California Zoning: Housing Construction and a New Ranking of Local Land Use Regulation

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ABSTRACT

New survey data on residential land use regulation in California have allowed us to create the Mercatus-Augmented Terner California Housing Regulation (MATCHR) Index, which characterizes formal restrictions on density in 265 California jurisdictions circa 2018. To expand index coverage, we augment the original Terner California Residential Land Use Survey data with published regulatory data. The formal restrictions are internally correlated, and exploratory factor analysis yields a strong single factor that can be used as an index of regulatory intensity. By contrast, several informal restrictions we analyze, including delays and the probability of rejection, are not internally correlated and have weak, if any, correlation with the MATCHR Index. The MATCHR Index is significantly correlated with 2012–2018 housing supply growth adjusted for demand and density. The correlation relies, however, on extreme values. Among municipalities with a MATCHR score within one standard deviation of the mean, we detect no systematic differences in growth. Informal restrictions have even less predictive power than formal ones: they show little relationship with growth outcomes even at the extremes. Our findings suggest that local California policymakers who want to increase housing supply may need to implement major policy changes.

JEL codes: R52

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California has earned a national reputation for its high cost of living. Median rent for a two-bedroom apartment is above $3,000 per month in San Francisco and above $2,000 per month in San Diego.[1] Despite decades of rising rent, home building in California has been lackluster. With home prices in most of the state far exceeding the cost of construction, rapid growth is a profitable proposition. However, home builders in California face both a physical and an institutional environment that make the provision of housing difficult. The physical environment cannot be altered, but institutional changes that allow increased housing provision would permit housing costs to fall. In this paper, we rank the regulatory intensity of 265 California jurisdictions and investigate the internal structure of local regulation and its relationship to growth.

Our analysis relies on a 2017–2018 survey of local regulators conducted by Sarah Mawhorter and Carolina Reid of the Terner Center for Housing Innovation at the University of California, Berkeley.[2] We approach Mawhorter and Reid's data with several questions in mind.

1. *Are there qualitatively different approaches to regulation?* We know that specific requirements vary from place to place, but do they vary in systematic ways? We analyze several measures of formal regulation from Mawhorter and Reid's Terner California Residential Land Use Survey (TCRLUS) and find a strong, single latent factor underlying the formal regulatory requirements, allowing us to rank municipalities within California according to their degree of regulation. We do not, however, find evidence of multiple latent factors, which would have indicated more complexity in the political process that generates regulation.

1. Chris Salviati, "Apartment List National Rent Report," Apartment List, August 1, 2019, https://www.apartmentlist.com/rentonomics/national-rent-data/.
2. Sarah Mawhorter and Carolina Reid, *Terner California Residential Land Use Survey* (Berkeley, CA: University of California, Berkeley, 2018).

2. *Does formal regulation predict growth?* We call this single regulatory factor the Mercatus-Augmented Terner California Housing Regulation (MATCHR) Index. The index is published below in appendix A. Higher index values and rankings indicate stricter regulation. There is a strong, significant ($p < 0.00001$) negative correlation between the MATCHR Index and housing supply growth surplus, as calculated in a previous paper.[3] However, the correlation relies on a handful of outliers at both extremes.
3. *Do the informal aspects of regulation, as measured in the TCRLUS, provide valuable information?* We chose a subset of the many survey questions covering informal aspects of the regulatory process, such as approval time, that seemed less subjective. However, unlike formal regulation, reported informal regulation appears to be random. Measures of informal regulation are not meaningfully correlated with each other, with formal regulation, or with growth outcomes. We cannot determine whether this implies that informal barriers to growth are irrelevant or merely illegible.
4. *What scale of policy change is needed in order for the change to have an impact?* Of the lowest-ranked cities, Dublin and Irvine provide the best model for California jurisdictions with developable land; they also have the most rapid housing growth in the state. A few examples show how Dublin and Irvine scored so low:
    - The two municipalities have single-family minimum lot sizes of 2,500 and 4,000 square feet, compared to the median of 6,000 square feet.
    - They have minimum front setbacks of 10 and 15 feet, compared to the median of 20 feet.
    - Dublin has no units-per-acre limit on multifamily density. (The median limit is 24 units per acre.)
    - The two municipalities have multifamily height limits of 75 and 50 feet, compared to the median of 35 feet.
    - The two municipalities have multifamily parking minimums of 1 and 1.6 spaces per unit, compared to the median of 2 spaces.
    - In Irvine, more than 25 percent of zoned land allows multifamily housing, rather than the common 6–25 percent.

3. Salim Furth, "Housing Supply in the 2010s" (Mercatus Working Paper, Mercatus Center at George Mason University, Arlington, VA, February 2019).

5. *Where do specific cities rank?* In addition to answering general questions, the MATCHR Index allows readers to evaluate the strictness of land use regulation across most urban and suburban California jurisdictions. We find that, while the big cities are not paragons of property rights, they are less regulated than most of their suburbs. Unsurprisingly, the municipalities with the worst growth records and strictest restrictions of property rights are small, very expensive suburbs such as Atherton and Bradbury.

This paper is organized as follows. First we present a brief review of the literature on measuring land use regulation. Then we discuss the TCRLUS data and present some relevant metadata. The details of the construction of the MATCHR Index follow. We then introduce housing supply growth and growth surplus data and present the correlations between the MATCHR Index and these housing market outcomes. Next we present our investigation of informal regulatory measures. We conclude by discussing policy options at the local and state levels that could alleviate the regulatory burden on housing supply in California.

LITERATURE REVIEW

California's housing market has attracted ample attention from researchers. Kevin Erdmann, Kyle Herkenhoff, Lee Ohanian, Edward Prescott, Chang-Tai Hsieh, and Enrico Moretti point to coastal California, along with New York, as having housing supply restrictions stringent enough to impact the national macroeconomy.[4] The present paper makes no new causal claims about the origins or impacts of land use regulation; we take it as given that strict zoning restricts human freedom, increases rent, and decreases housing supply to degrees that make it worthy of public concern.

Mawhorter and Reid's Terner California Residential Land Use Survey is the most recent addition to a still-sparse set of surveys measuring land use regulation at different times and places in the United States. Early forays into regulatory measurement are summarized by economist Stephen Malpezzi.[5]

4. Kevin Erdmann, *Shut Out: How a Housing Shortage Caused the Great Recession and Crippled Our Economy* (Arlington, VA: Mercatus Center at George Mason University, 2018); Kyle F. Herkenhoff, Lee E. Ohanian, and Edward C. Prescott, "Tarnishing the Golden and Empire States: Land-Use Restrictions and the U.S. Economic Slowdown," *Journal of Monetary Economics* 93 (2018): 89–109; Chang-Tai Hsieh and Enrico Moretti, "Housing Constraints and Spatial Misallocation," *American Economic Journal: Macroeconomics* 11, no. 2 (2019): 1–39.
5. Stephen Malpezzi, "Housing Prices, Externalities, and Regulation in U.S. Metropolitan Areas," *Journal of Housing Research* 7, no. 2 (1996): 209–41.

The best-known regulatory survey measure, the Wharton Residential Land Use Regulatory Index (WRLURI),[6] is still widely used in housing research.[7] The factor analysis approach used in this paper closely mirrors the method Joseph Gyourko, Albert Saiz, and Anita Summers used to create the WRLURI.[8] The WRLURI is a factor analysis built on a set of subindices. Our index differs in using an irregular subindex structure, with several variables entering the factor analysis directly, and in selecting only a subset of the available data to construct the index. Like the results of Gyourko, Saiz, and Summers, our results suggest that a single latent factor is the best summary of the data.

A few previous efforts have been made to measure land use regulation within California, including two surveys with near-complete coverage of jurisdictions.[9] These surveys, undertaken in 1989 and 1992, counted the number of growth-control measures undertaken in each jurisdiction, such as "reduced permitted residential density."[10] A more recent California index similar to the WRLURI, the Berkeley Land Use Regulatory Index, covered 86 Bay Area jurisdictions.[11]

The present paper suffers from shortcomings common to this literature. Coverage is incomplete. The data are available only as a cross-sectional snapshot. Survey responses are not necessarily reliable, especially regarding informal constraints on growth. Most importantly, regulators can achieve the same ends through a wide mix of restrictions. For instance, how does one compare a 50 percent lot coverage limit to a 1.5 floor area ratio limit?

Surveys are not the only approach to measuring regulatory stringency. Some researchers have used textual analysis of court cases to identify land use

6. Joseph Gyourko, Albert Saiz, and Anita Summers, "A New Measure of the Local Regulatory Environment for Housing Markets: The Wharton Residential Land Use Regulatory Index," *Urban Studies* 45, no. 3 (2008): 639–729.
7. See, for example, David Albouy and Gabriel Ehrlich, "Housing Productivity and the Social Cost of Land Use Restrictions," *Journal of Urban Economics* 107 (2018): 101–20; Catherine Brinkley, "High Rugosity Cities: The Geographic, Economic and Regulatory Pathology of America's Most Non-concentric Urban Areas," *Land Use Policy* 73 (2018): 215–24.
8. Gyourko, Saiz, and Summers, "New Measure of the Local Regulatory Environment."
9. Ned Levine, "The Effects of Local Growth Controls on Regional Housing Production and Population Redistribution in California," *Urban Studies* 36, no. 12 (1999): 2047–68.
10. Levine, "Effects of Local Growth Controls," 2050.
11. John M. Quigley, Steven Raphael, and Larry A. Rosenthal, "Measuring Land Use Regulations and Their Effects in the Housing Market," in *Housing Markets and the Economy: Risk, Regulation, and Policy; Essays in Honor of Karl E. Case*, ed. Edward M. Glaeser and John L. Quigley (Cambridge, MA: Lincoln Institute of Land Policy, 2009).

restrictions.[12] Economist Amy Dain's data rely on researcher inspection of published regulations,[13] an approach that we use to augment incomplete survey data. The hybrid approach to regulatory measurement combines the relative advantages of surveys and researcher inspection. The former are more time-efficient; the latter yields fewer missing values and is, in our view, more faithful to the written regulatory code.

REGULATORY DATA

In December 2018, Mawhorter and Reid released new data on land use regulation in California through the Terner Center for Housing Innovation. In this section and the following sections, we briefly describe these data and report our transformations of them. The strength of the Terner Center data is their extent and detail; a weakness is that few municipalities answered every single question in the TCRLUS. We overcome missing data in several ways: by focusing on variables with high response rates, by looking up key data directly in city codes, by exploiting logical connections among variables, and by averaging across nonmissing values of related variables. We then use exploratory factor analysis to collapse the multifaceted regulatory data into a simple index of regulation. These data characterize California's jurisdictions along one interpretable dimension that we can then compare to growth rates.

