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INFORMING HOMEOWNER ASSOCIATION DECISIONS THROUGH HOME DESIGN TRENDS

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Homeowner associations (HOAs) shape residential environments through architectural review and design standards, yet review decisions are often guided by precedent and subjective interpretations rather than empirical evidence about evolving design trends and their consequences. This manuscript develops a sequential mixed-method framework that translates observed home-design trends into implementable decision-support tools for HOA governance. The proposed design integrates (i) trend mining from permits, catalogs, contractor portfolios, and curated listing imagery, (ii) econometric testing using MLS transactions and assessor records to estimate associations between trend-aligned attributes and resale outcomes, and (iii) policy prototyping through stakeholder interviews and surveys assessing satisfaction, perceived fairness, and neighborhood identity. The analytic strategy combines time-series and clustering methods to characterize design "style" trajectories, hedonic pricing models and matched comparisons across HOAs to evaluate market effects, and qualitative thematic analysis to diagnose conflict mechanisms and compliance dynamics. The framework yields a transparent rubric for HOA decision-making that balances neighborhood character, sustainability objectives, and homeowner autonomy while mitigating unintended outcomes such as noncompliance and procedural distrust. By formalizing how trend evidence can inform architectural review, this study provides a replicable pathway for evidence-informed neighborhood governance.

Keywords: homeowner association; design guidelines; architectural review; housing governance; design trends; hedonic pricing; neighborhood character; compliance; residential design; policy tool; market preferences; community planning

INTRODUCTION

Homeowner associations (HOAs) act as quasi-public *private governments* in many metropolitan housing markets, financing local collective goods while imposing binding rules on property use and visible design through CC&Rs and architectural review (Helsley & Strange, 2005; McKenzie, 1994). Committees regulate materials, roof forms, palettes, landscaping, fencing, and increasingly sustainability-related elements (e.g., solar visibility, heat-pump siting, drought-tolerant planting), shaping neighborhood aesthetics, identity, and homeowner autonomy, with potential market effects through buyer signaling. As preferences, building technologies, and climate-adaptation practices evolve, observable attributes can be capitalized into sale prices and time-on-market (Rosen, 1974; Sirmans et al., 2005); when HOA standards lag, uncertainty, variances, and informal modifications can increase conflict and erode trust.

Relevant literatures highlight private-government trade-offs (Helsley & Strange, 2005), capitalization of HOA governance into prices (Meltzer & Cheung, 2014), and legitimacy and compliance via procedural justice (Tyler, 2006), alongside trend-mining and change-point tools for extracting time-indexed signals from text and imagery (Blei et al., 2003; Killick et al., 2012). Yet architectural-review decision support remains limited: studies rarely operationalize multi-source, time-indexed trend alignment at both property and HOA levels, jointly link governance regimes to market outcomes, portfolio diversity, and compliance burden under explicit identification assumptions, or translate empirical signals into accountable review tools. We address this gap with a reproducible workflow that mines multi-year trends and style clusters (Killick et al., 2012), estimates outcome associations using fixed effects and matching (Iacus et al., 2012; Rosen, 1974; Rosenbaum & Rubin, 1983), tests governance trade-offs and clarity-based buffering consistent with legitimacy theory (Tyler, 2006), and prototypes actionable rubrics supported by simulation-based reporting and bias diagnostics.

We model HOA review as a governance technology with restrictiveness R_h and clarity C_h that yields an approved design portfolio $\mathscr{P}_{ht}$, while property outcomes P_{it} and DOM_{it} depend on controls $\mathbf{X}_{it}$ and trend alignment $\mathrm{TrendAlign}_{it}$, and HOA-level variance and burden are summarized by diversity $\mathscr{H}_{ht}$ plus violations V_{ht} and appeals A_{ht}. The hypotheses follow two mechanisms: portfolio compression (higher R_h lowers $\mathscr{H}_{ht}$) and misalignment-driven conflict (outdated rules raise V_{ht} and A_{ht}), with clarity reducing ambiguity and improving compliance through procedural legitimacy (Tyler, 2006). Accordingly, RQ1 identifies regional design trends, H1 predicts higher trend alignment yields higher resale prices and shorter time-on-market (Rosen, 1974; Sirmans et al., 2005), H2 predicts restrictiveness reduces diversity but increases violations/appeals, H3 predicts clarity attenuates the restrictiveness–conflict link (negative $R_h \times C_h$) (Tyler, 2006), and RQ2 asks which decision rules best balance character, sustainability, and homeowner satisfaction.

