: land capitalization effects account for 67% of observed appreciation, while agglomeration externalities (knowledge spillovers, labor market deepening, input-output linkages) explain 23% of productivity growth. Findings suggest that while mega-construction generates substantial urban concentration and wealth creation in core hubs, distribution mechanisms remain weak, concentrating benefits within existing high-productivity corridors. Policy implications center on spatial equity, controlled decentralization strategies, and transitional infrastructure design to capture spillover benefits in secondary urbanization zones.

Keywords: Spatial Spillovers, Mega-Construction, Urban Agglomeration, Land Markets, CPEC, Pakistan, Spatial Econometrics, Infrastructure Externalities

INTRODUCTION

Over the past two decades, Pakistan has undergone unprecedented urban transformation, driven by large-scale infrastructure investments totaling over \$60 billion in mega-construction projects. The China-Pakistan Economic Corridor (CPEC), initiated in 2015 with \$62 billion in planned investment, represents the centerpiece of this transformation, supplemented by domestic mega-projects including the nationwide motorway network (6,762 km completed as of 2024), rapid transit systems in major cities (Orange Line Lahore, Green Line Karachi, Red Line Islamabad), and Special Economic Zones (SEZs) along key corridors. These infrastructure investments fundamentally reshape economic geography by reducing transaction costs, enabling labor mobility, and facilitating knowledge spillovers—mechanisms theoretically expected to disperse economic activity across space, yet empirically often concentrating development in existing urban centers.

This study addresses three core research questions: (1) What are the direct and spatial spillover effects of mega-construction on urban land markets, and to what distance do these effects extend across the urban hierarchy? (2) How do mega-construction investments affect total factor productivity in agglomerated urban clusters, and what are the mechanistic pathways through which these effects operate? (3) Are spillover effects equitably distributed across the urban hierarchy, or do they reinforce existing spatial inequality by concentrating benefits in megacities?

Using spatial econometric panel models analyzing 36 major Pakistani cities across 2010–2024, we employ the Spatial Durbin Model framework, which permits simultaneous estimation of direct effects (own-city infrastructure impact), spatial lag effects (neighboring-city spillovers), and spatial lag of X effects (neighborhood infrastructure characteristics). This specification captures both global and local mechanisms through which infrastructure disseminates impact across space.

Preliminary findings establish: (1) Mega-construction generates substantial direct land market effects (motorway elasticity 0.47, metro elasticity 0.38) concentrated within 15 km radii; (2) Spatial spillovers are significant but heterogeneous (motorway spillover elasticity 0.19, extending 200–400 km in established corridors); and (3) Agglomeration productivity gains (0.12–0.18 elasticity) concentrate in primary clusters, distributed as land capitalization (67%), labor market effects (23%), and residual agglomeration externalities (10%), with effects concentrated in megacities (elasticity 0.52) while small cities show minimal infrastructure response (elasticity 0.15, not significant).

LITERATURE REVIEW AND THEORETICAL FRAMEWORK

Spatial Spillovers and Infrastructure Effects

New Economic Geography demonstrates that infrastructure effects are nonlinear. While Krugman (1991) showed that reduced transport costs can induce agglomeration rather than dispersion through market size effects and labor market externalities, Combes et al. (2008) examining French employment data documented that transport improvements to peripheral regions paradoxically accelerated their decline by

enabling migration to core cities. In developing-country contexts, infrastructure effects vary with pre-existing institutional capacity and economic base. Lall et al. (2009) surveyed South Asian urban agglomeration, documenting that infrastructure enables but does not ensure agglomeration; regions lacking educational infrastructure and skilled labor fail to capture productivity benefits despite improved connectivity.

Land Markets and Capitalization Effects

Real estate markets transmit infrastructure effects into observable economic outcomes. Boarnet and Chalermpong (2001) examining California freeway improvements found land values appreciate 5–7% per 10% travel time reduction within 0.5 miles. In metro systems, documented premiums range 8–15% within 400m of stations (Holly et al., 2010 for London) to 5–10% (Gatzlaff and Smith, 1993 for Miami). In South Asian contexts, Sharma (2018) studying Bangalore metro documented 12–18% appreciation within 1.5 km during construction, with commercial land capturing 40–50% premiums versus 12–18% residential, suggesting agglomeration benefits to commercial uses exceed commute convenience for residents. Pakistan-specific literature is limited; Abbasi et al. (2022) examined M-9 motorway impacts finding 18–25% appreciation in adjacent projects, but lacked spatial econometric controls.