The TCRLUS was conducted from August 2017 to October 2018. Two hundred fifty-two incorporated California places and 19 counties (which regulate their unincorporated portions) responded to a range of questions about land use regulation, including local zoning, approval processes, affordable housing policies, and rental regulations.

Mawhorter and Reid have summarized and explored the main patterns found in the TCRLUS data.[14] They confirm many expected results and offer some new insights. For example, size limits on by-right development are most

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12. Peter Ganong and Daniel Shoag, "Why Has Regional Income Convergence in the U.S. Declined?," *Journal of Urban Economics* 102 (2017): 76–90.
13. Amy Dain, *Residential Land-Use Regulation in Eastern Massachusetts: A Study of 187 Communities* (Boston: Pioneer Institute for Public Policy Research and Rappaport Institute for Greater Boston, 2005); Amy Dain, *The State of Zoning for Multi-family Housing in Greater Boston* (Boston: Massachusetts Smart Growth Alliance, 2019).
14. Sarah Mawhorter and Carolina Reid, "Local Housing Policies across California: Presenting the Results of a New Statewide Survey" (Terner Center for Housing Innovation at the University of California, Berkeley, 2018); Sarah Mawhorter, "Housing Policies in California Cities: Seeking Local Solutions to a Statewide Shortfall" (Center for California Real Estate and Terner Center for Housing Innovation at the University of California, Berkeley, 2019).

common in downtown cores and in places served by transit, a pattern of regulation that runs "counter to efforts to encourage more sustainable, transit-oriented development."[15]

We select for factor analysis a subset of variables that measure formal restrictions on housing development. The distinction between formal and informal regulation goes back at least to 1971.[16] More recently, economists John Quigley and Larry Rosenthal distinguish "actual regulatory behavior and decisionmaking" from "formal rules as adopted."[17] Even in low-regulation, rapidly growing Texas suburbs, about a third of new housing units are created in "planned unit developments" for which the regulations are privately negotiated between the city and each developer.[18] Mawhorter and Reid showed their appreciation of the importance of informal constraints by including many questions that probe the subjective or otherwise unobservable aspects of the development process. We will return to a group of informal restrictions below; we do not, however, find that they are helpful in characterizing regulatory stringency.

The chosen variables are detailed in tables 1 and 2, which show the metadata and summary statistics, respectively. The variables cover the extent of residential zoning, minimum lot sizes, setbacks, multifamily density restrictions, and parking requirements. For chosen variables, we replace missing values where possible using the survey's internal logic or by directly looking up the missing data in published zoning codes and maps. The details of our transformations are given in appendix B.

Table 1 summarizes our transformations and additions to the TCRLUS data. The second column ("Original") identifies how many observations were nonmissing (and not altered) in the original data. The third column ("Missing") counts the observations that are left as missing values. The fourth and fifth columns identify how many observations were replaced, either by using the survey's internal logic or by making a manual change after consulting published regulations. The sixth column ("Transformation") notes where variables were transformed by multiplying by −1, inverting, or taking a logarithm. The final column ("Subindex") notes whether the variable is included in one of the subindices that are nested to create inputs to the exploratory factor model (see the following section).

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15. Mawhorter and Reid, "Local Housing Policies across California," 4.
16. Fred Bosselman and David Callies, *The Quiet Revolution in Land Use Control* (Washington, DC: Council on Environmental Quality, 1971).
17. John M. Quigley and Larry A. Rosenthal, "The Effects of Land Use Regulation on the Price of Housing: What Do We Know? What Can We Learn?," *Cityscape* 8, no. 1 (2005): 70.
18. Nolan Gray and Salim Furth, "Do Minimum-Lot-Size Regulations Limit Housing Supply in Texas?" (Mercatus Working Paper, Mercatus Center at George Mason University, Arlington, VA, May 2019).

TABLE 1. METADATA

Variable	Original	Missing	Replacements: Logical	Replacements: Manual	Transformation	Subindex
Land zoned for single-family	range given	1	268	2	–	–
Land zoned for multifamily	range given	1	268	2	multiplied by −1	–
SF minimum lot size	256	4	–	11	natural log	–
SF total off-street parking	251	3	12	5	–	–
SF front yard setback	265	6	–	–	–	setback index
SF side setback	255	14	1	1	–	setback index
SF backyard setback	258	12	1	–	–	setback index
MF minimum lot width	205	54	12	–	–	MF lot shape subindex
MF front yard setback	236	27	8	–	–	MF lot shape subindex
MF side yard setback	226	34	11	–	–	MF lot shape subindex
MF backyard setback	237	30	4	–	–	MF lot shape subindex
MF minimum lot size	213	51	–	7	natural log	MF index
MF maximum density	234	31	6	–	Inverted	MF index
MF maximum lot coverage	179	77	15	–	Inverted	MF index
MF height limit	248	21	1	1	Inverted	MF index
MF minimum unit size	84	147	40	–	–	MF index
MF maximum floor area ratio	53	173	45	–	Inverted	MF index
MF maximum by-right project size	45	28	193	5	Inverted	MF index
MF resident parking spaces	261	9	–	1	–	MF parking subindex
MF guest parking spaces	178	58	35	–	–	MF parking subindex
MF covered parking is required	268	3	–	–	–	MF parking subindex
MF tandem parking is allowed	267	4	–	–	multiplied by −1	MF parking subindex
MF parking garages are required	267	4	–	–	–	MF parking subindex

Note: SF = single-family, MF = multifamily.

Table 2 gives descriptive statistics for the regulated jurisdictions. Just over two-thirds of jurisdictions have similar minimum lot dimensions and setbacks for multifamily homes as for single-family homes. In fact, the sample medians are identical. Mawhorter and Reid muse, “It is somewhat surprising that multifamily housing is often subject to similar setback requirements as single-family housing.”[19]

19. Mawhorter and Reid, “Local Housing Policies across California,” 11.

TABLE 2. DESCRIPTIVE STATISTICS

Variable	Unregulated	Regulated	Mean	St. dev.	Min.	Max.
Land zoned for single-family	–	265	50.8	16.9	2.4	95.1
Land zoned for multifamily	–	265	19.3	10.7	1.3	61.5
SF minimum lot size	–	265	7,445.9	7,810.7	2,000	87,120
SF total off-street parking	1	264	2.2	0.6	1	4
SF front yard setback	–	263	20.1	5.3	10	60
SF side setback	1	254	6.5	4.4	2.5	50
SF backyard setback	1	256	16.4	6.5	4	60
MF minimum lot width	12	204	66.1	26.8	15	200
MF front yard setback	8	236	17.9	5.0	3	45
MF side yard setback	11	226	7.5	3.6	2.5	25
MF backyard setback	4	236	14.5	5.9	5	42.5
MF minimum lot size	–	220	11,787.5	33,728.3	1,500	435,600
MF maximum density	6	233	27.2	18.5	1	200
MF maximum lot coverage	15	178	0.6	0.1	0.3	1
MF height limit	1	248	40.2	13.5	20	136
MF minimum unit size	40	83	622.8	370.9	80	2,600
MF maximum floor area ratio	45	52	1.1	1.0	0.25	5
MF maximum by-right project size	97	131	10.5	61.9	2	700
MF resident parking spaces	1	257	1.8	0.4	0.67	3
MF guest parking spaces	35	175	0.5	0.3	0.1	2
MF covered parking is required	95	167	binary	binary	binary	binary
MF tandem parking is allowed	114	147	binary	binary	binary	binary
MF parking garages are required	201	61	binary	binary	binary	binary

Note: SF = single-family, MF = multifamily. Descriptive statistics cover only regulated observations and describe the data before log or reversal transformations.

The last three variables in the list are binary: they indicate whether covered parking or parking garages are required and whether tandem parking is allowed.

INDEX CONSTRUCTION

To overcome missing data, we construct nested indices by averaging the z-scores of extant data. Constructing a multifamily index posed particular interpretive challenges, since it includes parking regulations, lot shape regulations, density regulations, and other regulations. Averaging together the z-scores of important

TABLE 3. CORRELATIONS AMONG FACTOR ANALYSIS INPUTS

	Land SF	Land MF	SF min. lot	SF parking	SF setbacks
Land zoned for single-family	1				
Land zoned for multifamily	0.36	1			
SF minimum lot size (ln)	0.43	0.26	1		
SF total off-street parking	0.09	0.06	0.11	1	
Index of single-family setbacks	0.39	0.25	0.61	0.03	1
Index of multifamily variables	0.28	0.19	0.40	0.18	0.37

Note: SF = single-family, MF = multifamily. Land zoned for multifamily housing is reversed; a smaller share of land thus zoned indicates stricter regulation. N = 265.

and unimportant variables gives too much weight to the latter. And jurisdictions that report one setback often report all three (front, side, and back), which are highly correlated and will outweigh other variables in those cases, but not in others.

To mitigate this interpretive problem, we first create two sub-subindices: one for multifamily lot shape parameters (setbacks and lot width) and one containing five multifamily parking requirements, some of which are binary. We restandardize each subindex before proceeding.

We construct the multifamily index by averaging the z-scores of our two subindices and eight other variables.

We also construct an index of single-family setbacks. But, since our single-family data are much nearer to being complete, we can keep the rest of the single-family variables in the analysis on their own, allowing the factor analysis algorithm to determine their relative importance. Both indices are restandardized to ease interpretation in the factor analysis.

FACTOR ANALYSIS

We use exploratory factor analysis to characterize key variables from the Terner Center data in a parsimonious form and to uncover systematic typologies of regulation if they exist. Exploratory factor analysis is a method often used to discover the underlying structure of multifaceted data. It examines the correlations, shown in table 3, between all the measured variables in order to find any latent factors that may be driving relationships between them. We use exploratory factor analysis to find that there is a single factor underlying the augmented TCRLUS variables and subindices detailed above.

Some limitations to exploratory factor analysis are worth mentioning. First, this method assumes that the relationship between the measured variables and the identified factors is linear, which may not be the case. Ordinal or nominal scales of measurement in particular will "generally not meet assumptions of linearity."[20] The TCRLUS parking variables and their categorical nature could potentially weaken the model we employ, but given how we standardize the single-family parking variables and aggregate the multifamily parking variables into a nested subindex for our analysis, we believe that this issue is minimized. There has been some debate about the adequate sample size for exploratory factor analysis. Some researchers support a sample size of 100 or more as an adequate benchmark,[21] while others suggest that what is more important is the intuition that goes into balancing the sample size with the strength of the common factors extracted.[22] In either case, our sample of 265 is ample.

There are various forms of exploratory factor analysis, each of which fits a model to explain the correlations among measured variables in a sample. We use a noniterated principal axis (NIPA) model. NIPA factor analysis attempts to solve the following equation for Λ:[23]

$$R \approx \Lambda\Lambda^{T} + D_{\Psi},$$

where R is the matrix of correlations among measured variables in the sample. D_{Ψ} is the covariance matrix among unique latent factors, and the model assumes that there is no correlation between each of these factors. The difference between R and D_{Ψ} produces the reduced correlation matrix. NIPA factor analysis uses the squared multiple correlations of the measured variables to arrive at estimates of the communalities (or factors) that go into calculating the reduced correlation matrix. The only remaining unknown in the above equation is Λ, which represents the factor loadings.