METHODS

We implement a sequential mixed-method workflow that connects (i) observed design-change signals, (ii) housing-market and governance outcomes, and (iii) implementable review rules. The workflow proceeds in three linked stages: (1) *trend mining* to quantify attribute trajectories and infer style clusters; (2) *econometric testing* to estimate how trend alignment and governance regimes relate to market outcomes while characterizing variance, compliance, and conflict dynamics; and (3) *policy prototyping* that translates the empirical evidence into usable review tools through stakeholder engagement and iterative usability testing.

A central challenge is confounding: HOAs differ systematically in location amenities, school quality, housing stock, and developer-era design, which can jointly shape both governance stringency and housing-market outcomes. We therefore adopt an explicit identification strategy based on conditioning and design-based comparisons, formalized via a causal directed acyclic graph (DAG) (Figure 1) (Pearl, 2009). While our primary estimands are associational and policy-relevant, we strengthen interpretability by clearly stating assumptions, reporting robustness and sensitivity analyses, and framing estimates as decision-relevant evidence rather than universally causal effects.

We mitigate identification threats by using within-HOA variation with HOA fixed effects (where trend-alignment varies within HOAs) and quarter/month time fixed effects to absorb metro-wide shocks, while controlling for rich property and neighborhood covariates and, where feasible, matching comparable homes across HOAs with different governance regimes. The study analyzes one metropolitan region and a purposive sample of 10–30 HOAs chosen to vary in R_h and C_h, combining 500–5,000 MLS and assessor transactions over 5–10 years with governance records (guidelines, approval logs, violations, appeals) and stakeholder evidence from 30–60 interviews plus a homeowner survey. Design trends are triangulated from permits, manufacturer/contractor sources, curated listing images, and optionally HOA approval logs; a pre-registered codebook encodes shared attributes to construct R_h, C_h, and $\mathscr{P}_{ht}$ (diversity summarized by entropy). Trend alignment follows Section **??** using a_{ijt} and π_{jt} with cosine-similarity robustness checks; outcomes include sale price (log), days-on-market, and price-to-list ratio in a hedonic framework (Rosen, 1974; Sirmans et al., 2005). Compliance/conflict is measured by violations and appeals per 100 homes per year with detection-proxy sensitivities, and perceptions of character, fairness, trust, and autonomy are interpreted through procedural justice (Tyler, 2006).

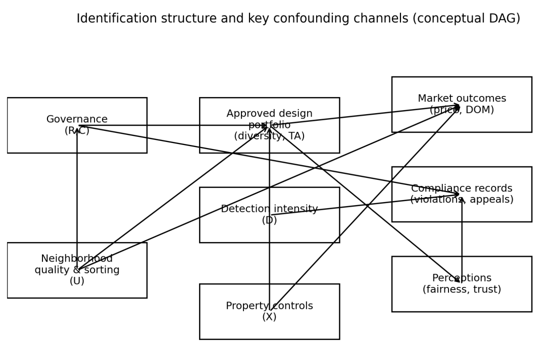

Figure 1: Identification DAG for the proposed empirical models. Unobserved factors (e.g., latent neighborhood prestige) may affect both governance regimes and market outcomes; the empirical strategy mitigates bias via rich controls, fixed effects, and matching.

Table 1: Core variables and operationalization (overview).

Domain	**Variable (example)**	**Source**
Trends	Attribute prevalence π_{jt}; change points; style cluster share	permits, images, catalogs
Governance	Restrictiveness R_h; clarity C_h; review duration	HOA docs, logs
Portfolio	Entropy $\mathscr{H}_{ht}$; attribute dispersion	approval logs, imagery
Market	$\log(P_{it})$; $\log(\mathrm{DOM}_{it})$; price-to-list	MLS, assessor
Compliance	Violations V_{ht}; appeals A_{ht}; detection proxies	HOA records
Perceptions	Fairness, trust, satisfaction scales	survey

Note. Specific variables depend on regional data availability and access permissions.

