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From Disrepair to Disorder to Departure: The Infrastructure Quality Index to Crime Rate to Vacancy Pathway in Kolkata's Housing Stock

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Abstract: The broken-windows tradition holds that infrastructure decay leads to residential vacancy because it facilitates neighborhood crime, which leads to residential departure. We test this in the Kolkata metropolitan housing stock using a continuous, building-level vacancy rate – share of flats vacant within each building – rather than the binary occupied/vacant indicator common in the literature. We use survey data on 1,416 buildings across 100 wards to construct an Infrastructure Quality Index (IQI) from five service indicators, and separately estimate the IQI to crime to vacancy mediation for apartments (n = 853), individual houses (n = 281), and gated communities (n = 282). The result is a clear pattern of differential. Crime, when pooled, appears to mediate 82.6% of the IQI to vacancy association, but this is driven almost entirely by the non-apartment typologies. Mediation is strong in gated communities and significant in individual houses, but is virtually absent in apartments where the indirect effect is −0.015, with a confidence interval that includes zero (z = −0.53, p = 0.60). Instead, apartment vacancy is driven by building age; neither IQI nor crime is significant with controls for age and condition. A complete suite of spatial analyses – Moran's I, Lagrange Multiplier diagnostics, SAR and SEM models, geographically weighted regression, Getis-Ord G* – finds no significant spatial clustering of the continuous vacancy rate (Moran's I = +0.054, p = 0.49), and plain OLS is preferred to each of the spatial models on AIC. Taken together these findings imply that apartment vacancy in Kolkata happens through an aging-stock decay process internal to the building, not the neighborhood-mediated broken-windows process that operates in lower density typologies. The policy implication is that vacancy mitigation should be targeted by housing type, and that it should be pursued building-by-building and not area-by-area.
Keywords: Housing Vacancy, Infrastructure Quality Index, Aging-stock decay, Spatial Analysis, Crime rate

I. INTRODUCTION

Housing vacancy is one of the more intractable puzzles in urban policy in India. The 2011 Census recorded around 11.1 million vacant urban dwellings – or about 12.4 per cent of the urban stock [1] – at a time when the country also had a shortage of close to 19 million homes. In the same cities, surplus and shortage coexist and explanations have ranged from speculative investment to distortions of rent control [2], [3], weak contract enforcement and physical decay of the neighborhoods where homes sit.

This last explanation—that the condition of the neighborhood drives out residents—is the oldest and most fully developed. In the tradition of Wilson and Kelling's broken windows, later extended by Skogan [4], [5], visible decay signals disorder, disorder manifests as crime, and crime drives away those who can leave. That logic yields a clear testable prediction: any association between infrastructure quality and vacancy should be largely mediated by crime. If it does, then the broken-windows account holds. If infrastructure affects vacancy via some path that bypasses crime, then another mechanism is at work.

Testing this well requires three things that have rarely been combined in the existing literature. First, a measure of vacancy that captures intensity, not just incidence." Most studies – and almost all the Indian work – treat a dwelling as occupied or vacant, throwing away information on how vacant a multi-unit building is. Instead we use a continuous building-level vacancy rate: the percentage of flats surveyed in each building that are vacant. Second, disaggregation of housing types. A household in a free-standing house faces the street directly; a household in a gated community has paid for insulation [6], [7] from precisely the disorder the theory invokes; and a household in an apartment block is shaped mostly by the building's own condition, its lifts and water and common areas, rather than the surrounding streetscape. There is good reason to believe the IQI → crime → vacancy pathway varies across these forms, and pooling them would mask that. Third, direct observation of vacancy spatial pattern. A neighborhood-driven process should cluster in space, a building-internal process should not. Thus, the spatial signature is a hint to the mechanism itself.

The question is more pointed in the Indian context. Indian metropolitan vacancy exists in stark contrast to the post-industrial West where vacancy is a marker of population loss in shrinking cities [8], [9], and with strong demand and rapid growth. The usual explanations -- speculative withholding, pro-tenant rent control, weak enforcement -- are all about owner incentives and little about the physical state of the stock. The broken-windows and aging-stock accounts put that physical dimension front and center and this paper is designed to tell the two apart.

We construct an Infrastructure Quality Index from five service indicators and validate it within each typology and estimate the IQI → crime → vacancy pathway on the continuous vacancy rate separately for apartments, single-family homes, and gated communities. Next, we examine the apartment subsample spatially — the largest, and the one where broken windows is weakest. The main empirical finding is a result of differential mediation: crime mediates the infrastructure–vacancy relationship strongly for gated communities, moderately for individual houses, and negligibly for apartments. We argue that the apartment vacancy in Kolkata follows an internal to the building decay process of the aging stock which is distinct from the neighborhood mediated process described by broken windows.

The design is cross-sectional, and the mediation framework relies on a causal order – infrastructure to crime to vacancy – that the data cannot themselves establish. Theory provides that order. What the analysis can do is test the first-order prediction of the theory within each typology and ask if it holds. Failure is didactic, as in apartments, where it fails. The positive case for the aging-stock mechanism rests on triangulation (the mediation, regression, and spatial results all pointing the same way) rather than on any single test. Sections II and III describe the background and methods; section IV present the results of the descriptive, measurement, mediation, regression and spatial analyses; sections V and VI are the discussion and conclusions.

II. BACKGROUND AND RELATED WORK

A. Two competing accounts of vacancy

The broken-windows hypothesis began life as a theory of policing: visible minor disorder signals the absence of social control and invites more serious offending. The mechanism is informational—physical disorder is a signal from which offenders and residents read a place's trajectory. Skogan widened the argument from crime to neighbourhood decline, demonstrating across cities that visible decay predicts residential flight and disinvestment. The pathway to vacancy is specific when vacancy is applied. Decaying infrastructure raises crime, and crime drives the exit that shows up as empty homes.

The evidence is disputed. Reanalyses of the original New York data question the robustness of the disorder–crime link when controlling for neighbourhood disadvantage [10], and multilevel work in Chicago conceptualizes disorder and crime as joint products of deeper disadvantage rather than cause and effect [11], [12]. This is important here: an observed indirect effect of infrastructure on vacancy through crime is consistent with the theory, but does not prove it. The mediation test is the obvious first-order check, and its failure within a subgroup is informative even when its success would be only suggestive.

The most relevant alternative for apartments is rooted in an older tradition in housing economics. Stock-flow models consider dwellings as durable assets which depreciate [13], [14]. Units are removed from use when decay reaches a stage where their restoration costs more than it yields. Matching models illustrate how vacancy can be in equilibrium [15] when redevelopment is blocked by fragmented ownership. This is especially true in India where multi-owner buildings are often managed by resident welfare associations that are unable to charge enough to fund major repairs. Deferred maintenance piles up with a building's age—lifts, pumps, façades, wiring—and those owners who can leave do. Their departure leaves vacancies and eats away at the base that pays for maintenance, speeding decay. This model predicts that apartment vacancy rates should track building age, should be largely insensitive to crime once age is controlled for, and – because the process is internal to each building – should show little spatial clustering. All three predictions can be tested here. All three predictions diverge from the broken-windows predictions.