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20. Leandre R. Fabrigar and Duane T. Wegener, *Exploratory Factor Analysis: Understanding Statistics* (New York: Oxford University Press, 2012), 25.
21. See rules of thumb published in Richard L. Gorsuch, *Factor Analysis*, 2nd ed. (Hillsdale, NJ: Erlbaum, 1983); Brian S. Everitt, "Multivariate Analysis: The Need for Data, and Other Problems," *British Journal of Psychiatry* 126, no. 3 (1975): 237–40; and Jum C. Nunnally, *Psychometric Theory* (New York: McGraw-Hill, 1978).
22. Robert C. MacCallum et al., "Sample Size in Factor Analysis: The Role of Model Error," *Multivariate Behavioral Research* 36, no. 4 (2001): 611–37; Robert C. MacCallum et al., "Sample Size in Factor Analysis," *Psychological Methods* 4, no. 1 (1999): 84–99; Wayne F. Velicer and Joseph L. Fava, "Effects of Variable and Subject Sampling on Factor Pattern Recovery," *Psychological Methods* 3, no. 2 (1998): 231–51.
23. We borrow this notation from Fabrigar and Wegener, *Exploratory Factor Analysis*, 43.

TABLE 4. FACTOR LOADINGS (UNROTATED)

Variable	Factor 1	Uniqueness
Land zoned for single-family	0.58	0.63
Land zoned for multifamily	0.41	0.77
SF minimum lot size	0.73	0.46
SF total off-street parking	0.15	0.91
Index of single-family setbacks	0.69	0.49
Index of multifamily variables	0.51	0.71

Note: SF = single-family, MF = multifamily. Land zoned for multifamily housing is reversed; a smaller share of land thus zoned indicates stricter regulation. N = 265.

Intuitively, factor loadings represent how much each variable is influenced by each latent factor. Once NIPA produces these estimates, it calculates the estimates for the latent factors that are in turn calculated by summing the squared loadings for each row of the factor loading matrix.

The NIPA method yields a single significant factor with an eigenvalue of 1.80 and significant loadings on all but one variable.[24] We consider any loading of 0.25 or lower to be insignificant.[25] Table 4 shows the factor loadings and unique variances. The factor loadings, in an unrotated factor analysis, can be understood as reflecting how much each variable correlates with the latent factor. For the "Land zoned for single-family" variable, for example, its loading can be interpreted as saying that the variable has a correlation of 0.58 with the latent factor. Variables that have relatively strong loadings are more intuitively related to the latent factor in question.

The "uniqueness" in table 4 refers to the variance that is "unique" to each variable and not shared with the other variables. The greater the uniqueness, the lower the relevance of the variable in the factor model. Therefore, in table 4, we display each variable's uniqueness as another way to illustrate the takeaway discerned from looking at its loading under the factor. Any variable that is highly

24. The Kaiser rule says to include only factors with an eigenvalue of one or greater. In this case our choice was easy, because Factor 2 had an eigenvalue of just 0.12. Eigenvalues are calculated from the reduced correlation matrix, and they correspond to the variance in the measured variables accounted for by each latent factor. Sometimes factors with eigenvalues under, but close to, one can be deemed appropriate to include as well, if there is a conceptual explanation. See Louis Guttman, "Some Necessary Conditions for Common-Factor Analysis," *Psychometrika* 19, no. 2 (1954): 149–61; Henry F. Kaiser, "The Varimax Criterion for Analytic Rotation in Factor Analysis," *Psychometrika* 23, no. 3 (1958): 187–200; Henry F. Kaiser, "The Application of Electronic Computers to Factor Analysis," *Educational and Psychological Measurement* 20, no. 1 (1970): 141–51.
25. Cutoffs for loadings can vary in the literature, but they generally fall between 0.20 and 0.50 depending on the application.

TABLE 5. FACTOR LOADINGS (OBLIQUE PROMAX ROTATION)

Variable	Factor 1R	Factor 2R	Uniqueness
Land zoned for single-family		0.41	0.63
Land zoned for multifamily		0.45	0.77
SF minimum lot size	0.69		0.46
SF total off-street parking			0.91
Index of single-family setbacks	0.70		0.49
Index of multifamily variables	0.43		0.71

Note: SF = single-family. Land zoned for multifamily housing is reversed; a smaller share of land thus zoned indicates stricter regulation. Only factor loadings greater than 0.25 are displayed. N = 265.

correlated with the latent factor should have a higher loading as well as a lower unique variance.

The clear conclusion of the unrotated factor analysis is that residential regulatory stringency is a meaningful dimension, with applications to both single- and multifamily housing. Nonetheless, we are interested in identifying potentially different typologies of zoning in California.

Usually, only models producing two or more common factors are considered eligible for rotation. However, unrotated exploratory factor analysis imposes orthogonality between potential latent factors. We believe that any potential latent factors behind regulatory stringency are likely related and therefore violate this assumption, so we perform a rotated factor analysis to investigate possible variations in types of regulatory stringency.

We use an oblique promax rotation in order to investigate correlated factors. Table 5 displays the results. Most of the variables load onto Factor 1R, with the exceptions of the zoning share variables, which load onto Factor 2R. Single-family parking requirements continue to be unrelated. This is initially promising and is clearly interpretable: Factor 1R summarizes the contents of the zoning code, and Factor 2R summarizes the zoning map. However, the two factors are so highly correlated in the data (the correlation coefficient is 0.93) that they cannot usefully represent differences in regulatory approaches. In preferring the unrotated factor analysis, we are guided by psychometricians Louis Thurstone's and Michael Browne's preferences for simple structure.[26]

For clarity in subsequent discussion and publications, we refer to Factor 1 as the Mercatus-Augmented Terner California Housing Regulation Index. The

26. Louis L. Thurstone, *Multiple-Factor Analysis: A Development and Explanation of the Vectors of the Mind* (Chicago: University of Chicago Press, 1947); Michael W. Browne, "An Overview of Analytic Rotation in Exploratory Factor Analysis," *Multivariate Behavioral Research* 36, no. 1 (2001): 111–50.

MATCHR Index has a mean of zero and a standard deviation of 0.86 across all 265 jurisdictions. Among the 194 cities with growth surplus data in the subsequent analysis, the sample mean is 0.05 and the standard deviation is 0.92.

GROWTH DATA

In a previous paper,[27] one of us estimated how much housing supply growth[28] was expected in each census tract based on the outcomes in similarly dense, similarly demanded census tracts nationwide. Demand, in that paper, is estimated as a convex combination of the increase in rent (by zip code) and the increase in housing supply (by metro[29]). This estimate embodies the assumption that all locations in a metro are substitutes, with log-additive differences in time-varying amenities accounting for differences in rent. Subtracting expected growth from actual growth yields a "growth surplus" for each tract. In most California counties, surplus growth from 2012 to 2018 was negative: the counties built less housing than similarly composed places around the United States, racking up large "growth deficits."

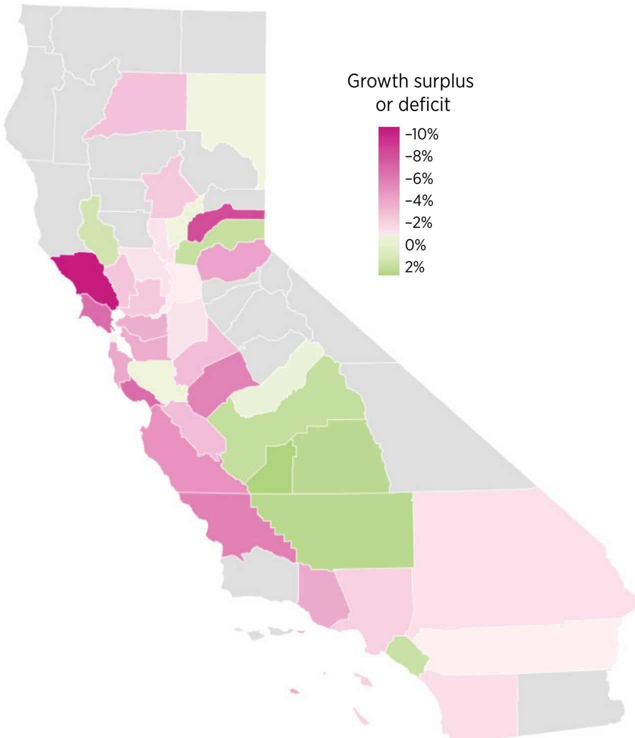
Growth surplus is reported as a percentage of each place's housing stock. Thus, a county that had 100,000 housing units in 2012 and was expected to build 2,000 homes over the next six years but built only 1,500 would have a growth deficit of 500 homes, or 0.5 percent. Figure 1 shows the growth surplus for each California county in percentage terms. Where the surpluses are negative—that is, where there are deficits—the counties are colored pink.

California's statewide growth deficit was about 200,000 new homes from 2012 to 2018. Building that many more homes would not have kept rent constant; it would merely have kept California in line with similar places around the country. What these deficits tell us, however, is that California's institutions and environment are worse than the US norm for housing production.

In the following section, we use growth and growth surplus data mapped from census tracts to municipalities for which we compute the MATCHR Index.

27. Furth, "Housing Supply in the 2010s." The methodology covered only metropolitan and micropolitan areas and was occasionally limited by data availability. Demand growth was estimated at the census tract level using the growth in occupied residential addresses and the growth in the Zillow Rental Index. Since the Zillow Rental Index is unavailable in some areas, there are some places for which we could report housing growth accurately but could not calculate a growth surplus.
28. In the present paper, "housing supply growth" denotes the percentage growth in the number of residential addresses as reported by the US Postal Service. "HUD Aggregated USPS Administrative Data on Address Vacancies," Office of Policy Development and Research dataset, accessed October 2018, https://www.huduser.gov/portal/datasets/usps.html.
29. Here and throughout, "metro" refers to a Core-Based Statistical Area.

FIGURE 1. GROWTH SURPLUS OR DEFICIT BY COUNTY, 2012–2018



Note: Growth surplus refers to the 2012–2018 growth in housing supply relative to similarly dense, similarly demanded places around the country, expressed as a percentage of total 2012 housing supply.

Source: Salim Furth, "Housing Supply in the 2010s." The map was created using Datawrapper.

We were not confident that we could identify the unincorporated sections of counties in our data, so we do not include counties in the subsequent analysis.

REGULATION AND GROWTH

The most exclusionary municipalities in California, as measured by the MATCHR Index, had large growth deficits.[30] The least exclusionary municipalities had mixed results but included two of the state's biggest growth successes—Irvine and Dublin.