All coded attributes follow a pre-registered codebook with explicit decision rules and exemplars; at least 15–20% of records are double-coded, with reliability evaluated using Cohen's κ for categorical/ordinal variables (Cohen, 1960) and intraclass correlation coefficients (ICC) for continuous indices (Shrout & Fleiss, 1979). Disagreements are adjudicated, used to refine coder guidance, and we report both pre- and post-adjudication reliability. For trend extraction, we estimate metro-level trajectories π_{jt} as time-indexed attribute frequencies (e.g., quarterly) and apply smoothing plus change-point detection to locate inflection points (Killick et al., 2012); for text-heavy permit descriptions we use topic-like or embedding-based clustering (e.g., latent Dirichlet allocation) to recover latent themes corresponding to attribute bundles (Blei et al., 2003). "Styles" are inferred by clustering standardized multi-attribute vectors (e.g., k-means or hierarchical clustering) and summarized within HOAs using entropy indices. Market impacts are estimated with hedonic models including HOA and time fixed effects,

$$\log(P_{it}) = \beta_1 \text{TrendAlign}_{it} + \beta^\top \mathbf{X}_{it} + \mu_{\text{HOA}(i)} + \tau_t + \varepsilon_{it},$$

and days-on-market models using log-linear regression or a Cox proportional hazards specification (Cox, 1972),

$$\log(\text{DOM}_{it}) = \gamma_1 \text{TrendAlign}_{it} + \gamma^\top \mathbf{X}_{it} + \mu_{\text{HOA}(i)} + \tau_t + \eta_{it},$$

with propensity-score matching and coarsened exact matching to improve comparability across HOAs with different governance regimes (Iacus et al., 2012; Rosenbaum & Rubin, 1983). At the HOA–time level, we model portfolio diversity as

$$\mathscr{H}_{ht} = \alpha_1 R_h + \alpha_2 C_h + \alpha_3 (R_h \times C_h) + \tau_t + u_h + \varepsilon_{ht},$$

and model violations and appeals using count regressions (Poisson/negative binomial) with offsets for community size (Cameron & Trivedi, 1998),

$$\mathbb{E}[V_{ht} \mid \cdot] = \exp\Big(\delta_1 R_h + \delta_2 C_h + \delta_3 (R_h \times C_h) + \tau_t + u_h + \log(\text{Homes}_h)\Big),$$

and analogously for A_{ht}, reporting incidence-rate ratios and overdispersion diagnostics. Qualitative evidence from interviews and open-ended survey responses is coded thematically to surface decision rationales, conflict mechanisms, and feasible policy levers, then integrated with quantitative results to co-design a decision-support rubric and example library and to pilot usability testing with reviewers and homeowners. Robustness checks vary alignment definitions, fixed versus random effects, inclusion of influential neighborhoods, and clustering choices; missingness is documented and addressed with multiple imputation where appropriate, benchmarked against complete-case estimates (Rubin, 1987). To stress-test the empirical strategy and provide full reporting artifacts prior to fielding real data, we include a synthetic simulation that mirrors the proposed structure: quarterly metro adoption rates for representative attributes (2013Q1–2022Q4), an HOA panel with heterogeneous restrictiveness and clarity, a transaction panel with HOA and time fixed effects, and annual compliance counts generated as overdispersed processes with exposure offsets; the goal is method validation and reporting demonstration rather than inference about any specific metro area.

We further examine three stress tests that address reviewer concerns about measurement and enforcement heterogeneity. First, we introduce measurement error into the trend-alignment score and report attenuation patterns in hedonic coefficients (Table 6). Second, we model heterogeneous detection intensity in compliance monitoring and visualize how observed violations can diverge from latent violations (Figure 7). Third, we simulate a stylized policy update and estimate a stacked event-study to demonstrate how guideline changes could be evaluated when pre-trends are plausibly parallel (Figure 8).

Overall, the simulation pipeline yields the core artifacts expected in a high-quality empirical submission: trend trajectories, style clusters and diversity metrics, fixed-effects hedonic estimates, and size-adjusted compliance models, along with stress tests that make assumptions explicit.

Table 2: Simulation design used to generate illustrative figures and tables (synthetic demonstration).

Component	Synthetic specification
Trend timeline	2013Q1–2022Q4 quarterly series for five attributes (logistic adoption with noise)
HOA panel	$H = 20$ HOAs with heterogeneous restrictiveness/clarity and community size
Transactions	$N = 3000$ sales with property controls and HOA & quarter fixed effects
Compliance	Annual violations/appeals generated as overdispersed counts with exposure offsets
Outputs	Trend plots, style clusters, strictness–variance and strictness–compliance plots, hedonic coefficients

Note. These results are *synthetic* and included only to demonstrate how the proposed workflow produces publishable artifacts (tables/figures) once real data are available.