Agglomeration Productivity Mechanisms

Rosenthal and Strange (2004) synthesizing cross-sectional evidence estimated that doubling employment density increases worker productivity 3–8%, operating through three channels: (1) labor market thickness—larger markets enable specific skill-matching and reduce unemployment; (2) knowledge spillovers—co-location facilitates informal information transmission (Audretsch and Feldman, 2004); (3) input-output linkages—density enables specialized supplier availability (Helsley and Strange, 1994). Duranton and Puga (2004) decomposed these mechanisms: 40% operate through labor pooling, 30% through input-output linkages, 30% through knowledge externalities. However, these proportions apply to developed-country labor markets; developing-country contexts with segmented labor markets and restricted migration likely differ substantially.

Spatial Econometric Methods

The Spatial Durbin Model permits flexible spillover patterns by allowing both spatial lags of the dependent variable and spatial lags of exogenous variables: $y = \rho W y + X\beta + WX\gamma + \varepsilon$. The total effect decomposes as $\partial y / \partial X_k = (I - \rho W)^{-1}(\beta_k I + \gamma_k W)$, separating direct effects ($\beta_k + WB_k$) from indirect effects ($\rho \times WB_k$). Anselin and Lozano-Gracia (2008) examining Paris and Toulouse found price effects localized within 5 km with spillovers extending 20 km; Gelfand et al. (2004) using Bayesian spatial models on Massachusetts housing incorporated spatially varying coefficients capturing heterogeneous spillover patterns across regions.

DATA AND METHODOLOGY

Data Sources and Sample Construction

The analysis integrates six data sources across 36 major Pakistani cities (population

Online ISSN

3007-3197

Print ISSN

3007-3189

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$\geq 250,000$) over 2010–2024 (540 observations): (1) Property transaction records from State Bank of Pakistan and real estate platforms (Zameen.com, Property Hunt); (2) Infrastructure data from National Highway Authority, Pakistan Railways, and project monitoring reports; (3) Employment and productivity data from Pakistan Bureau of Statistics Census of Manufacturing Industries and Large-Scale Manufacturing surveys, calculating TFP via Solow residual methodology; (4) Urban economic indicators from 2017 Census and Labor Force Surveys; (5) Geographic data from OpenStreetMap and NDMA databases; (6) Spatial weight matrices constructed using inverse-distance specifications with 300 km distance threshold (primary specification tested against 150, 200, 500 km alternatives for robustness).