30. Growth surplus is calculated at the census tract level. Since census tracts are not generally coterminous with municipalities, we use a geographic correspondence "crosswalk" to assign a share of each tract to each municipality it covers. We proceed under the assumption that growth is evenly spread across each census tract. We expect that this assumption slightly biases our findings toward zero.

California's 10 biggest cities are less regulated than the state average, but with substantial diversity. San Diego and San Francisco are among the least regulated jurisdictions in the state, with MATCHR scores of −1.14 and −0.98, respectively. Oakland, Sacramento, and Los Angeles all have substantially below-average MATCHR scores as well. Bakersfield, San Jose, and Long Beach are a bit below average; Anaheim is substantially more regulated than average; and Fresno lacks data (see appendix A). In particular, the big cities have less regulation of parking and allow smaller lot sizes than other places. However, they are not outstanding on zoning shares. And their multifamily height limits are, surprisingly, about average for the state. For example, Long Beach has a multifamily height limit of just 28 feet, imposing a visual profile inconsistent with its character as a major city.[31]

Among the large cities, Oakland and Long Beach built the least housing between 2012 and 2018. They grew[32] by just 1.5 percent and 0.8 percent, respectively, and had growth deficits of 5.5 percent and 2.7 percent. In Oakland, only one census tract added more than 130 residential addresses in the six-year period. In both San Jose and San Francisco, by contrast, at least 25 tracts added more than 130 addresses, and 4 tracts added more than 1,000 addresses.

Huntington Beach, which is being sued by the state for failing to plan for sufficient means-tested housing,[33] has been above average at allowing housing growth. It has a MATCHR score of −0.56 and the city's housing stock grew by 4 percent from 2012 to 2018, achieving a small growth surplus. Construction in Huntington Beach was headlined by the redevelopment of a few blocks of low-density commercial land into multifamily housing near Golden West College. California cities that want to similarly provide housing without disrupting existing neighborhoods can do so by rezoning low-value commercial corridors to allow dense residential use.

The extremes of exclusion are in the toniest suburbs of the big cities. Atherton, Bradbury, and Los Altos Hills have the highest MATCHR scores. Six more high-income suburbs bounded by foothills, along with Truckee, round out the top 10 MATCHR scores. Of the top 10, only Truckee and Yorba Linda permitted substantial housing growth from 2012 to 2018, and only Yorba Linda had a growth surplus.

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31. Long Beach's zoning code does contemplate zones for 38-foot and 65-foot buildings, but they are sparsely mapped. See Long Beach, CA (website), "Development Services," accessed August 8, 2019, http://www.longbeach.gov/lbds/.
32. Growth, here as throughout the paper, is measured in number of housing units.
33. Jeff Horseman and Susan Christian Goulding, "Gov. Gavin Newsom Targets Huntington Beach with Lawsuit over Affordable Housing," *Orange County Register*, January 25, 2019.

TABLE 6. CORRELATIONS BETWEEN MATCHR INDEX AND GROWTH OUTCOMES

	Housing growth	Growth surplus	N
All municipalities	−0.16	−0.35	194
	(0.03)	(0.00)	
MATCHR score in [−0.9, 0.9]	0.02	0.05	165
	(0.77)	(0.51)	
> 10,000 residences	−0.11	−0.06	143
	(0.21)	(0.51)	

Note: p-values are in parentheses.

Eleven cities in our sample had double-digit growth deficits. Of these, six have MATCHR scores at least two standard deviations above the mean. Just three have exclusionary factors below zero, one of which (Santa Rosa) is only on the deficit list because it lost thousands of homes to the Tubbs Fire in 2017.

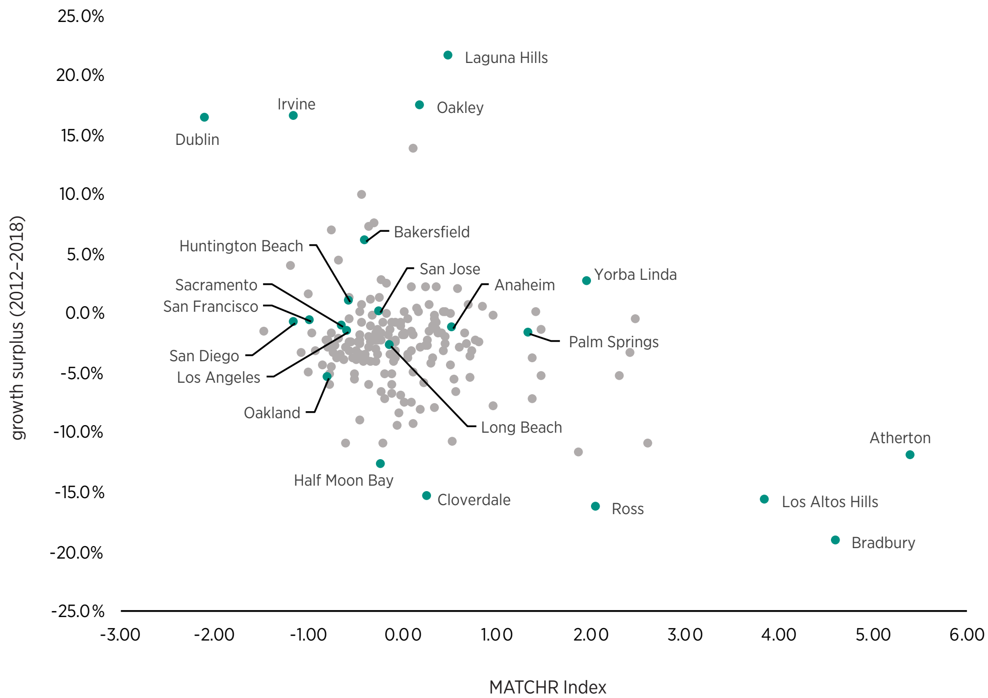
At the more inclusive end of the spectrum, the alignment between MATCHR score and growth surplus is weaker. Eleven jurisdictions with complete data had MATCHR scores at least one standard deviation below zero. Two of these, Dublin and Irvine, had double-digit growth surpluses. And eight of the least-regulated 11 jurisdictions had growth surpluses above the sample average of −2.3 percent.

As a result of these extreme cases, there is a strong, significant correlation between our measure of regulatory stringency and growth surplus. As table 6 shows, MATCHR Index and growth surplus are correlated at −0.35. The MATCHR Index's correlation with the raw housing growth rate is weaker (−0.16). The weakness of the latter relationship is likely due to the fact that growth occurs most rapidly in places with available land and high demand growth, not necessarily in the least-regulated places. By controlling for demand growth and baseline density, the surplus growth calculation improves our ability to detect the impact of regulatory stringency.

An ordinary least squares regression of growth surplus on MATCHR score indicates that this summary of regulatory intensity can account (in a statistical, not necessarily a causal, sense) for 12 percent of the variation in growth surplus across 194 California municipalities, and that a one-standard-deviation increase in regulation is associated with 2 percentage points less residential growth over six years.

The correlations, however, are clearly driven by extreme cases. Among 165 jurisdictions with exclusionary factor scores within one standard deviation of

FIGURE 2. MATCHR INDEX AND GROWTH SURPLUS



zero, there is no correlation between MATCHR score and growth surplus. Since the extreme cases are disproportionately small municipalities, the correlation is also insignificant if we restrict the sample to municipalities with at least 10,000 housing units. Figure 2 shows why the correlation is highly significant but not very robust: there is a strong relationship among the outliers and no relationship among the "inliers."

Two tentative conclusions emerge from this correlation analysis. First, it appears that our exclusionary factor can successfully identify the most exclusionary municipalities, but that moderate differences among places are either undetectable or relatively unimportant in the determination of growth outcomes. Second, the growth surplus method performs better than unconditional growth at identifying exclusionary jurisdictions.[34]

34. A peer reviewer suggested that we check the correlations between supply growth and the components of the MATCHR Index to verify that we are not diluting a stronger explanatory variable with excess information. We find that all the components of the MATCHR Index have weaker relationships with supply growth than does the index as a whole.

INFORMAL REGULATION

The MATCHR Index relies only on codified regulations. But informal aspects of regulation such as regulatory delays, regulators' discretion, and legal uncertainty can block or forestall formally legal residential construction.[35] It remains an open question whether codified or informal regulatory practices explain more of the cross-sectional differences in American housing markets.

In this instance, at least, informal barriers as reported in the survey have little explanatory power. We examine the associations between growth outcomes and delays, fees, rejection probabilities, and planning employment.

We build up variables representing informal regulation from the underlying TCRLUS data. For delays, we use the midpoints of the ranges in the Terner Center survey and create a Delay Index by averaging the z-scores of nonmissing variables for each jurisdiction. We also use the midpoints of the ranges in the Terner Center survey for fees. For rejection probabilities, we use the six Terner Center variables that express how often projects proceed from application to approval to permit to completion. Since many of the survey answers are shockingly pessimistic about the odds of projects moving through the pipeline, we take the most optimistic end of the range of answers rather than the midpoints and multiply them together (since a project must pass all hurdles to deliver). Then we subtract this completion probability from one. For planning employment, we rate part-time staff members as one-third of a full-time equivalent and divide residential planning staff by the number of residences, excluding places with only one planner.[36] We also exclude Los Altos Hills, which reported an improbably large residential planning staff of 22 full-time and 5 part-time staff members.

Unlike the formal regulatory barriers that underlie the MATCHR Index (see table 3), the informal barriers that constitute this set are almost completely uncorrelated with each other (see table 7). Two are somewhat correlated with the MATCHR Index.

When we test the associations between housing growth, growth surplus, and informal barriers, we find insignificant results for all but two variables. The two with interesting results are the multifamily rejection probability and planning employment. Both variables show extremely high cross-sectional diversity.

35. See the theoretical model presented in Furth, "Housing Supply in the 2010s," 11–24.

36. Small jurisdictions with a single residential planner face indivisibility constraints, so measuring planners per residence seems unreliable. For cities with at least 3,000 residences, there is no evidence of scale variance in number of planners per residence.

TABLE 7. CORRELATIONS AMONG INFORMAL REGULATORY VARIABLES AND THE MATCHR INDEX

	MATCHR Index	Delay Index	SF rejection odds	MF rejection odds	SF fee	MF fee
MATCHR Index	1					
Delay Index	0.16	1				
SF rejection odds	0.02	0.09	1			
MF rejection odds	0.17	0.04	0.69	1		
SF fee	−0.03	0.01	0.04	−0.05	1	
MF fee	0.01	0.09	0.02	0.00	0.83	1
Planners/residence	0.03	0.01	−0.04	0.00	0.05	−0.01

Note: SF = single-family, MF = multifamily. Correlations are pairwise, so the number of observations varies by cell.