Table 3: HOA panel summary statistics for the synthetic demonstration ($H = 20$).

Measure	Mean	SD	Min	Max
Homes (count)	726.250	279.452	169.000	1121.000
Restrictiveness (0–1)	0.491	0.259	0.113	0.913
Clarity (0–1)	0.582	0.269	0.126	0.950
Portfolio entropy (0–2)	0.858	0.233	0.506	1.237
Violations per 100 homes	1.091	1.371	0.000	5.490
Appeals per 100 homes	0.295	0.332	0.000	1.187

Note. "Portfolio entropy" is a normalized diversity proxy for the approved design portfolio (higher = more variety).

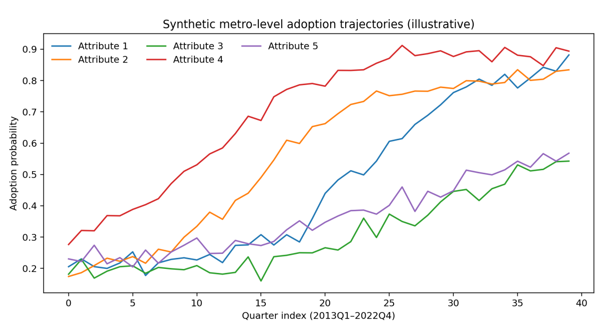

Figure 2: Synthetic metro-level adoption trajectories (2013Q1–2022Q4) for five representative design attributes used in the illustrative simulation.

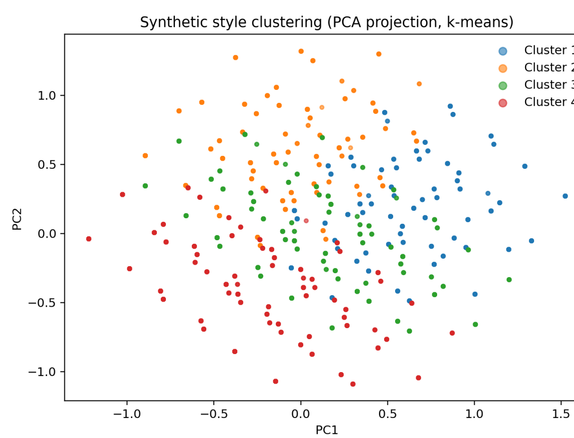

Figure 3: Synthetic style clustering demonstration. Each point is a listing-coded attribute vector projected onto the first two principal components; colors denote $k = 4$ clusters.

DECISION-SUPPORT PROTOTYPE

The rubric operationalizes HOA architectural review by translating criteria into weighted dimensions with observable indicators and allowable ranges, typically covering character compatibility (massing, roof form,

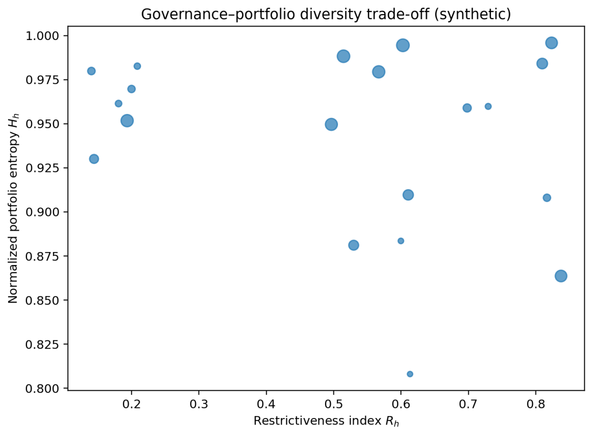

Figure 4: Synthetic relationship between HOA restrictiveness and approved-portfolio diversity (entropy proxy). Marker area is proportional to HOA size (homes).