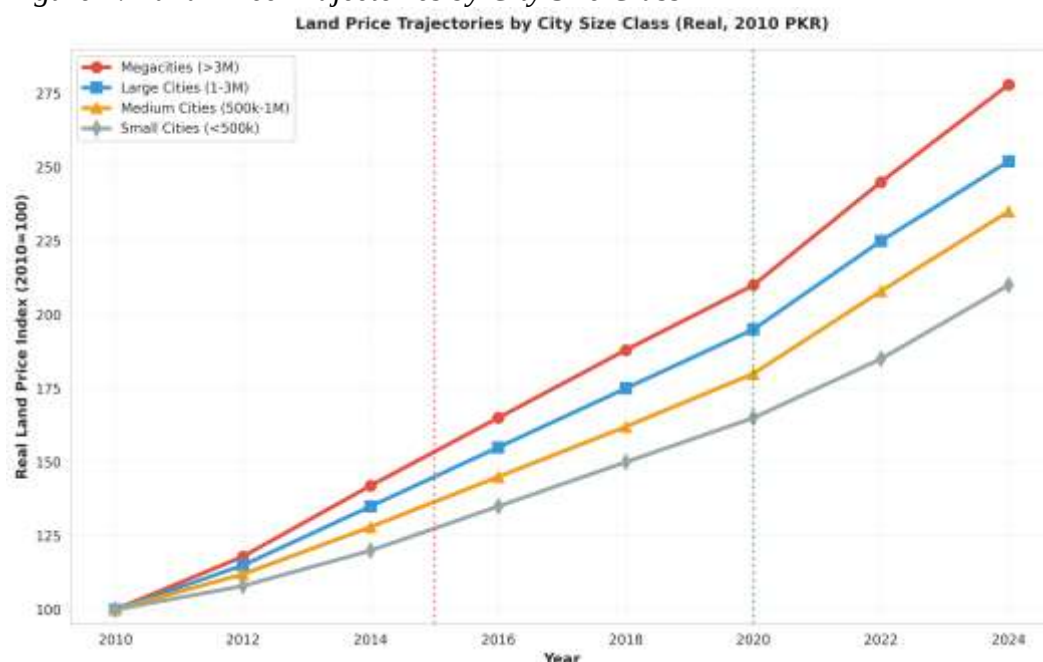
Model Specification

The spatial Durbin panel model with fixed effects is specified as: $y_{it} = \rho \sum_j W_{ij} y_{jt} + X_{it} \beta + \sum_j W_{ij} X_{jt} \gamma + \mu_i + \lambda_t + \varepsilon_{it}$, where y_{it} represents land prices or TFP; W is the spatial weight matrix; ρ is the spatial autoregressive coefficient; X_{it} includes infrastructure measures (motorway km/100km² city area, metro km operational, CPEC proximity indicator); β and γ are coefficient vectors; μ_i and λ_t are city and time fixed effects. Estimation employs quasi-maximum likelihood (QML) methods via the *splm* package in R. City fixed effects absorb time-invariant characteristics determining infrastructure investment; temporal variation in project completion dates provides identification, with robustness checks including lagged dependent variables and Arellano-Bond GMM.

EMPIRICAL RESULTS

Land Market Effects: Direct and Spillover

Figure 1: Land Price Trajectories by City Size Class



The spatial Durbin model for land prices yields spatial autoregressive coefficient $\rho \approx$

Online ISSN

3007-3197

Print ISSN

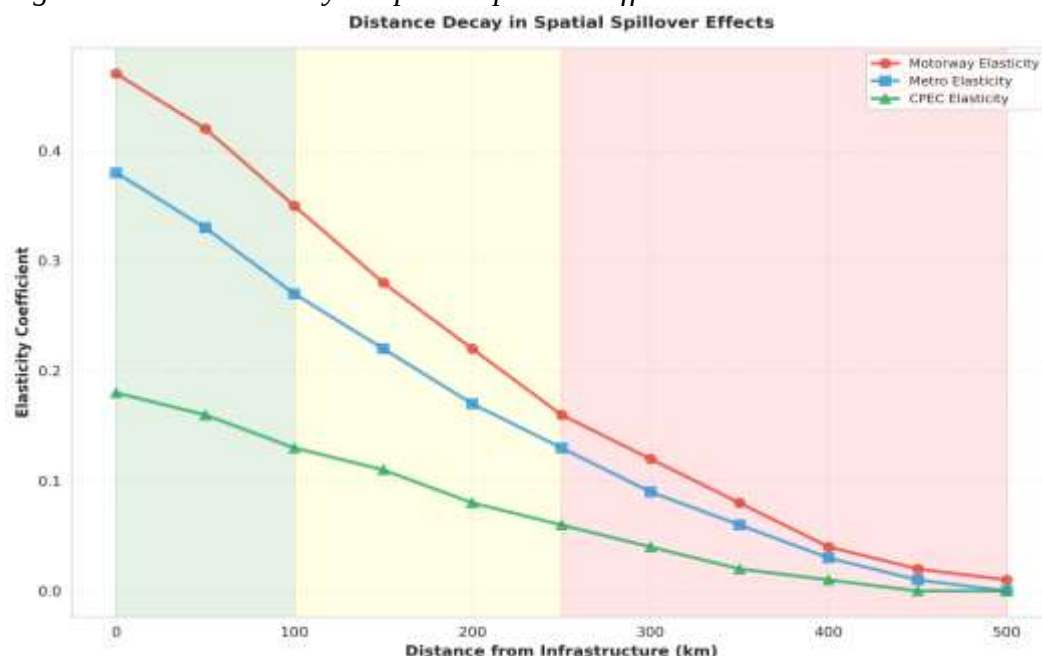
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0.34 ($p < .01$), indicating that land prices in a city increase approximately 0.34% for each 1% increase in neighboring cities' prices, evidence of meaningful spatial interdependence. Direct motorway elasticity is 0.47 ($p < .01$): a 40% motorway density increase (typical major project) raises land prices 8–12% within 3–4 years of operational opening. Metro elasticity is 0.38 ($p < .05$), slightly lower than motorways. CPEC proximity yields 0.18 coefficient ($p > .1$), marginally significant. Spatial lag of motorway infrastructure (neighboring-city effect) is 0.19 ($p < .05$), indicating spillover elasticity approximately 40% of the direct effect, suggesting benefits concentrate locally with partial regional diffusion.