The multifamily rejection rate spans [0%, 99.9875%[37]] and residential planning employees per thousand housing units spans [0.03, 4.63]. Since we are testing six pairs of relationships, we suggest that readers use the Bonferroni correction for multiple comparisons, shrinking confidence intervals by a factor of six.

The relationship between multifamily rejection probability and growth surplus is statistically and theoretically weak. Although there is a significant negative correlation ($p = 0.002$) between multifamily rejection rate and growth surplus, the significance relies on Atherton and Clayton, two communities where multifamily construction is banned formally as well as blocked informally and that do not report having received any applications for multifamily housing. Regressing growth surplus on both the MATCHR Index and multifamily rejection probability, we find that the multifamily rejection rate is marginally significant ($p = 0.013$), with the significance again depending on places that make no formal accommodation for multifamily housing. Although it is hard to imagine that a high rate of project rejection is not a meaningful determinant of growth, it may be the case that this variable and its single-family counterpart were unable to measure rejection rates accurately.

The association between planner employment and growth is intuitive: faster-growing places employ more residential planners. An additional residential planner per thousand residences is associated with a growth rate 2.5 percentage points higher, which is more than half a standard deviation in the relevant sample. When we look at the impact of planners on growth surplus, however, the relationship becomes negative and insignificant, whether or not we control for

37. "So you're telling me there's a chance?" (Lloyd Christmas in *Dumb and Dumber*, 1994).

MATCHR score. Thus, more planners are employed in places that are likely to grow, but they do not appear to help or hinder growth.[38]

Examining informal regulation alongside MATCHR score confirms the latter's validity: MATCHR score maintains statistical significance (at conventional statistical intervals) in the presence of each informal regulatory barrier.

One could conclude, based on this evidence, that fees, delays, and probability of rejection are not, in fact, barriers to housing growth. However, we think it is more likely that surveys like the TCRULUS (in which each respondent is a unique data point) cannot elicit accurate data on subjective aspects of the regulatory process. Comparing the TCRLUS to their own case study, legal scholars Moira O'Neill, Giulia Gualco-Nelson, and Eric Biber gently conclude that disparities are "most likely due to the fact that local data might not be the most accurate."[39]

POLICY RESPONSES

Policymakers concerned about housing affordability, economic dynamism, and property rights have shown newfound interest in easing land use regulation in the last few years. For their actions to be effective in California, they must do more than make minor adjustments within the current hostile regulatory environment that stymies housing production statewide.

Although the laws that restrict housing supply in California are local, many restrictions apply almost universally, with little distinction. Furthermore, even some relatively lightly regulated cities in California—San Francisco and Berkeley, for example—are nationally known for their effective political opposition to growth. And California as a whole has a longstanding reputation as a high-regulation state.

At the local level, California policymakers can make adjustments within the existing zoning framework to ease key restrictions. The two cities we have identified as major successes, Dublin and Irvine, have laws that make it relatively easy to build both single- and multifamily housing: small minimum lot sizes and setback requirements, generous height limits, and low parking requirements.

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38. A Florida study found that planning expenditures were a valid proxy for stricter regulation. Keith Ihlanfeldt and Tom Mayock, "Housing Bubbles and Busts: The Role of Supply Elasticity," *Land Economics* 90, no. 1 (2014): 79–99.
39. Moira O'Neill, Giulia Gualco-Nelson, and Eric Biber, "Comparing Perceptions and Practice: Why Better Land Use Data Is Critical to Ground Truth Legal Reform" (Terner Center for Housing Innovation at the University of California, Berkeley, 2018).

Both Dublin and Irvine have the benefit of ample developable land. In Irvine's case, El Toro Marine Corps Air Station was decommissioned and is gradually being redeveloped, mostly as housing. Many California cities do not have a similar wealth of vacant land. In those cases, the most significant policy changes may be to allow housing construction in areas currently zoned for commerce and to allow denser construction or subdivision within existing residential areas. However, without any clear success stories or patterns in the data, these recommendations are only our considered opinion.

State policymakers have the authority to universally preempt local zoning laws. The state has already mandated that localities allow accessory dwelling units[40] and has forbidden some of the indirect barriers that localities use to avoid permitting such units (such as the $50,000-per-unit fees charged by the city of Atascadero, according to the TCRLUS). A much more ambitious effort is underway at present: Senate Bill 50, introduced by Sen. Scott Wiener, would preempt strict density and bulk restrictions near most transit stations and in "jobs-rich" areas, replacing them with moderate multifamily restrictions.

The market benefits of state-led deregulation must be weighed against the political complexity of engaging both the state and local governments in zoning, which could lead to a variety of unintended consequences. Law professor John Infranca explores different approaches to state preemption of land use and recommends simplicity.[41]

In addition to banning some of the barriers to growth, state policymakers ought to creatively rethink the incentive structure facing local officials and voters. Rather than retaining a direct taxing authority, California municipalities receive varying shares of a statewide 1 percent property tax. The result is that officials view residential development as a net fiscal loss. Reworking the ways that various tax revenues are allocated could ease the institutional incentives that regulators have to block residential growth.

Finally, the state of California adds its own costs and barriers to growth. Our colleagues found that the California building code—which applies to every jurisdiction in the state—has more restrictions than the entire regulatory codes of many other states.[42] Restoring a building code that conforms to international

40. "Accessory Dwelling Units (ADUs)," California Department of Housing and Community Development, accessed March 22, 2019, http://www.hcd.ca.gov/policy-research/accessory dwellingunits.shtml.
41. John Infranca, "The New State Zoning: Land Use Preemption amid a Housing Crisis," *Boston College Law Review* 60, no. 3 (2019): 823–87.
42. James Broughel and Jonathan Nelson, "A Snapshot of California Regulation in 2019" (Mercatus Policy Brief, Mercatus Center at George Mason University, Arlington, VA, 2019).

standards and focuses on safety would lower the cost of new housing construction in California.

Private actors also have a role to play in ameliorating California's housing crisis. Public policy frames and constrains the housing market but does not determine its content. Individuals and private organizations engage with the public process, take the financial risks, and make the creative decisions that ultimately produce new homes and neighborhoods. There is thus room for property owners, activists, developers, and others to actively influence the provision of housing in their own cities.

In a companion piece to this paper,[43] one of us presents a possible approach to changing the politics of development: giving nearby renting residents a direct financial interest in the success of new housing development. Renters already have an indirect financial interest in expanding housing supply, whether they plan to be renters or buyers in the future, but the impact of any one project is small. A small group of renters with a direct financial interest in housing development might balance out the vocal few antidevelopment homeowners who often dominate public engagement on housing issues.[44]

CONCLUSION

By augmenting TCRLUS data with published regulatory data and exploiting logical relationships between survey questions, we are able to extract an underlying factor that covers all but six of the California jurisdictions that responded to the TCRLUS. The result is the MATCHR Index, which characterizes formal regulatory intensity for 265 California cities and counties. While the underlying TCRLUS data are much richer, the MATCHR Index may be useful to economists who want to avoid the statistical perils of testing for the effects of dozens of highly correlated regulatory inputs and to policymakers who want to quickly identify the most and least exclusionary jurisdictions in the state.

We find that while the MATCHR Index is not significantly correlated with housing growth, it has a strong negative correlation with growth surplus, which is the residual of a nonparametric estimation of growth rates on demand growth and density. This relationship shows the value of growth surplus as a concept as

43. Salim Furth, "Development Dividends: Sharing Equity to Overcome Opposition to Housing" (Mercatus Policy Brief, Mercatus Center at George Mason University, Arlington, VA, 2019).
44. Katherine Levine Einstein, Maxwell Palmer, and David M. Glick, "Who Participates in Local Government? Evidence from Meeting Minutes," *Perspectives on Politics* 17, no. 1 (2019): 28–46.

well as affirming that MATCHR scores have captured meaningful variation in regulatory intensity.

Our conclusions must be tempered, however, by the fact that the correlation between MATCHR scores and growth surplus relies on outliers. The data suggest that there are a few extremely exclusive municipalities and a few relatively accommodative ones (including the big cities of San Diego and San Francisco). Near the middle of the distribution, even apparently substantial differences in regulation do not yield different outcomes. To provide a sense of scale: a log standard deviation separates 5,000- from 8,000-square-foot minimum lot sizes, but places with lot size regulations anywhere in that range have, on average, similar growth outcomes.

We also look at informal aspects of regulation, including delays, rejection probability, and planner employment, but find that these were largely uncorrelated with each other, with formal regulation, and with growth outcomes. We interpret this as evidence against the reliability of survey-based measures of informal regulation rather than as evidence that informal barriers to growth are irrelevant.

To break California out of its high-regulation, low-growth, high-rent equilibrium, the state's policymakers will need to show creativity and boldness.

APPENDIX A: MATCHR INDEX AND GROWTH OUTCOMES BY JURISDICTION

TABLE A1. MATCHR INDEX AND GROWTH OUTCOMES BY CITY

City	FIPS Code	MATCHR Index	Rank	Number of residences (2018Q1)	Housing growth (2012–2018)	Growth surplus (2012–2018)
Emeryville	622594	−2.15	1	6,946	–	–
Dublin	620018	−2.09	2	21,446	24.0%	16.3%
Avalon	603274	−1.48	3	–	–	–
West Hollywood	684410	−1.47	4	24,970	4.0%	−1.5%
Colma	614736	−1.19	5	668	30.3%	4.0%
Irvine	636770	−1.15	6	101,622	19.3%	16.5%
San Diego	666000	−1.14	7	533,444	3.6%	−0.8%
El Cerrito	621796	−1.07	8	10,602	0.9%	−3.3%
West Sacramento	684816	−1.06	9	19,612	5.6%	–
Richmond	660620	−1.00	10	39,663	0.8%	−4.9%
Chico	613014	−1.00	11	38,159	4.8%	1.7%
San Francisco	667000	−0.98	12	377,626	4.3%	−0.7%
Daly City	617918	−0.96	13	32,090	2.9%	−1.6%
Rancho Santa Margarita	659587	−0.92	14	17,806	3.5%	−3.1%
Susanville	677364	−0.87	15	4,269	2.6%	–
Arcata	602476	−0.86	16	7,687	0.9%	–
Vallejo	681666	−0.85	17	45,168	1.0%	−4.3%
Merced	646898	−0.84	18	27,854	1.2%	–
Bishop	606798	−0.84	19	1,947	3.7%	–
Glendale	630000	−0.82	20	77,543	3.6%	−2.2%
Fairfield	623182	−0.79	21	38,857	4.6%	−2.9%
Oakland	653000	−0.79	22	168,805	1.5%	−5.5%
Livermore	641992	−0.79	23	31,432	3.9%	−2.2%
San Rafael	668364	−0.78	24	23,684	1.1%	−5.1%
Albany	600674	−0.77	25	7,632	0.1%	−6.0%
Fort Bragg	625058	−0.77	26	3,039	4.1%	–
Milpitas	647766	−0.76	27	22,474	11.4%	7.0%
Berkeley	606000	−0.76	28	49,040	1.9%	−4.4%
Laguna Niguel	639248	−0.75	29	25,659	1.6%	−1.6%
South Gate	673080	−0.73	30	24,168	0.5%	−3.3%