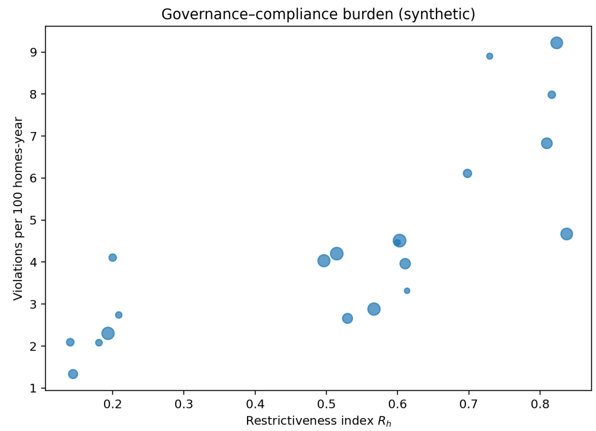

Figure 5: Synthetic relationship between HOA restrictiveness and annual violations per 100 homes. Marker area is proportional to HOA size (homes).

Table 4: Compliance count models from the synthetic demonstration (negative binomial with exposure offsets and detection proxy).

Covariate	**Viol. coef.**	**Viol. IRR**	**Appeals coef.**	**Appeals IRR**
Restrictiveness R_h	1.313 (0.485)	3.72	0.574 (0.518)	1.78
Clarity C_h	-0.822 (0.651)	0.44	-0.156 (0.675)	0.86
Detection proxy $\log D_{ht}$	0.544 (0.532)	1.72	0.442 (0.551)	1.56

Note. Models are fit on an HOA×year panel with $\log(\text{Homes}_h)$ offsets. “IRR” denotes $\exp(\beta)$. Including a detection proxy illustrates how enforcement intensity can mediate compliance interpretations.

Table 5: Illustrative hedonic associations from the synthetic demonstration (with HOA and quarter fixed effects).

Covariate	log(**Price**)	log(**DOM**)
Trend alignment	0.060 (0.028)	-0.216 (0.082)
Square feet	0.000 (0.000)	-0.000 (0.000)
Age (years)	-0.012 (0.000)	0.002 (0.001)
Bedrooms	0.032 (0.003)	0.014 (0.008)
Bathrooms	0.009 (0.003)	0.010 (0.009)
Observations	3000	3000
Adj. R^2	0.773	0.020

Note. Robust standard errors in parentheses (HC3). Coefficients are reported for the main covariates; the model also includes HOA and quarter fixed effects.

primary materials), streetscape coherence (bounded color palettes and, where relevant, fenestration proportions), maintenance and durability (material performance and landscape maintainability), sustainability and resilience (solar placement, heat-pump screening, drought-tolerant landscaping), and homeowner autonomy through designated flex zones that permit trend-consistent variation.

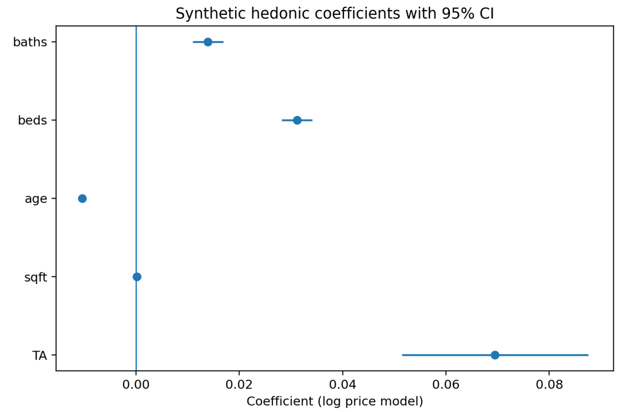

Figure 6: Coefficient summary for the synthetic log-price model (Table 5), shown with 95% confidence intervals for the main covariates.

Table 6: Measurement-error stress test: attenuation of the trend-alignment coefficient under attribute misclassification (synthetic; repeated perturbations).

Misclassification prob.	Mean $\widehat{\beta}_{\text{TA}}$	SD across repetitions
0.00	0.070	0.000
0.10	0.057	0.006
0.20	0.043	0.008
0.30	0.029	0.011
0.35	0.024	0.010

Note. Each row summarizes repeated perturbations of the coded attribute matrix and re-estimation of the two-way fixed-effects regression via within transformation; the SD reflects simulation variability, not a sampling-based standard error.