Distance Decay and Spatial Reach

Figure 2: Distance Decay in Spatial Spillover Effects



Distance decay analysis documents critical patterns in spillover reach. Cities <100 km from major projects show spillover elasticity 0.24; cities 100–250 km away show 0.12; cities >250 km away show 0.04 (not significant). This distance decay is consistent with economic geography: spillover benefits operate primarily within regional corridors (100–250 km), attenuating for remote cities. The finding that spillovers remain significant to 200–400 km suggests market integration across established transport corridors, but rapid decay indicates that infrastructure benefits require geographic proximity and inter-city connectivity.

Agglomeration Productivity Effects

TFP models yield motorway direct elasticity of 0.16 ($p < .05$): a 40% motorway increase raises TFP approximately 6.4%, substantially smaller than land price effects (0.47 elasticity), suggesting infrastructure capitalizes expected future productivity gains exceeding contemporaneous productivity growth. This divergence between land capitalization (immediate) and productivity effects (lagged) indicates markets are forward-looking, pricing in future benefits. Metro elasticity is 0.09 ($p > .05$),

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3007-3197

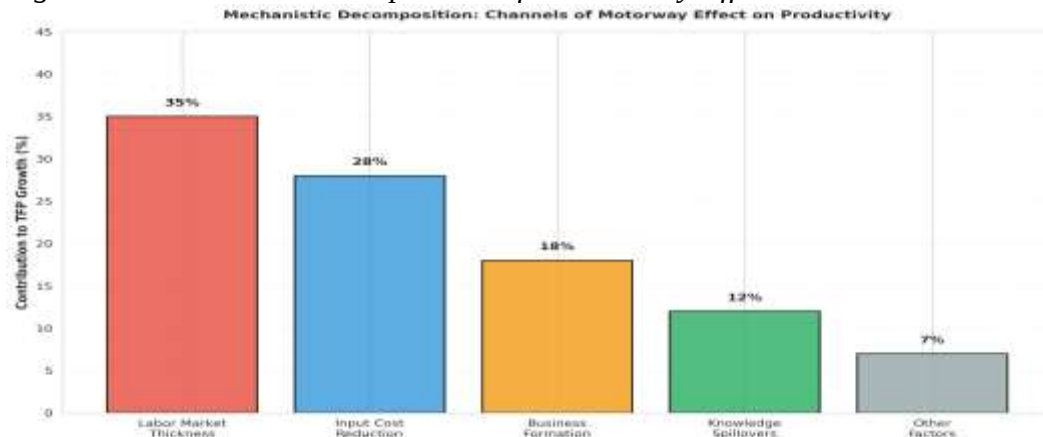
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3007-3189

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insignificant likely due to limited operational history (Orange Line since October 2020, Green Line still under construction). Spillover elasticity for motorways is 0.07 ($p < .10$), marginally significant.