City	FIPS Code	MATCHR Index	Rank	Number of residences (2018Q1)	Housing growth (2012–2018)	Growth surplus (2012–2018)
Grover Beach	631393	−0.72	31	5,623	0.5%	−2.7%
Rohnert Park	662546	−0.70	32	16,760	1.4%	−3.7%
Culver City	617568	−0.69	33	17,344	1.1%	−2.1%
Roseville	662938	−0.69	34	52,545	8.4%	4.4%
Redondo Beach	660018	−0.67	35	30,889	0.1%	−3.4%
Plymouth	657834	−0.66	36	287	12.9%	–
Sacramento	664000	−0.64	37	194,180	2.1%	−1.1%
Pacific Grove	654848	−0.63	38	7,911	0.5%	−3.9%
Reedley	660242	−0.63	39	7,110	1.5%	–
Bell	604870	−0.61	40	9,063	0.0%	−2.8%
San Luis Obispo	668154	−0.61	41	22,043	2.2%	−10.9%
Los Angeles	644000	−0.58	42	1,430,969	2.8%	−1.5%
Santa Cruz	669112	−0.57	43	22,774	2.2%	−3.1%
Chula Vista	613392	−0.57	44	82,748	4.6%	1.4%
San Bruno	665028	−0.57	45	16,247	2.0%	−2.4%
Huntington Beach	636000	−0.56	46	82,954	4.1%	1.0%
Santa Barbara	669070	−0.56	47	37,373	1.7%	–
Lindsay	641712	−0.56	48	3,342	3.8%	–
Marina	645778	−0.56	49	7,946	9.0%	−0.5%
Redwood City	660102	−0.55	50	31,293	7.0%	−2.4%
Yuba City	686972	−0.54	51	23,306	1.0%	–
Salinas	664224	−0.54	52	42,618	0.4%	−3.7%
Mount Shasta	649852	−0.53	53	1,872	3.8%	–
El Centro	621782	−0.52	54	14,210	2.0%	–
South San Francisco	673262	−0.52	55	21,350	−1.6%	−5.5%
Santa Paula	670042	−0.52	56	9,082	2.1%	−5.1%
Davis	618100	−0.50	57	26,873	1.8%	−3.2%
Seaside	670742	−0.50	58	11,076	1.4%	−3.9%
Grass Valley	630798	−0.49	59	6,291	5.1%	−3.7%
Turlock	680812	−0.48	60	25,172	2.1%	–
Citrus Heights	613588	−0.47	61	35,445	0.1%	−2.4%
Eureka	623042	−0.47	62	11,728	0.5%	–
Watsonville	683668	−0.46	63	13,836	1.5%	−2.2%
El Monte	622230	−0.46	64	28,672	1.1%	−1.8%

City	FIPS Code	MATCHR Index	Rank	Number of residences (2018Q1)	Housing growth (2012–2018)	Growth surplus (2012–2018)
Woodland	686328	−0.46	65	20,359	3.3%	0.2%
Belmont	605108	−0.45	66	10,830	0.3%	−3.5%
Carson	611530	−0.45	67	26,601	1.7%	−2.5%
Brisbane	608310	−0.45	68	1,981	3.8%	−8.9%
Santa Fe Springs	669154	−0.44	69	5,548	11.4%	10.0%
Mountain View	649670	−0.44	70	36,842	5.4%	0.7%
Mission Viejo	648256	−0.43	71	34,908	1.9%	−0.7%
Alameda	600562	−0.42	72	32,262	1.4%	−4.0%
Livingston	642006	−0.41	73	3,527	3.4%	–
Hayward	633000	−0.40	74	50,078	2.3%	−3.7%
Manhattan Beach	645400	−0.40	75	14,815	−0.3%	−3.9%
Burlingame	609066	−0.40	76	13,036	−0.3%	−3.4%
Bakersfield	603526	−0.39	77	127,346	6.4%	6.1%
Kingsburg	638562	−0.39	78	4,136	0.8%	–
Stockton	675000	−0.37	79	98,982	0.4%	–
Pittsburg	657456	−0.37	80	23,302	6.2%	7.3%
El Cajon	621712	−0.37	81	36,054	0.9%	−2.9%
Gonzales	630392	−0.36	82	690	6.9%	−6.0%
Rosemead	662896	−0.36	83	14,488	0.6%	−1.9%
Baldwin Park	603666	−0.35	84	17,713	1.3%	−1.1%
Imperial Beach	636294	−0.35	85	9,830	1.5%	−2.4%
Firebaugh	624134	−0.35	86	2,185	7.4%	–
Imperial	636280	−0.34	87	5,725	21.1%	–
San Pablo	668294	−0.34	88	9,775	0.8%	−4.1%
Santa Maria	669196	−0.34	89	30,010	5.1%	1.2%
National City	650398	−0.32	90	16,856	3.5%	−0.1%
Los Banos	644028	−0.32	91	12,419	3.7%	–
Brentwood	608142	−0.31	92	19,787	14.0%	7.6%
Manteca	645484	−0.31	93	25,708	10.3%	–
Riverbank	661068	−0.31	94	7,263	1.8%	–
Oceanside	653322	−0.30	95	65,945	2.0%	−2.3%
Concord	616000	−0.29	96	46,964	0.4%	−4.0%
Port Hueneme	658296	−0.29	97	8,252	2.1%	−2.3%
Downey	619766	−0.29	98	35,170	0.4%	−1.6%
Paramount	655618	−0.29	99	14,400	0.0%	−3.0%

City	FIPS Code	MATCHR Index	Rank	Number of residences (2018Q1)	Housing growth (2012–2018)	Growth surplus (2012–2018)
Ridgecrest	660704	−0.27	100	12,264	1.8%	–
Garden Grove	629000	−0.27	101	47,803	1.0%	−1.4%
Duarte	619990	−0.26	102	7,386	0.7%	−3.5%
Torrance	680000	−0.26	103	57,355	0.2%	−2.3%
South El Monte	672996	−0.26	104	4,742	3.5%	−1.7%
Weed	683850	−0.25	105	1,265	−0.4%	–
Modesto	648354	−0.24	106	74,810	0.3%	–
Ontario	653896	−0.24	107	49,452	4.5%	1.3%
Inglewood	636546	−0.23	108	38,628	1.1%	−2.2%
San Jose	668000	−0.23	109	331,000	5.8%	0.1%
Tustin	680854	−0.23	110	29,411	6.3%	2.9%
Pinole	657288	−0.22	111	7,096	0.1%	−6.5%
Pasadena	656000	−0.22	112	59,467	1.9%	−1.7%
Visalia	682954	−0.22	113	46,863	5.7%	–
Santa Rosa	670098	−0.21	114	64,225	−3.4%	−10.9%
Half Moon Bay	631708	−0.21	115	4,365	3.7%	−12.8%
American Canyon	601640	−0.21	116	6,131	2.1%	−0.7%
Benicia	605290	−0.20	117	11,389	0.9%	−7.2%
San Leandro	668084	−0.20	118	32,408	0.3%	−5.1%
Santa Clara	669084	−0.18	119	48,049	6.0%	2.5%
Newark	650916	−0.18	120	14,174	5.8%	0.0%
Sanger	667056	−0.18	121	7,497	6.3%	–
Bellflower	604982	−0.16	122	24,730	0.8%	−1.8%
Farmersville	623616	−0.16	123	2,689	−0.6%	–
Galt	628112	−0.14	124	8,164	5.2%	–
Lakeport	639710	−0.14	125	2,340	4.7%	–
Lathrop	640704	−0.14	126	5,844	8.2%	–
Carlsbad	611194	−0.13	127	45,077	2.5%	−1.3%
Pico Rivera	656924	−0.13	128	16,451	−0.4%	−2.5%
Mill Valley	647710	−0.13	129	6,248	0.7%	−3.4%
Shasta Lake	671225	−0.12	130	4,233	1.6%	−5.9%
Vista	682996	−0.12	131	32,325	3.3%	−0.7%
Long Beach	643000	−0.12	132	175,873	0.8%	−2.7%
Dixon	619402	−0.11	133	6,411	4.6%	−5.1%
Monterey	648872	−0.11	134	13,522	0.0%	−2.4%

City	FIPS Code	MATCHR Index	Rank	Number of residences (2018Q1)	Housing growth (2012–2018)	Growth surplus (2012–2018)
Menifee	646842	−0.11	135	33,085	9.8%	−6.7%
Lancaster	640130	−0.10	136	54,358	0.9%	–
Escondido	622804	−0.09	137	47,900	1.3%	−4.0%
Santa Clarita	669088	−0.08	138	63,779	2.9%	−0.7%
Norwalk	652526	−0.08	139	27,779	−0.9%	−3.1%
Palo Alto	655282	−0.08	140	28,305	1.8%	−2.4%
Stanton	673962	−0.07	141	11,620	0.8%	−2.2%
Laguna Beach	639178	−0.07	142	12,561	0.9%	−3.7%
Sebastopol	670770	−0.06	143	3,291	2.0%	−9.4%
Red Bluff	659892	−0.06	144	6,215	2.9%	–
Antioch	602252	−0.04	145	36,350	2.2%	−8.3%
Costa Mesa	616532	−0.03	146	42,887	2.1%	−1.1%
Paso Robles	622300	−0.03	147	11,902	2.6%	−6.8%
Cypress	617750	−0.02	148	16,441	1.1%	−0.7%
La Mesa	640004	−0.01	149	25,825	1.0%	−1.8%
Dinuba	619318	0.00	150	6,578	7.6%	–
Beaumont	604758	0.00	151	14,536	10.4%	–
Healdsburg	633056	0.01	152	4,776	3.0%	−7.5%
Tehama	678106	0.02	153	118	8.0%	0.2%
Napa	650258	0.02	154	30,562	1.9%	−1.7%
Santa Ana	669000	0.02	155	76,744	1.4%	−1.8%
Anderson	602042	0.03	156	4,504	2.6%	–
Blythe	607218	0.03	157	5,730	−5.9%	–
Jackson	636980	0.04	158	2,034	4.3%	–
Cupertino	617610	0.06	159	21,049	1.4%	−3.5%
Union City	681204	0.06	160	21,216	0.9%	−3.8%
Westminster	684550	0.06	161	28,512	3.0%	−0.4%
Whittier	685292	0.09	162	29,316	0.8%	−3.1%
Gilroy	629504	0.09	163	16,703	10.7%	2.2%
Pacifica	654806	0.09	164	14,549	−0.3%	−7.4%
Millbrae	647486	0.10	165	8,657	1.9%	−1.5%
Simi Valley	672016	0.11	166	42,605	1.1%	−4.9%
Mammoth Lakes	645358	0.11	167	10	–	–
Corona	616350	0.11	168	47,931	2.8%	−1.8%
Chino	613210	0.12	169	25,956	18.6%	13.9%