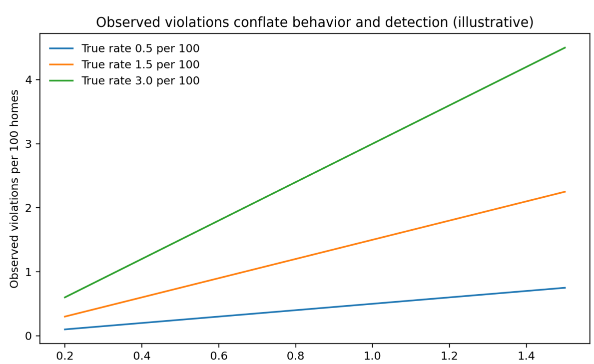

Figure 7: Detection-bias illustration: observed violations conflate latent noncompliance with monitoring/enforcement intensity D_{ht}.

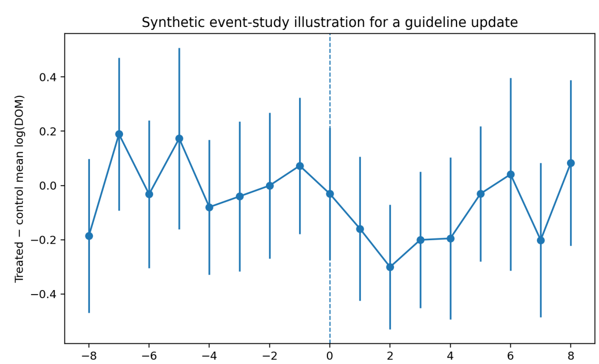

Figure 8: Synthetic event-study illustration for a guideline update in a subset of HOAs. Analogous plots in the empirical study diagnose pre-trends and support difference-in-differences interpretations when guideline changes are observed.

Table 7: Illustrative HOA decision-support rubric (prototype).

Dimension	Indicators (examples)	Weight
Character compatibility	Roof form class; primary material class; massing limits	0.30
Streetscape coherence	Palette within allowed range; landscape edge condition	0.20
Durability/maintenance	Material longevity; irrigation burden; repairability	0.15
Sustainability/resilience	Solar visibility rules; water-wise landscape; shading	0.20
Autonomy/flexibility	Use of flexible zones; documented alternatives	0.15

Note. Weights are calibrated through stakeholder input and validated against outcomes (appeals, satisfaction, market metrics).

A practical implementation includes a pilot period, reviewer training, a public example library, and a feedback loop to update weights based on appeals, satisfaction, and observed market effects.

DISCUSSION

This paper frames HOA architectural review as an empirically tractable governance process with observable inputs (proposals and evolving design trends), intermediate states (the realized approved design portfolio), and measurable outputs (market performance, compliance burden, and perceived legitimacy), and it disciplines—rather than automates—aesthetic discretion by introducing measurable signals (trend trajectories, portfolio dispersion metrics, and outcome-linked evaluations) that make decisions more transparent and updateable, consistent with hedonic valuation in differentiated-product markets where willingness to pay for attributes shifts over time (Rosen, 1974) A central implication is that neighborhood character is a dynamic equilibrium: rigid replication may preserve short-run uniformity but can impede resilience upgrades and raise legitimacy costs when rules appear arbitrary or technologically outdated, motivating constrained design envelopes and auditable rubrics that allow controlled, goal-consistent variation within enforceable bounds; by separating restrictiveness from clarity, the framework highlights a practical lever whereby even strict constraints can yield lower perceived arbitrariness and higher compliance when clarity is improved through objective criteria, examples, rationales, and consistent decision records (Tyler, 2006) To support technical credibility, the manuscript adds simulation-based stress tests demonstrating the measurement pipeline, multi-HOA panel modeling with exposure adjustments, and explicit diagnosis of threats such as coding error and detection bias in recorded violations, treating compliance counts as jointly driven by behavior and enforcement intensity rather than pure noncompliance; remaining limitations include residual confounding from household sorting, reconciliation challenges in multi-source measurement, and uncertain external validity across metros, motivating quasi-experimental extensions, source-by-source diagnostics with sensitivity bounds, and deliberate replication, while the overall contribution remains an implementable architecture for evidence-informed HOA design governance that links measurable constructs to outcomes and translates results into a transparent, auditable, and periodically updateable decision protocol (Tyler, 2006). This manuscript proposes a complete, replicable approach to inform HOA design decisions through systematic home-design trend evidence and outcome evaluation by integrating trend mining, econometric testing, and policy prototyping to translate diffuse market and design signals into implementable architectural review tools, with the expected outcome of improved transparency, reduced conflict, and better alignment between neighborhood governance, housing market realities, and sustainability transitions.

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