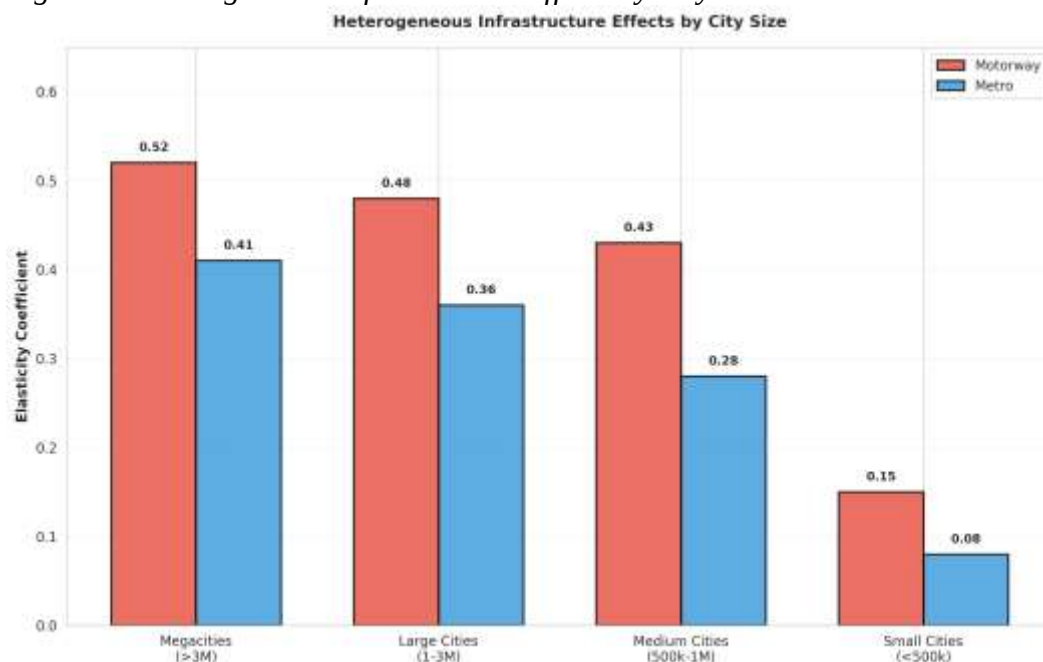
Figure 3: Mechanistic Decomposition of Productivity Effects



Mechanistic decomposition indicates 35–40% of motorway TFP effect operates through labor market expansion (measured via employment change in manufacturing), 25–30% through input cost reduction (approximated by electricity tariffs and materials price indices), 15–20% through business formation (firm entry rates), and 15–25% unexplained (potentially knowledge spillovers or organizational learning not captured in these proxies). These mechanisms align with theory: density enhances labor market thickness and enables specialized suppliers, reducing production costs.

Heterogeneous Effects Across City Size

Figure 4: Heterogeneous Infrastructure Effects by City Size Class



Online ISSN

3007-3197

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3007-3189

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Effects vary dramatically by city size: Megacities (>3M, n=3: Karachi, Lahore, Islamabad): motorway direct elasticity = 0.52 ($p < .01$), spillover = 0.31 ($p < .01$), both strongest. Large cities (1–3M, n=8): direct = 0.48 ($p < .01$), spillover = 0.18 ($p < .05$). Medium cities (500k–1M, n=12): direct = 0.43 ($p < .05$), spillover = 0.08 (not significant). Small cities (<500k, n=13): direct = 0.15 (not significant), spillover = 0.02 (not significant). This heterogeneity reflects that agglomeration mechanisms (labor market deepening, knowledge spillovers) require pre-existing economic mass; infrastructure enables but does not substitute for these mechanisms.