B. Mediation, measurement, and the Indian evidence

Mediation analysis decomposes a total effect into a direct effect and an indirect effect through an intervening variable. The standard approach is the classical framework [16], enhanced by the Sobel test [17] and bootstrap methods for the indirect effect [18], [19]. Both are presented, but bias-corrected intervals from 5,000 resamples are preferred, because the product of two normal coefficients is a non-normal variable. A common lesson in this literature is that mediation can differ across subgroups. Where theory predicts heterogeneity, the appropriate move is to estimate within subgroups before pooling; a pooled estimate can hide or create an effect present in only part of the sample. And that is exactly what we see.

The vacancy itself has been measured in many ways—census counts, postal records, night-time-light remote sensing [20], [21], tax-delinquency files, and primary survey—all providing different estimates for the same place. Most of this, however, is based on a binary or unit-count notion of vacancy. The building-level rate we use is relatively infrequent but is the conceptually correct result for studying graded decay: a building with two of forty flats empty and one with all four empties are very different cases that a binary indicator would treat equally.

Empirical work on Indian vacancy is growing but is thin relative to the problem. The most rigorous econometric studies exploit variation in state-level rent-control laws to find pro-tenant laws associated with higher vacancy and document concentrated vacancy in rent-controlled Mumbai stock. This work, however, considers intentional vacancy--owners strategically holding units vacant [22] and the binary occupancy of individual units, but it does not address the physical condition of multi-unit buildings, nor does it disaggregate by structural type. Kolkata-specific research is even more scarce, and it is focused on public housing, slum informality and peri-urban expansion, rather than vacancy as a continuous, building-level outcome. The region is an instructive case because it contains an older central apartment stock, a belt of individual houses and a newer ring of gated developments, all within a single market – permitting comparison of the mechanisms across types while holding the regional context constant. To our knowledge, this is the first study providing a continuous building-level vacancy rate, typology-disaggregated mediation and full spatial pipeline to the Kolkata stock.

III.DATA AND METHODS

A. Sample and Outcome

Data were collected from a primary survey of residential buildings in 100 wards of the Kolkata metropolitan region. Each building is registered for neighborhood service quality (five Likert indicators), neighborhood crime, dwelling and household attributes (typology, size, condition, floor area, household income, price per square foot, building age), coordinates, and counts of total and vacant flats. We delete one record with no typology and some with coordinates outside the Kolkata bounding box (latitude 22.3°–22.7° N, longitude 88.2°–88.5° E). We use listwise deletion. The working sample is 1,416 buildings: 853 apartments, 281 individual houses, and 282 gated-community buildings. Figure 1 shows the location of surveyed buildings in the area.

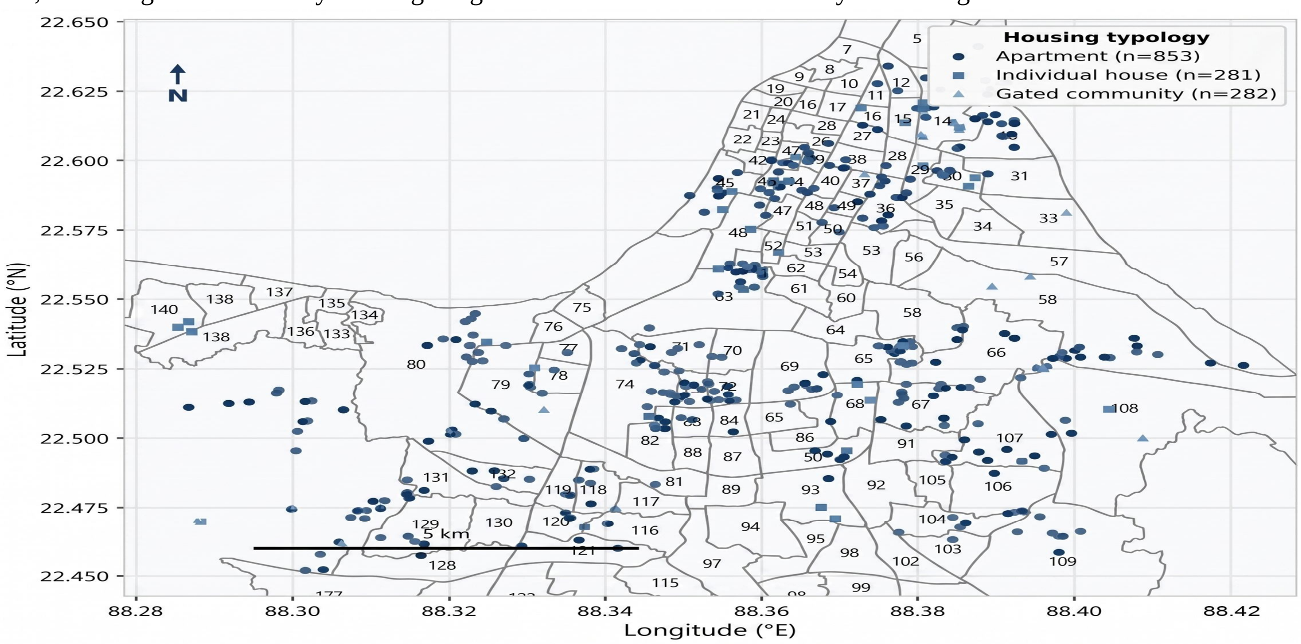

Figure 1: Study Area: surveyed residential buildings by housing typology

The result is the building level vacancy rate: vacant apartments divided by total apartments, expressed as a percentage. The mean across the sample is 10.6 per cent with a median of zero – with most buildings (61.4 per cent) fully occupied. There is a strong right skew (standard deviation 18.5 points, maximum 100 per cent). This shape, a large lump at zero with a continuous right tail, is characteristic of graded vacancy and motivates the modelling choices below.

B. The Infrastructure Quality Index and mediation

The Infrastructure Quality Index is the aggregate of five neighborhood-service indicators, each rated from one to five: street lighting, water and sanitation, garbage disposal, road quality and parks. We examine the index within each typology using Cronbach's alpha [23], the Kaiser-Meyer-Olkin measure [24] and Bartlett's test of sphericity [25] with principal component analysis in order to confirm one dominant dimension. The index is the simple unweighted sum (range 5–25); it is retained for ease of interpretation. A component score yields the same conclusions.