City	FIPS Code	MATCHR Index	Rank	Number of residences (2018Q1)	Housing growth (2012–2018)	Growth surplus (2012–2018)
Lake Elsinore	639486	0.12	170	18,450	16.7%	−9.3%
Lomita	642468	0.14	171	8,516	4.3%	0.5%
Avenal	603302	0.16	172	2,462	2.1%	–
Saint Helena	664140	0.17	173	2,784	1.7%	–
Rancho Cordova	659444	0.17	174	27,296	6.1%	0.1%
Walnut Creek	683346	0.18	175	33,519	1.9%	−2.9%
Novato	652582	0.19	176	21,249	0.6%	−8.0%
Oakley	653070	0.20	177	11,906	6.6%	17.4%
Kerman	638226	0.21	178	4,242	8.7%	–
La Quinta	640354	0.22	179	20,877	3.8%	−5.8%
San Bernardino	665000	0.24	180	65,033	0.3%	−2.7%
Arroyo Grande	602868	0.25	181	7,718	3.4%	2.3%
Loma Linda	642370	0.26	182	9,688	2.1%	−2.7%
Cloverdale	614190	0.27	183	3,534	5.1%	−15.5%
Calistoga	609892	0.27	184	2,300	3.1%	−2.3%
Lakewood	639892	0.28	185	27,499	0.3%	−1.5%
Palm Desert	655184	0.28	186	34,315	3.2%	0.8%
Yucaipa	687042	0.30	187	19,671	1.0%	−4.2%
Monrovia	648648	0.31	188	14,441	0.4%	−3.8%
Coachella	614260	0.31	189	9,693	3.5%	−1.1%
Elk Grove	622020	0.32	190	53,356	4.7%	–
Fillmore	624092	0.33	191	4,502	4.9%	−7.9%
Pleasanton	657792	0.33	192	28,314	5.5%	−0.2%
La Palma	640256	0.34	193	5,228	1.1%	−0.4%
Moorpark	649138	0.34	194	11,421	5.4%	−0.9%
San Ramon	668378	0.36	195	28,824	6.8%	2.3%
San Juan Capistrano	668028	0.36	196	12,751	10.7%	−1.4%
Covina	616742	0.36	197	16,787	2.1%	−0.8%
Placentia	657526	0.38	198	17,628	1.3%	−1.6%
Victorville	682590	0.40	199	37,855	0.9%	–
Temple City	678148	0.42	200	11,657	0.8%	−1.7%
Soledad	672520	0.43	201	4,144	5.3%	–
La Habra	639290	0.44	202	20,279	2.5%	0.1%
Camarillo	610046	0.44	203	25,981	3.1%	−3.1%

City	FIPS Code	MATCHR Index	Rank	Number of residences (2018Q1)	Housing growth (2012–2018)	Growth surplus (2012–2018)
Arcadia	602462	0.45	204	20,222	0.3%	−2.5%
Riverside	662000	0.45	205	97,999	1.7%	−1.9%
Buena Park	608786	0.46	206	25,349	2.1%	0.1%
Fullerton	628000	0.50	207	48,674	2.6%	0.0%
Beverly Hills	606308	0.50	208	16,318	0.2%	−4.3%
Laguna Hills	639220	0.50	209	13,807	23.7%	21.6%
Moreno Valley	649270	0.53	210	55,554	1.2%	–
Colton	614890	0.53	211	16,045	0.2%	−10.8%
Anaheim	602000	0.54	212	108,631	2.5%	−1.2%
Danville	617988	0.54	213	15,810	1.4%	−5.5%
San Jacinto	667112	0.56	214	14,809	2.1%	–
San Anselmo	664434	0.56	215	5,309	−0.3%	−6.5%
Montclair	648788	0.59	216	10,648	4.2%	2.1%
Sierra Madre	671806	0.61	217	5,004	0.5%	−2.8%
Fountain Valley	625380	0.65	218	19,332	0.7%	−1.6%
San Gabriel	667042	0.68	219	13,075	1.0%	−2.6%
Rancho Cucamonga	659451	0.70	220	58,745	3.6%	0.7%
Westlake Village	684438	0.72	221	3,383	0.3%	−5.4%
Atascadero	603064	0.72	222	11,291	4.3%	−3.6%
Los Gatos	644112	0.73	223	13,060	1.6%	−3.1%
Yreka	686944	0.77	224	3,632	3.5%	–
Indian Wells	636434	0.78	225	4,348	2.6%	−2.2%
Del Mar	618506	0.81	226	2,482	−0.6%	−2.4%
Fontana	624680	0.84	227	54,365	3.7%	0.6%
Desert Hot Springs	618996	0.94	228	10,904	4.1%	–
Los Altos	643280	0.97	229	11,518	4.4%	−0.1%
Moraga	649187	0.97	230	5,803	0.8%	−7.8%
Twentynine Palms	680994	0.97	231	8,921	−0.4%	–
Hesperia	633434	1.15	232	29,009	1.9%	–
Palm Springs	655254	1.34	233	33,537	1.9%	−1.7%
La Canada Flintridge	639003	1.37	234	7,079	0.3%	−7.2%
Rancho Palos Verdes	659514	1.38	235	16,251	0.5%	−3.7%

City	FIPS Code	MATCHR Index	Rank	Number of residences (2018Q1)	Housing growth (2012–2018)	Growth surplus (2012–2018)
West Covina	684200	1.41	236	33,508	2.7%	0.2%
Encinitas	622678	1.48	237	25,928	3.0%	−1.3%
Solana Beach	672506	1.48	238	6,382	−1.0%	−5.2%
Clayton	613882	1.87	239	4,060	0.3%	−11.7%
Yorba Linda	686832	1.97	240	24,141	7.6%	2.6%
Ross	662980	2.06	241	173	−0.6%	−16.3%
Apple Valley	602364	2.30	242	26,532	2.7%	–
Monte Sereno	648956	2.31	243	1,264	0.3%	−5.2%
Rolling Hills Estates	662644	2.42	244	3,138	0.3%	−3.3%
Truckee	680588	2.48	245	5,577	17.1%	−0.4%
Hillsborough	633798	2.60	246	3,959	0.8%	−10.9%
Los Altos Hills	643294	3.87	247	2,941	1.3%	−15.7%
Bradbury	607946	4.61	248	349	−0.6%	−19.2%
Atherton	603092	5.41	249	2,571	0.7%	−12.0%

Note: Owing to rounding, cities with the same MATCHR index have different ranks.

TABLE A2. MATCHR INDEX BY COUNTY

County	FIPS Code	MATCHR Index	Rank
Yolo	6113999	−0.76	1
San Luis Obispo	6079999	−0.64	2
Los Angeles	6037999	−0.61	3
Sonoma	6097999	−0.60	4
Tulare	6107999	−0.46	5
Yuba	6115999	−0.38	6
San Mateo	6081999	−0.27	7
Glenn	6021999	−0.27	8
Marin	6041999	−0.12	9
Contra Costa	6013999	−0.07	10
Tehama	6103999	0.02	11
Orange	6059999	0.14	12
Calaveras	6009999	0.20	13
Santa Barbara	6083999	0.42	14
San Bernardino	6071999	0.99	15
Shasta	6089999	1.56	16

Notes: Counties govern their unincorporated portions. Owing to rounding, counties with the same MATCHR index have different ranks.

APPENDIX B: REPLACING MISSING VALUES

Where possible, we replaced missing values in the Terner Center data to correctly reflect the land use regulations in place. This appendix describes those replacements. The Stata do-file that executes the changes is available from the authors upon request.

The survey asked officials, in approximate terms, how much of their developed and developable land allows single-family housing, multifamily housing, and nonresidential use. The answers are inconsistent, however. In the most egregious case, El Cajon reported that at least 76 percent of its land allows single-family housing, at least 76 percent allows multifamily housing, and at least 51 percent allows nonresidential use. The city's zoning map, however, does not indicate that a multiuse zone exists in the town. At the opposite extreme, Colma (which is mostly cemeteries) accounted for at most 35 percent of its developable or developed land. To enforce consistency, we replaced each given range with its midpoint and then normalized so that the three shares sum to 100.

In some cases, we replaced missing data for crucial variables with answers taken from the published zoning codes of the jurisdictions in question. These manual additions to the data made no qualitative differences in the conclusions, but they expanded the sample size and allowed us to produce a regulatory summary index for almost the entire TCRLUS sample. We succeeded in finding sufficient data for all but three counties and three cities.

For example, for the city of Dixon, we examined the zoning map, determined that R1-6 is the modal single-family zoning designation, and looked up its minimum lot size (6,000 square feet) in the city's zoning code.[45]

In the single-family minimum lot size variable, *zon_sfminlotsize*, we replaced values in Danville,[46] Moorpark,[47] Rancho Cordova,[48] Ross,[49] Santa

45. Dixon, CA, Mun. Code chap. 18.01 (February 2019), https://www.codepublishing.com/CA/Dixon/?Dixon18/Dixon1801.html&?f; "City of Dixon Zoning Map," October 2013, https://www.ci.dixon.ca.us/DocumentCenter/View/67/Zoning-Map?bidId=.
46. "Town of Danville Zoning Map," August 30, 2017, https://www.danville.ca.gov/DocumentCenter/View/1020/Zoning-Map-PDF?bidId=.
47. Moorpark, CA, Mun. Code § 17.24.020 (February 2019), https://qcode.us/codes/moorpark/; "City of Moorpark—Zoning Map," September 17, 2008, https://www.moorparkca.gov/DocumentCenter/View/175/Zoning-Map---Large?bidId=.
48. Rancho Cordova, CA, Mun. Code (February 2019), https://www.codepublishing.com/CA/RanchoCordova/; "Rancho Cordova Zoning and Future Land," December 2014, https://www.cityofranchocordova.org/home/showdocument?id=10453.
49. "Town of Ross Zoning Map," February 28, 2000, https://www.townofross.org/sites/default/files/fileattachments/planning/page/277/zoning-map.pdf.

Barbara,[50] Truckee,[51] West Covina,[52] West Sacramento,[53] Westlake Village,[54] and Shasta County,[55] as well as in Dixon. Alpine County was left as a missing value because minimum lot size is determined on a "site-by-site basis."[56]

Atherton,[57] Avenal,[58] Brisbane,[59] Ross,[60] and Tehama[61] gave no data for minimum single-family parking; we looked up the data in the jurisdictions' respective codes. To our surprise, Atherton appears to have no parking minimum in its code, except for accessory dwelling units.