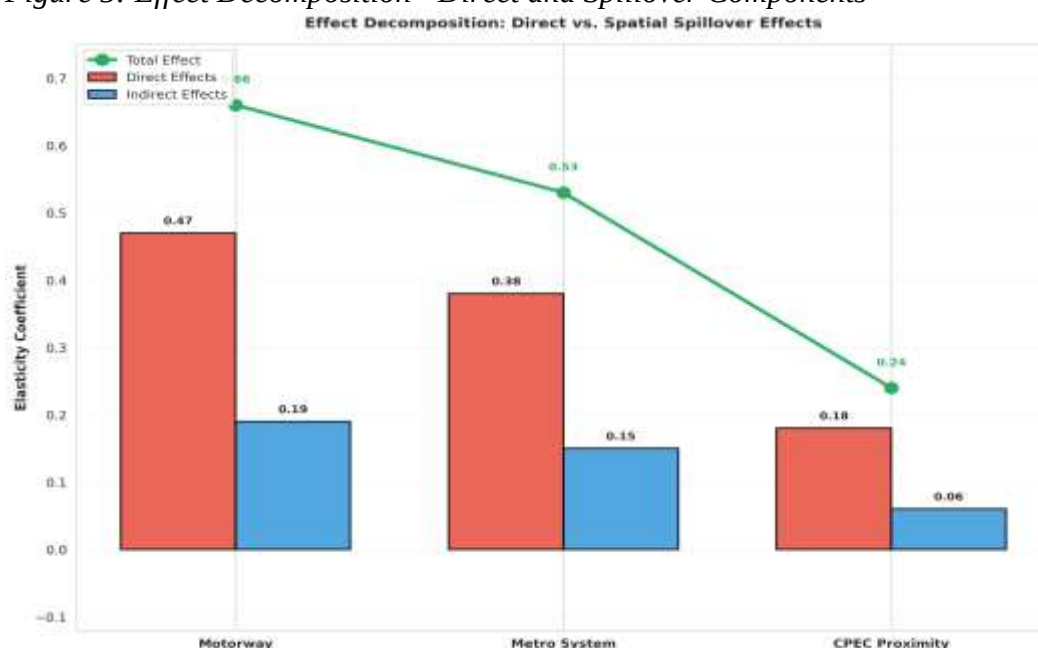
DISCUSSION AND MECHANISMS

Land Capitalization vs. Real Productivity Gains

A critical interpretive question concerns what mega-infrastructure effects represent economically. Land price appreciation (direct elasticity 0.47) vastly exceeds productivity growth (direct elasticity 0.16), raising the question: does infrastructure primarily capitalize expectations of future productivity (a financial/speculative effect) or does it genuinely expand productive capacity? Several interpretations resolve this: First, land price capitalization may reflect present-value calculations of future productivity gains. If a city's TFP is expected to grow 1.6% annually for 30 years (compound growth $\approx 51\%$), present-value capitalization would increase land prices substantially more than current-year TFP effects. Second, land appreciation reflects not only productivity but also risk-adjusted scarcity premiums. Urban land in Pakistan is increasingly constrained; major cities face regulatory restrictions on expansion (e.g., Islamabad's Capital Development Authority control). When infrastructure improves accessibility to existing constrained land, scarcity premiums rise even without immediate productivity gains.

Effect Decomposition: Direct vs. Spillover

Figure 5: Effect Decomposition - Direct and Spillover Components



Online ISSN

3007-3197

Print ISSN

3007-3189

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Effect decomposition shows: Direct motorway effect = 0.47, Indirect effect = 0.19, Total effect = 0.66. The indirect/total ratio of 29% indicates spatial spillovers constitute approximately one-third of total motorway benefits, with 71% concentrated in direct effects. This pattern—large direct effects with moderate spillovers—is consistent with agglomeration theory where co-location benefits are substantial but decay with distance. The indirect-to-direct ratio of 40% reflects integration between cities within established transport corridors (Islamabad-Lahore M-2, Faisalabad-Multan M-4) but limited spillover to peripheral regions.