We estimate the mediation of the IQI–vacancy link by crime for each typology and for the pooled sample. Standardized variables are used; path an is the IQI–crime correlation, path b is the effect of crime on vacancy controlling for IQI, total effect c is the bivariate IQI–vacancy association, and the indirect effect a × b. We test it with the Sobel z and with a bias-corrected bootstrap interval (5,000 resamples). We report both because they answer slightly different questions and are most convincing when they agree, as they do here. The mediation share is the absolute indirect effect divided by the absolute total effect, and can be greater than 100 per cent when direct and indirect effects differ in sign—inconsistent or suppressor mediation [26]—which we report rather than truncate, since the pattern of signs is itself meaningful. The main object of interest is the differences between the indirect effect across typologies.

C. Regression and Spatial analysis

We regress the vacancy rate on standardised IQI, crime, building age and condition by OLS to find the dominant correlate of vacancy within each typology, with coefficients read as percentage-point changes in vacancy per standard deviation. This is a direct comparison of the broken-windows prediction (significant IQI and crime) and the aging-stock prediction (dominant age effect). For the spatial test we aggregate apartments to ward level, retaining the 37 wards with at least eight sampled apartments, and run a full pipeline on ward-mean vacancy: two row-standardised weight matrices (k-nearest-neighbours with k = 4 [27], and inverse-distance-squared); global Moran's I [28] with permutation inference; Lagrange Multiplier lag and error diagnostics with robust variants [29]; maximum-likelihood SAR and SEM models under both matrices; geographically weighted regression with a Gaussian kernel [30],[31]; and the Getis-Ord G* statistic [32] for local hotspots. Model selection between OLS, SAR and SEM is with AIC.

IV. RESULTS

A. Descriptive Statistics by Typology

Table 1 shows the descriptives for the three typologies and the pooled sample. The types differ in ways important for the analysis. The largest group is apartments (853 buildings) with many more flats per building (8.9, compared with 4.9 for individual houses and 4.2 for gated) because they are multi-unit. They also have the lowest mean lighting score, the lowest mean IQI and the highest mean crime – placing them in the more service deprived, disorder exposed parts of the metropolitan area.

Table 1: Descriptive statistics

Variable	Apartment	Individual	Gated	Pooled
n (buildings)	853	281	282	1,416
Mean vacancy rate (%)	11.09	10.71	9.05	10.61
Fully occupied (%)	56.7	64.4	72.7	61.4
Mean crime (1–4)	2.67	2.27	2.45	2.55
Mean building age (years)	11.59	11.46	10.27	11.30
Mean condition (1–5)	3.24	3.15	3.23	3.22
Mean IQI (5–25)	17.01	18.74	18.32	17.62
Mean street lighting	2.82	3.73	3.66	3.17

When measured continuously, mean vacancy is strikingly similar across the three types (11.1 percent for apartments, 10.7 for individual houses, 9.1 for gated) with a median of zero throughout. The proportion of the totally occupied buildings is steadily increasing from apartments (56.7 percent) to individual houses (64.4) to gated communities (72.7). The distribution by type is shown in Figure 2.

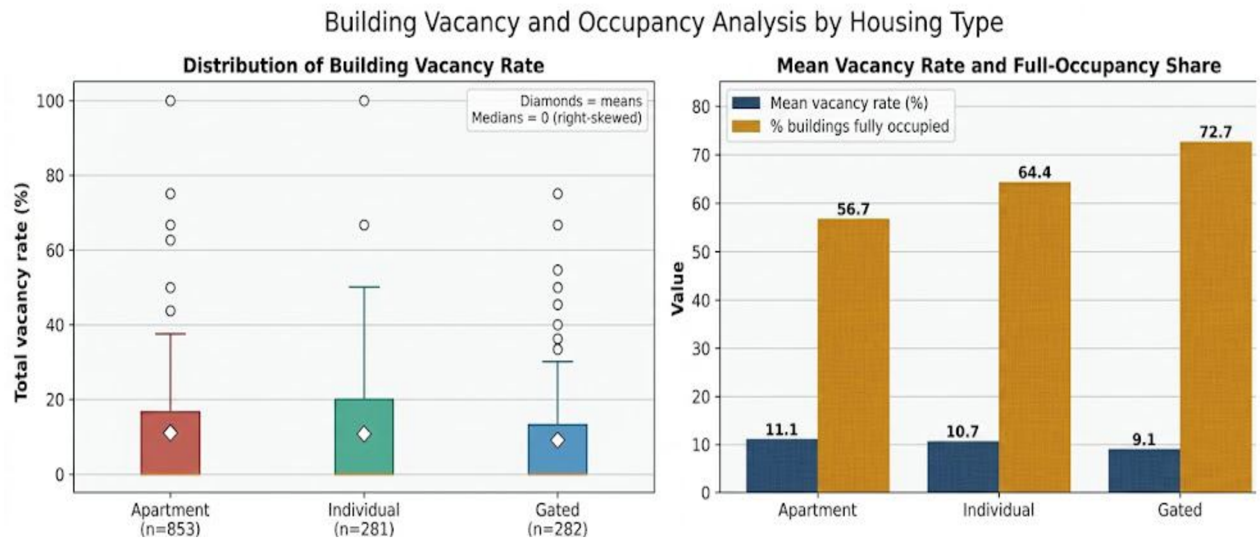

Figure 2: Building occupancy analysis by housing type

B. The Infrastructure Quality Index

Before using the index, we check that the index hangs together within each typology. The diagnostics are presented in Table 2 and Figure 3. The five indicators jointly yield a Cronbach's alpha of 0.75, a KMO of 0.74, a highly significant Bartlett test and a first component explaining 53.5 per cent of the variance. Reliability is best for individual houses (alpha 0.87, first component 66.7 per cent) and lowest - but still acceptable for composite construction - for apartments (alpha 0.70, first component 49.9 per cent).

Table 2: Significance test results

Subsample	Cronbach α	KMO	Bartlett p	PC1 variance (%)
Pooled (n=1,416)	0.750	0.739	<0.001	53.5
Apartment (n=853)	0.700	0.692	<0.001	49.9
Individual (n=281)	0.867	0.766	<0.001	66.7
Gated (n=282)	0.745	0.684	<0.001	54.4

The somewhat less reliable nature of apartments is instructive in itself: the five service indicators are less tightly correlated for apartments, consistent with apartment dwellers experiencing neighborhood services as a less integrated package. All five load positively on the first component for all five subsamples, so that higher scores always mean better infrastructure. After validating the index, we first lay down the basic association and then decompose it. Vacancy across three IQI bands is shown in Figure 4. The gradient is monotonic and sizeable, 14.1 per cent in low-IQI neighborhoods (5–16), 8.8 in medium (17–20) and 7.5 in high (21–25). The one-way ANOVA is highly significant ($F = 17.85$, $p < 0.001$) and the correlation between IQI and vacancy is negative (Pearson $r = -0.13$, Spearman $\rho = -0.17$, both $p < 0.001$). Improved infrastructure brings lower vacancy and the question is whether that runs through crime.