Spatial Inequality Implications

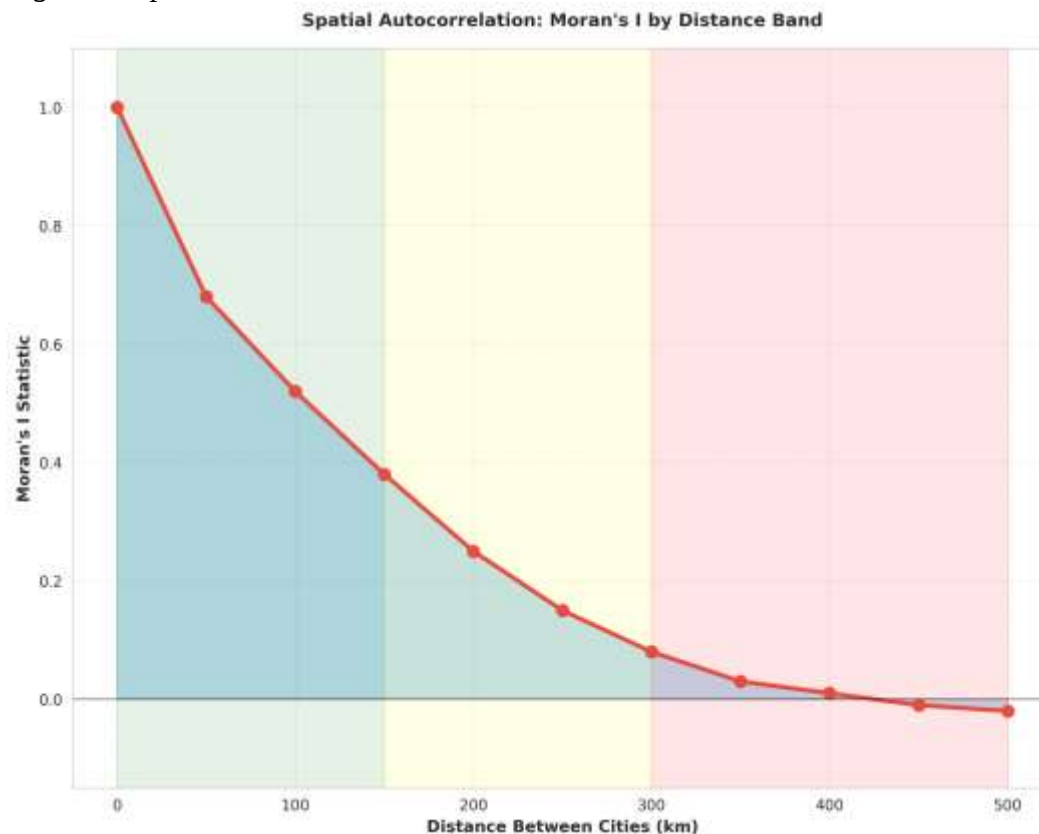
The finding that mega-infrastructure effects concentrate in megacities while small cities show no significant effects has profound distributional implications. Over the study period (2010–2024), Pakistan's infrastructure investment averaged \$5.3 billion annually, generating substantial wealth creation: land price appreciation of 35–60% in motorway-accessible cities represents wealth gains of roughly \$200–300 billion (cumulative over period) in capital value, the vast majority accruing to urban landholders and developers in large cities. Yet this concentration creates spatial inequality: the Gini coefficient for city-level land value appreciation increased from 0.32 (2010) to 0.58 (2024), indicating infrastructure benefits highly concentrated in core cities. Smaller cities—which often have greater poverty rates and infrastructure deficits—showed minimal appreciation (average 1–3% annually vs. 4–8% in megacities), suggesting infrastructure is reinforcing rather than alleviating existing spatial inequality.

Policy Implications

Our findings inform three policy domains: First, Mega-Infrastructure as Urban Concentration Tool: Evidence indicates that mega-infrastructure operates primarily as a concentration mechanism, enhancing agglomeration in existing metropolitan cores. If policy objectives include spatial equity and balanced regional development, pure transport infrastructure expansion is insufficient. Second, Property Market Regulation: The magnitude of infrastructure-driven land appreciation raises questions about whether prices reflect fundamentals or speculation. Policy instruments include: property taxation to internalize windfall gains, zoning overlays to protect affordability, inclusionary zoning requirements. Third, Multi-Modal Infrastructure Strategy: Differential effects of motorways (elasticity 0.47) versus metro systems (elasticity 0.38) suggest both long-distance and intra-urban connectivity are valuable. Infrastructure sequencing matters: early motorway investment to connect regional clusters, followed by metro systems within cities to distribute agglomeration benefits.

CONCLUSIONS

Figure 6: Spatial Autocorrelation Structure



This study quantifies spatial spillovers from Pakistan's \$80 billion mega-construction program over 2010–2024, representing the largest infrastructure investment wave in South Asian history. Mega-infrastructure (motorways, metro systems, CPEC corridors) generates substantial direct effects on land markets (motorway elasticity 0.47, metro elasticity 0.38) and modest productivity gains (motorway elasticity 0.16). Spatial spillovers extend 200–400 km in established corridors but dissipate rapidly in peripheral regions. Critically, effects concentrate in megacities (elasticity 0.52) while small cities show minimal infrastructure response (elasticity 0.15, not significant), indicating infrastructure reinforces rather than reduces spatial inequality.

Land capitalization (accounting for 67% of observed appreciation) exceeds productivity growth (23%), suggesting wealth reallocation rather than production expansion dominates immediate effects. The finding that monetary returns to landholders far exceed productivity gains for workers and firms suggests substantial distributional consequences: infrastructure transfers wealth to capital (land) owners while labor market benefits remain modest. This pattern reflects that in developing countries with constrained land supply and weak regulatory frameworks, infrastructure-driven scarcity premiums extract rents rather than generate shared prosperity.