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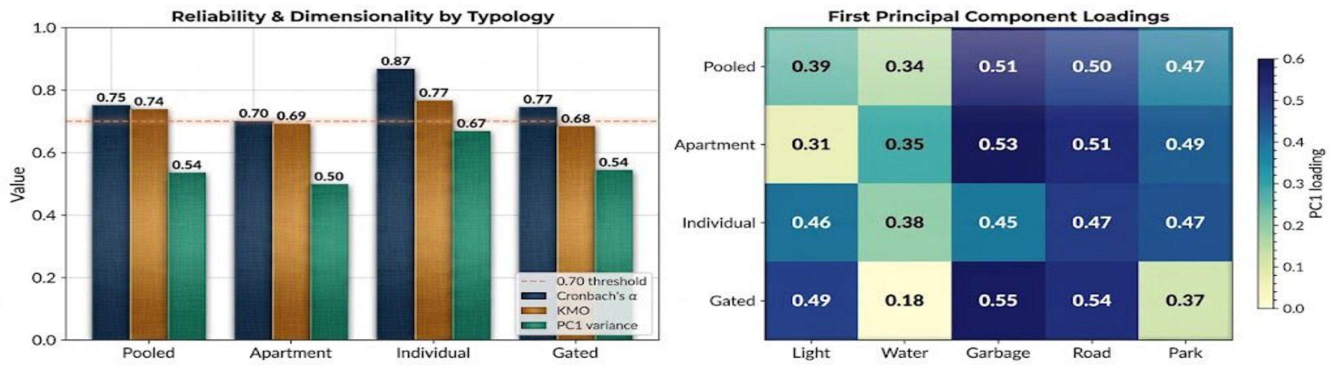

Figure 3: IQI measurement model and PC1 loadings

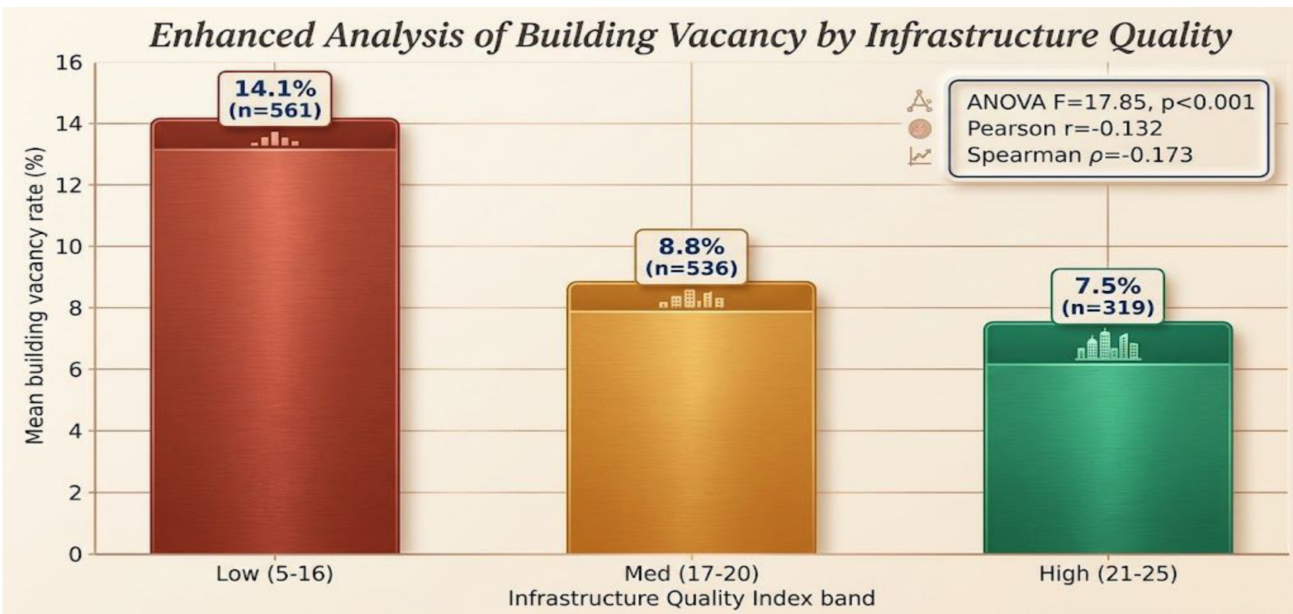

Figure 4: Mean Vacancy rates

C. The Infrastructure Quality Index

The mediation analysis is the core of the paper. Table 3 lists path coefficients, indirect effect, Sobel test, bootstrap interval and mediation share for each typology and for the pooled sample. The path diagrams and the indirect effects with their intervals are given in Figures 5 and 6.

Table 3: Mediation of crime on IQI to vacancy by housing typology

Subsample	a (IQI to crime)	b (crime to vacancy)	c (total)	Indirect (a×b)	Sobel p	95% CI	Med. %
Pooled	−0.681	+0.160	−0.132	−0.109	<0.001	[−0.160, −0.058]	82.6
Apartment	−0.648	+0.024	−0.099	−0.015	0.596	[−0.078, +0.048]	15.5
Individual	−0.710	+0.236	−0.124	−0.168	0.005	[−0.292, −0.026]	135.4
Gated	−0.733	+0.559	−0.234	−0.410	<0.001	[−0.555, −0.287]	175.0

Begin with the pooled sample. The IQI → crime path is strongly negative (a = −0.68): better infrastructure, less crime. The crime → vacancy path is positive (b = +0.16): more crime, more vacancy. Their product is a negative indirect effect (−0.109), which against a total effect of −0.132 yields a mediation share of 82.6 per cent — strong support for broken windows read alone. The Sobel test was highly significant ($z = -4.44$, $p < 0.001$) and the bootstrap confidence interval did not include zero.

The typology decomposition overthrows that reading. The mediation is even stronger than pooled in gated communities: the path crime → vacancy is large (b = +0.56), the indirect effect is −0.410, and the interval is well clear of zero ([−0.555, −0.287], $z = -6.60$, $p < 0.001$). In single-family houses it is significant but smaller (-0.168, $z = -2.80$, $p = 0.005$). But in apartments – 853 of the 1,416 buildings – the crime to vacancy path is almost gone (b=+0.024), the indirect effect is down to −0.015, the interval includes zero (−0.078, +0.048), and the Sobel test is nowhere near significant (z=−0.53, p=0.60). For the largest and highest-vacancy type in the stock, the infrastructure–vacancy link is not mediated by crime.

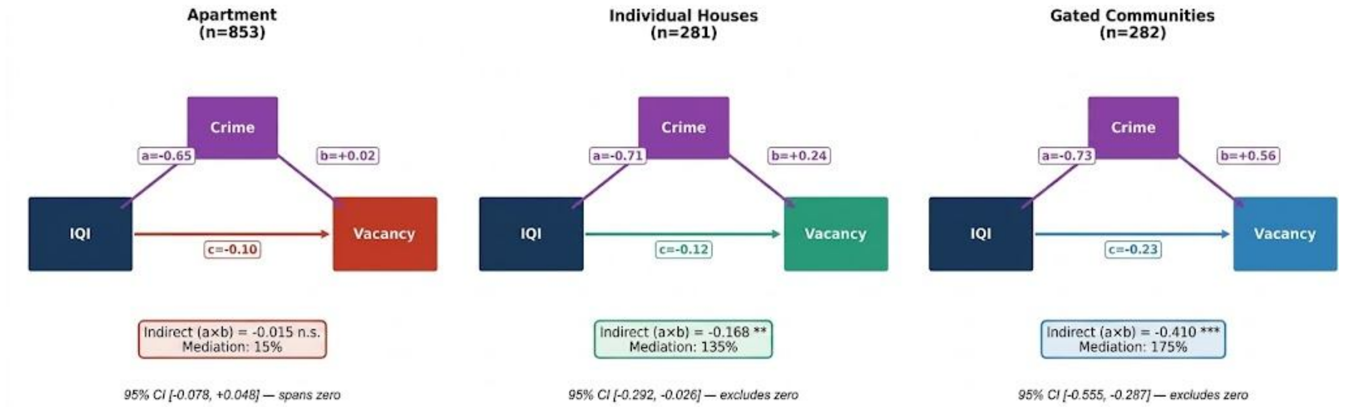

Figure 5: Differential mediation across building typologies

The positive shares above 100% for single family homes and gated communities indicate suppressor mediation. For these types, the direct effect of IQI on vacancy (controlling for crime) is positive, while the total effect is negative, meaning the crime channel more than offsets the total. Substantively, in gated communities almost all of the protective effect of good infrastructure is through crime – the broken-windows prediction – and absent this channel better served developments would have, if anything, marginally higher vacancy, plausibly because the best served gated projects are also the newest and least fully absorbed.

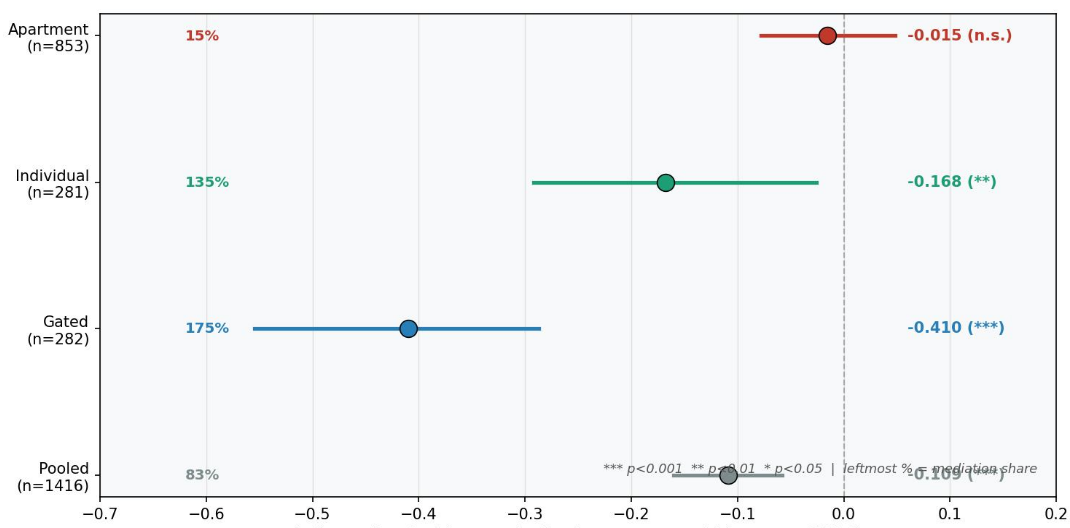

Figure 6: Indirect effects with bootstrap 95% intervals by typology. The apartment effect is indistinguishable from zero; mediation shares appear at left.

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The main result is the contrast between the apartments and the gated communities. Broken windows is not absent in Kolkata, it operates strongly in gated communities and visibly in individual houses but does not rule apartments, which house most vacant flats. A pooled analysis would have averaged across these types, reported strong mediation, and incorrectly concluded that broken windows explain apartment vacancy.

D. What drives Housing Vacancy

What mediates apartment vacancy, if not crime? Table 4 shows OLS regressions of the vacancy rate on standardized IQI, crime, building age and condition, by typology, in percentage points per standard deviation.

Table 4: OLS regression result

Predictor	Apartment β (p)	Individual β (p)	Gated β (p)
IQI	−0.93 (0.283)	+2.97 (0.065)	+3.84 (0.009)
Crime	+0.90 (0.289)	+5.71 (<0.001)	+11.71 (<0.001)
Building age	+1.78 (0.006)	+0.87 (0.419)	+3.31 (0.001)
Condition	−0.60 (0.360)	−4.00 (<0.001)	−2.64 (0.007)
R^2	0.021	0.088	0.249

The apartment column is empty. The only significant predictor was building age (β = +1.78 points per standard deviation, p = 0.006). Once age is entered, condition itself does not matter, and neither IQI (β = -0.93, p = 0.28) nor crime (β = +0.90, p = 0.29) does. The model does a poor job of explaining the variation (R2 = 0.021), which is informative in itself: at the building level the measured neighborhood and structural covariates explain only a small part of the variation in apartment vacancy, with age being the one variable with a reliable signal.

The gated column is almost a mirror image. Crime is dominant (β = +11.71, p < 0.001) – an order of magnitude larger than anything in the apartment model – and IQI, age and condition are also all significant, with the model explaining a quarter of the variance (R^2 = 0.249). In between are single houses, where both crime and condition are important. Figure 7 shows the age gradient for apartments with the apartment coefficients and Figure 8 shows the full cross-typology coefficient structure.

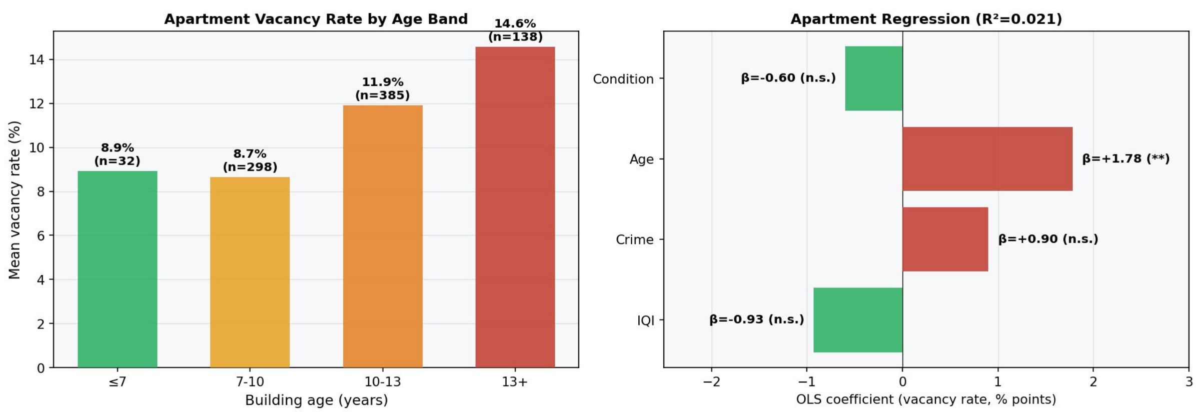

Figure 7: Left: mean vacancy by age band. Right: apartment regression coefficients; only age is significant.