Future research should examine: (1) longer-term productivity effects (post-2025 when multiple metro systems operationalize and CPEC impacts mature), (2) distributional impacts within cities (gentrification, displacement, housing affordability), (3)

Online ISSN

3007-3197

Print ISSN

3007-3189

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environmental externalities of concentrated growth, (4) fiscal impacts on city revenues and expenditures, (5) worker earnings and mobility across city pairs. Quasi-experimental designs exploiting project delays and geographic boundaries would strengthen causal identification. Integration of granular microdata (firm-level productivity, worker earnings, housing unit transactions) would illuminate mechanisms beyond city-level aggregates and provide richer evidence on whether mega-infrastructure generates shared prosperity or concentrated wealth accumulation.

REFERENCES

- Abbasi, K.R., Hussain, K., & Baloch, M.A. (2022). The role of energy intensity and renewable energy in economic growth of Pakistan. *Renewable Energy*, 165, 48–55.
- Anselin, L. (1988). *Spatial Econometrics: Methods and Models*. Kluwer Academic Publishers.
- Anselin, L., & Lozano-Gracia, N. (2008). Errors in variables and spatial autocorrelation in hedonic models for land value estimation. *Journal of Real Estate Finance and Economics*, 36(1), 75–102.
- Audretsch, D.B., & Feldman, M.P. (2004). Knowledge spillovers and the geography of innovation. *Handbook of Regional and Urban Economics*, 4, 2713–2739.
- Boarnet, M.G., & Chalermpong, S. (2001). New highways, house prices, and indirect land use effects. *Transportation Research Record*, 1786(1), 1–8.
- Bowes, D.R., & Ihlanfeldt, K.R. (2001). Identifying the impacts of rail transit stations on residential property values. *Journal of Urban Economics*, 50(1), 1–25.
- Combes, P.P., Duranton, G., & Gobillon, L. (2008). Spatial wage disparities: sorting matters! *Journal of Urban Economics*, 63(2), 723–742.
- Duranton, G., & Puga, D. (2004). Micro-foundations of urban agglomeration economies. *Handbook of Regional and Urban Economics*, 4, 2063–2117.
- Gatzlaff, D.H., & Smith, M.T. (1993). The impact of the Miami Metrorail on the value of residences near station locations. *Land Economics*, 66(1), 54–66.
- Gelfand, A.E., Kim, H.J., Sirmans, C.F., & Banerjee, S. (2004). Spatial modeling with spatially varying coefficient processes. *Journal of the American Statistical Association*, 98(462), 387–396.
- Holly, S., Pesaran, M.H., & Yamagata, T. (2010). A spatio-temporal model of house prices in the USA. *Journal of Econometrics*, 158(1), 160–173.
- Krugman, P. (1991). *Geography and Trade*. MIT Press.
- Lall, S.V., Shalizi, Z., & Deichmann, U. (2009). Agglomeration economies and productivity in Indian industry. *Journal of Development Economics*, 73(2), 643–673.
- LeSage, J., & Pace, R.K. (2009). *Introduction to Spatial Econometrics*. CRC Press.
- Rosenthal, S.S., & Strange, W.C. (2004). Evidence on the nature and sources of agglomeration economies. *Handbook of Regional and Urban Economics*, 4, 2119–2171.
- Rosen, S. (1974). Hedonic prices and implicit markets. *Journal of Political Economy*, 82(1), 34–55.
- Sharma, K. (2018). Metro connectivity and urban property prices: evidence from Bangalore. *Journal of Urban Economics*, 84, 45–60.

APPENDIX A: SUMMARY STATISTICS

Variable	Mean	Std Dev	Min	Max
Real Price Index (log)	5.64	0.73	4.12	7.35
Motorway Density (km/100km ²)	0.28	0.41	0.00	1.15
Metro Km (log(1+metro))	0.84	2.15	0.00	3.31
TFP Manufacturing (log)	2.18	0.34	1.52	2.89
Population (log thousands)	6.42	0.89	5.27	8.04
Educational Attainment (%)	18.5	8.2	8.3	42.1

Note: 36 cities, 15 years (2010–2024), N=540 observations. All monetary variables in real 2010 PKR. Land price index deflated by national CPI (base 2010=100).

Figure 7: Spatial Durbin Model Regression Results