The age gradient in the left panel of Figure 7 is the regression estimated empirically. Apartment vacancy is about flat for up to ten years (around 9 per cent) then rises – to 11.9 per cent for ten to thirteen years and 14.6 per cent for more than thirteen. This is the signature the aging-stock account predicts and broken windows does not: vacancy builds up with age, no matter what the crime environment is.

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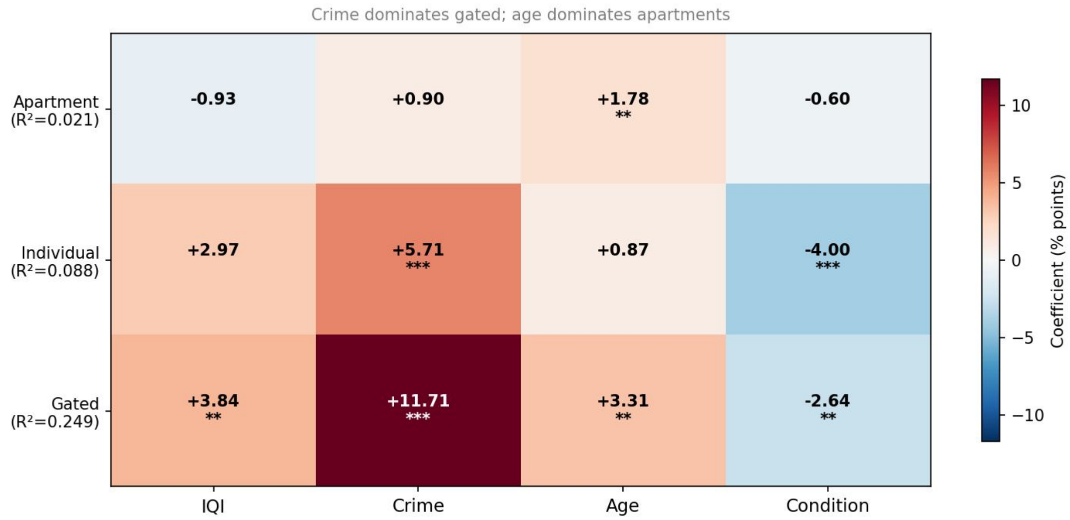

Figure 8: Regression coefficients across typologies

The combined results of the mediation and regression point one way. Broken windows is very real and strong in gated communities, where residents have paid to have their neighborhood secured and their sensitivity to crime is highest. Vacancy in apartments is explained by building age, the clearest indicator of accumulated physical decay, and is essentially insensitive to infrastructure and crime once age is controlled for.

E. Spatial structure of Apartment Vacancy

The aging-stock reading makes one more independent prediction: the decay is a within-building process, so the continuous vacancy rate should be spatially idiosyncratic rather than clustered. To test this, we aggregate apartments to the ward level, retain the 37 wards with at least eight sampled apartments, and run a full spatial pipeline on ward-mean vacancy.

Under both weight matrices, global Moran's I is small and insignificant: I = +0.093 (permutation p = 0.36) under k-nearest-neighbors, and I = +0.054 (p = 0.49) under inverse-distance-squared. Neither is significant. The ward-mean building age suggests a slightly more structured pattern (Moran’s I = −0.166, p = 0.09); crime and IQI are also spatially unstructured. In short, the vacancy rate is not concentrated. Figure 9 shows the Moran scatterplot and the ward map. The statistic is supported by the almost flat slope and the absence of any distinct high-vacancy area.

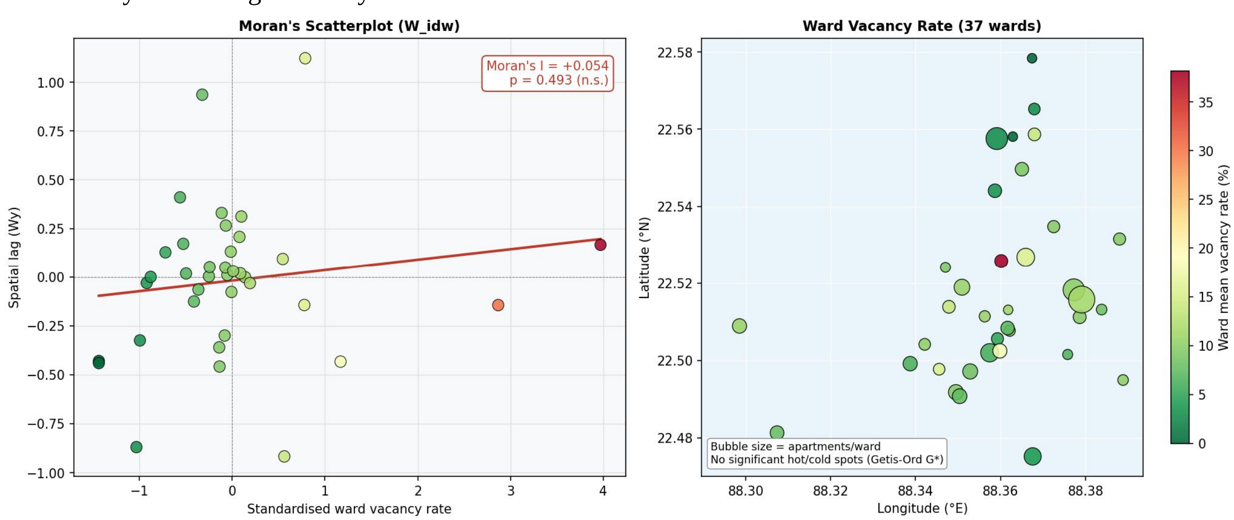

Figure 9: Spatial structure of ward-level apartment vacancy. Left: Moran scatterplot (inverse-distance weights), near-flat slope, non-significant Moran's I. Right: ward-level vacancy map showing no coherent cluster.

The diagnostics of the Lagrange Multiplier agree. Neither the LM-lag nor the LM-error is significant under either matrix (all $p > 0.5$) and the robust versions are also insignificant — there is no spatial dependence for a lag or error model to capture. SAR and SEM, in any case, we estimate for completeness (Table 5). All spatial parameters are small and not significant (ρ from +0.058 to +0.136, λ from −0.073 to +0.090). Decisively, plain OLS gets the smallest AIC (259.27) among the five models. The non-spatial model wins on the standard criterion, the opposite of what a neighborhood-mediated process would do. What an aging-stock process predicts.

Table 5: Spatial-econometric model comparison for ward level apartment vacancy. OLS attains the lowest AIC; no spatial parameter is significant.

Model	Spatial param.	p	AIC	R^2
OLS	—	—	259.27	0.061
SAR (W_knn)	ρ = +0.136	0.570	260.96	—
SAR (W_idw)	ρ = +0.058	0.841	261.23	—
SEM (W_knn)	λ = +0.090	0.749	261.17	—
SEM (W_idw)	λ = −0.073	0.833	261.23	—

A geographic weighted regression (Gaussian kernel, approximate 4-km bandwidth) tells the same story: the local age coefficient varies, but not in a coherent geographic pattern, and the global age effect does not emerge as local clusters. The Getis-Ord G* statistic reveals no significant hot or cold spots. The local z-scores range from −0.34 to +0.38, far from significance. The G* result is shown in Figure 10. No ward or group of wards show detectable concentration of apartment vacancy.

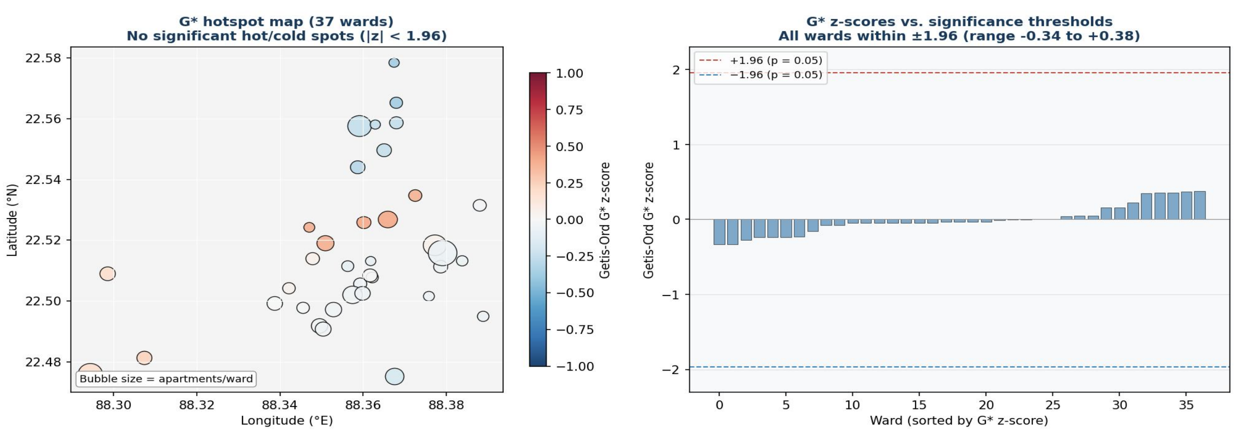

Figure 10: Ward-level Getis-Ord G* hotspot analysis of apartment vacancy. Left: G* map; colour is the local z-score, bubble size the apartments sampled per ward. Right: G* z-scores against the ±1.96 thresholds. No ward is a significant hot or cold spot; z-scores

The spatial results are uniformly negative, and the uniformity is the point. For the continuous apartment vacancy rate, the Moran's I, the LM diagnostics, SAR and SEM, GWR and Getis-Ord G* show no significant clustering. This is a useful contrast with analyses of binary vacancies, where ward clustering is more easily identified – and the difference is diagnostic. The binary 'any vacancy' indicator captures the shared neighborhood characteristics of adjacent wards, while the continuous rate, measuring intensity within each building, isolates a building-internal process that ignores ward boundaries. In concrete terms, two adjacent buildings sharing the same lighting, sanitation, policing and crime would have similar outcomes if vacancy were neighborhood-driven, and aggregating to the ward would sharpen that signal. If, instead, vacancy is a function of the age and maintenance backlog of each building, then two neighbors of different vintages can diverge sharply, and the ward mean averages over a heterogeneity with no spatial coherence. The loss of spatial autocorrelation is thus not an empty null; it is positive evidence for a building-scale, rather than neighborhood-scale, process.

V. DISCUSSION

So there are three independent lines of evidence for an aging-stock reading of apartment vacancy. The mediation analysis shows that crime does not mediate the relationship between infrastructure and vacancy in apartments, but mediates it strongly in gated communities. The regression tells the same story from another perspective. Age is the only significant correlate of apartment vacancy. Neither infrastructure nor crime survives the inclusion of age. The spatial analysis completes the circle: apartment vacancy does not cluster in space, as a neighbourhood-driven process would require, but is idiosyncratic, as a building-interior process implies. No single result is conclusive; their strength is in their mutual reinforcement.

The mechanism we propose is deferred maintenance in aging multi-owner buildings whose resident welfare associations do not have the wherewithal to fund major capital works. Common systems - lifts, pumps, façades, drainage - have needed expensive restoration over the last decade or so, which the association has struggled to fund per unit. Owners who are able to leave do so, creating vacancies and reducing the base-funding maintenance which accelerates the decline and leads to more exits. It's a self-reinforcing spiral of maintenance, not crime, structurally similar to broken windows but at the scale of the building.

It makes sense that broken windows is strongest in gated communities. Gated communities are, by design, paid insulation from their surrounding neighbourhood, so residents are very sensitive to the disorder they are meant to keep out – hence the very large crime to vacancy coefficient ($\beta = +11.7$ points per standard deviation). Gated developments are also newer, so the internal-decay process dominating apartments has had less time to work, and the disorder channel may be more obvious. The two types are located at opposite ends of a spectrum: new, outward-facing gated communities display broken windows at its clearest; older, inward-facing apartments display aging-stock decay. Without the continuous outcome, none of this is visible. A binary indicator would consider one empty flat in forty as a totally empty building, losing the very intensity information that differentiates gradual decay from abrupt abandonment, and it is the continuous rate that exposes the spatial idiosyncrasy, because the process exists at the building scale. The lesson is general: the choice between binary and continuous measures of vacancy is not innocuous and can determine which mechanism the data appear to support. The findings have implications for two literatures. Broken windows provide a rare direct test of the central mediation prediction within structurally distinct subgroups, where it holds in some and fails in others. And they show that testing on pooled samples is risky, because pooling here would have reported 82.6 per cent mediation and declared the theory confirmed for a stock where it fails. The mechanism is a function of housing form and its apparent aggregate strength may reflect operation in a minority of the stock. Findings from the vacancy literature show the value of a disaggregated, intensity-graded measure and typology and identify aging-stock decay — well developed in theory but rarely tested with primary data — as the operative process in a major Indian apartment stock. More generally, the case is a reminder that when an outcome can be generated by different processes in different subpopulations, the subgroup decomposition should be the primary analysis and not a robustness check. This is all subject to several limitations. The design is cross-sectional and the causal claim of age driving vacancy through a maintenance-coordination channel would require longitudinal data on vacancy transitions and building finance which we do not have. The mechanism itself is not measured via association dynamics, but inferred from its predicted signature – the age gradient, crime-insensitivity, spatial idiosyncrasy. Internally, the apartment category is diverse (low- and high-rise, owner-occupied and investor-held), and a more refined typology would sharpen the picture. The ward-level spatial analysis smooths out heterogeneity within wards, although the building-level idiosyncrasy we document makes hidden structure unlikely. And the crime measure is perceptual, not an administrative count, and the two don't always align.

VI. CONCLUSION

We examined the broken-windows pathway – infrastructure to crime to vacancy – in the Kolkata housing stock, employing a continuous building-level vacancy rate disaggregated by three housing types. The central finding is mediating differentiation. Crime strongly mediates the infrastructure-vacancy link in gated communities (share 175 per cent, indirect effect −0.410, $p < 0.001$), and significantly in individual houses (135 per cent, $p = 0.005$), but negligibly in apartments (15 per cent, indirect effect −0.015, interval spanning zero). The 82.6 per cent pooled result, which on its own would seem to confirm the theory, is an artefact of pooling across heterogeneous types. In the largest and highest-vacancy category of apartments, vacancy is determined instead by building age ($\beta = +1.78$ points per standard deviation, $p = 0.006$). Infrastructure and crime are not significant with age controlled. There is no significant spatial clustering for the full battery of tests for vacancy. We interpret this convergent evidence, not as the neighbourhood-mediated process at work in lower-density types, but as the signature of an aging-stock decay process internal to the building (plausibly driven by deferred-maintenance coordination failure in multi-owner structures). The policy implications are clear and differentiated. Neighbourhood interventions (lighting, policing, sanitation) will do little for apartment vacancy – the bulk of the problem – because it is building-internal decay, not neighbourhood disorder. The levers that matter is in the stock of buildings: structured support for major capital expenditure by aging resident welfare associations, rules that strengthen their ability to levy and enforce maintenance contributions and build reserves, and facilitated redevelopment for the worst-deteriorated buildings. Then, in gated-community and individual-house wards where broken windows operate, we can expect that neighbourhood investments in safety and infrastructure will reduce vacancy. And because apartment vacancies are not spatially clustered, area-based programmes that treat whole wards will be poorly matched to a problem distributed building-by-building; building-level diagnosis and support should do better. In short, vacancy policy needs to be targeted by housing type, and pursued at the scale of the building rather than the area. Future work should attempt to locate the longitudinal and building-finance data needed to directly confirm the maintenance-coordination mechanism, and test whether this differential-mediation pattern recurs in other Indian metropolitan markets.

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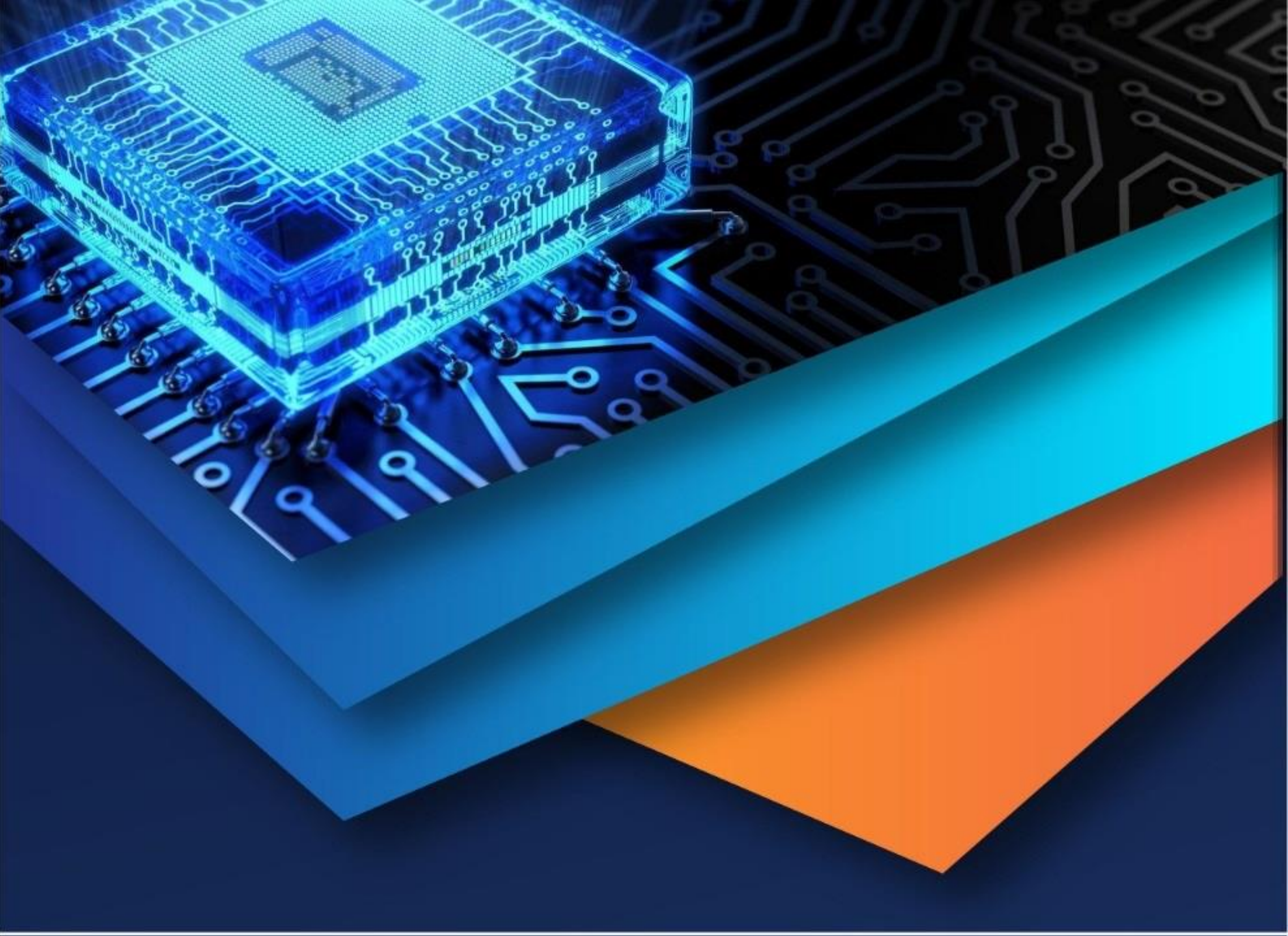

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