We added a side setback value for San Francisco of three feet, which would be at least as stringent as the requirement for most single-family lots in the city.[62]

We corrected one case of mismatched units in the TCRLUS data. The height limits in Fillmore (*zon_mfheightlimit* and *zon_sfheightlimit*) are given as "2"—but the variable is listed in feet, not stories, so we correct it to "35," following

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50. "City of Santa Barbara Zoning Map," October 1, 2017, https://www.santabarbaraca.gov/civicax/filebank/blobdload.aspx?BlobID=201638.
51. Built subdivisions in Truckee are moved into the "RS-X" zone, which denotes "no further subdivision allowed." Of the unbuilt RS zones, the most area is in RS-0.50, which indicates one dwelling per two acres. Converting from gross density (presumed) to minimum lot size at 87 percent coverage yields a minimum lot size of 75,794 square feet. "Truckee Zoning," December 14, 2018, https://www.townoftruckee.com/home/showdocument?id=11807.
52. "Zoning: City of Covina," March 2, 2015, https://covinaca.gov/pc/page/zoning-map.
53. West Sacramento, CA, Mun. Code (December 2018), http://qcode.us/codes/westsacramento/?view=desktop&topic=0; "City of West Sacramento Zoning Map," October 2016, https://www.cityofwestsacramento.org/home/showdocument?id=4240.
54. Westlake Village, CA, website, "Zoning," accessed February 1, 2019, https://www.wlv.org/214/Zoning.
55. "Shasta County Map," County of Shasta GIS (Geographic Information System), accessed February 1, 2019, https://maps.co.shasta.ca.us/ShastaCountyMap/.
56. Alpine County, CA, Code chap. 18.56 (February 2019), https://www.codepublishing.com/CA/AlpineCounty/?AlpineCounty18/AlpineCounty1856.html.
57. Atherton, CA, Mun. Code (October 2018), https://www.codepublishing.com/CA/Atherton/.
58. Avenal, CA, website, "Table 9-5: Parking Requirements," accessed February 1, 2019, https://www.cityofavenal.com/DocumentCenter/View/621/Table-9-5-Parking-Requirements-.
59. Brisbane, CA, Mun. Code chap. 17.34 (February 2019), https://library.municode.com/ca/brisbane/codes/code_of_ordinances?nodeId=TIT17ZO_CH17.34OREPA.
60. Ross, CA, website, "Chapter 18.16: Single Family Residence (R-1) District," accessed February 1, 2019, https://www.townofross.org/sites/default/files/fileattachments/administration/page/249/18.16_single_family_residence_r-1_district.pdf.
61. Tehama, CA, Mun. Code chap. 17.12 (February 2019), https://library.municode.com/ca/tehama/codes/code_of_ordinances?nodeId=TIT17ZO_CH17.12REDI.
62. San Francisco Planning Department, "Buildable Area for Lots in RH, RM, RC, and RTO Districts," Zoning Administrator Bulletin No. 5, April 2005, http://default.sfplanning.org/publications_reports/ZAB_05_Buildable_Area.pdf; San Francisco, CA, Mun. Code, Planning Code (February 2019), http://library.amlegal.com/nxt/gateway.dll/California/planning/planningcode?f=templates$fn=default.htm$3.0$vid=amlegal:sanfrancisco_ca$sync=1.

the city's code, which specifies a height limit of 35 feet or 2 stories, whichever is less.[63]

We also corrected one likely typo: the minimum lot size for multifamily development in Lakeport is listed as an improbably small 600 square feet. The municipal code indicates that the correct value is 6,000 square feet.[64] Several other entries in *zon_mfminlotsize* seemed unlikely; an audit found that most of these reflected the distinct zoning concept of minimum site area per unit. We changed the entries for Dinuba,[65] Kingsburg,[66] Los Banos,[67] Mount Shasta,[68] and Pacific Grove[69] to published parcel or site minimums. We changed La Habra to missing, since it did not publish a clear site minimum. And we confirmed that small individual parcels in multifamily developments are possible in Sacramento and Yolo County.

In other cases, we used logical relationships between variables to interpret or replace missing data. The TCRLUS Codebook explains four distinct "missing value" codes. Of these, we usually interpreted "−97", which denotes "N/A, blank, zero," to indicate that the relevant regulation did not exist in the jurisdiction.[70]

Many cities skipped the "total off-street parking" question for single-family homes but gave values for either or both of "covered off-street parking" and "uncovered off-street parking." Observing that *prk_sftotal = prk_sfcovered + prk_sfuncovered* for almost all jurisdictions with data in all three fields, we made that calculation and replaced missing *prk_sftotal* data in 19 jurisdictions.

In two cases, we made subjective judgments to add missing data from published zoning maps. The cities of Solana Beach[71] and Mountain View[72] did not report land shares; we estimated the shares, reporting, for example, that "some

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63. Fillmore, CA, Mun. Code art. II, § 6.04.04 (November 1994), http://www.fillmoreca.com/home/showdocument?id=205.
64. Lakeport, CA, Mun. Code chap. 17.06 (February 2019), https://www.codepublishing.com/CA/Lakeport/#!/Lakeport17/Lakeport1706.html#17.06.
65. Dinuba, CA, Mun. Code § 17.24.050 (2008), http://www.dinuba.org/images/docs/forms/Dinuba_Zoning_Ordinance.pdf.
66. Kingsburg, CA, Mun. Code chap. 17.32 (February 2019), https://library.municode.com/ca/kingsburg/codes/code_of_ordinances?nodeId=TIT17ZO_CH17.32ULMIREDI.
67. Los Banos, CA, Mun. Code § 9-3.805 (February 2019), https://qcode.us/codes/losbanos/.
68. Mt. Shasta, CA, Mun. Code chap. 18.16 (February 2019), https://www.codepublishing.com/CA/MtShasta/#!/MtShasta18/MtShasta1816.html#18.16.
69. Pacific Grove, CA, Mun. Code § 23.24.040 (February 2019), https://www.codepublishing.com/CA/PacificGrove/#!/PacificGrove23/PacificGrove2324.html#23.24.040.
70. It is not clear to us how to distinguish "blank" in this case from the definition of the most common missing value code ("−99"): "Question seen but not answered."
71. "City of Solana Beach Official Zoning Map," May 2007, https://www.ci.solana-beach.ca.us/vertical/Sites/%7B840804C2-F869-4904-9AE3-720581350CE7%7D/uploads/Zoning_Map.pdf.
72. Mountain View, CA, "Zoning Map," March 2018, https://www.mountainview.gov/civicax/filebank/blobdload.aspx?blobid=10990.

(26 to 50%)" of Mountain View's developable or developed land falls into each of the three given categories.

Missing values pose an interpretive dilemma for multifamily regulations in communities that have very little multifamily zoning. While we normally think of the lack of a restriction (say, the absence of a height limit) as the least restrictive option in that dimension, many of the "−97" ("N/A, blank, zero") missing codes in multifamily restrictions are in places like Atherton that make no allowance for multifamily housing and thus need not regulate its details. We thus interpret "−97" as nonregulation in most jurisdictions but interpret it as a missing value in jurisdictions that answered "almost none" when asked "How much land is zoned to allow multifamily housing?" We also interpret "−97" as a missing value for multifamily minimum lot size, since lot size is almost universally regulated and an audit of the cities reporting −97 in that variable suggested that all do indeed have minimum lot sizes.

We used logic and manual additions to transform *brd_mfmaxunits,* which contains responses to the question "What is the maximum project size for multifamily by-right development?" and is part of a suite of questions about by-right development. First, we replaced missing values of *brd_mfmaxunits* for 76 jurisdictions that replied "no" to *brd_allow*, which asked, "Does your jurisdiction allow by-right development in some cases?" These were bottom-coded at 2, the smallest logical size of a multifamily development.

Next, we top-coded (as unregulated) 114 jurisdictions that had replied "no" to *brd_mflimit* ("Is there a project size limit for multifamily by-right development?"). These included four that had confusingly entered "0" as the limit in *brd_mfmaxunits*. We also looked for missing values in places that had checked *brd_residential* ("Projects of any size can be built by-right in all residential zones"), but none persisted.

Seven jurisdictions reported values of *brd_mfmaxunits* below two, our logical minimum. To clarify that they are (in fact) no more restrictive, we replaced seven zeroes and ones with twos.

We were skeptical of a number of jurisdictions that reported no limit on multifamily project size development but are known for having no multifamily housing at all. We thus audited all jurisdictions that reported that "almost none (0–5%)" of their land was zoned for multifamily housing but that claimed to have no restriction on by-right multifamily project size. Of these, we found that Bradbury,[73]

73. Bradbury, CA, Mun. Code chap. 58 (April 2019), https://library.municode.com/ca/bradbury/codes/code_of_ordinances?nodeId=COOR_TITIXDECO_PTVZODIALLAUS.

Clayton,[74] Indian Wells,[75] Los Altos Hills,[76] and Ross[77] have no land zoned for multifamily and thus do not allow such projects by-right.

Some regulations are given as minimums, so high values are most restrictive. Others—such as *brd_mfmaxunits*—are the reverse. We transformed the latter so that high values were uniformly more restrictive. In one case, that was a judgment call: we interpret a high share of developable land restricted to single-family use as a more restrictive regulation. Analysis bears out this choice. Even when we did not normalize zoned shares to sum to 100, extensive single-family zoning was correlated with stricter regulation.

There are two simple ways to reverse a variable: invert it, or multiply it by −1. We used each method where appropriate, depending on which preserved a useful value for nonregulation. Thus, a city without a height limit can be thought of as having an infinite height limit. But it is more useful, statistically, to invert the height limit so that jurisdictions that do not regulate height can be assigned an "inverse height limit" of 0.

We took natural logs of the minimum lot size variables, for single-family and multifamily housing, to reduce their skewness.

We completed a transformation of the variables by standardizing them to a mean of 0 and standard deviation of 1, thus creating "z-scores."

In the course of analyzing data, we occasionally noted likely contradictions between published regulations and survey answers. For example, Simi Valley reported that "a lot (51–75%)" of its land is zoned for multifamily housing. This does not appear to be true.[78] However, we did not correct these cases.

74. "City of Clayton Official Zoning Map," January 2017, https://ci.clayton.ca.us/fc/community-development/planning/zoning-map-january-2017.pdf.
75. Indian Wells has a mapped "Medium High Density Residential" zone, but it only allows multifamily housing as a conditional use. See Indian Wells, CA, Mun. Code § 21.27.030 (January 2019), https://qcode.us/codes/indianwells/.
76. Los Altos Hills, CA, Mun. Code (August 2019), http://www.losaltoshills.ca.gov/294/Municipal-Code.
77. "Town of Ross Zoning Map."
78. Simi Valley, CA, Mun. Code chap. 9-24 (June 2019), https://library.municode.com/ca/simi_valley/codes/code_of_ordinances?nodeId=TIT9DECOSIVAMUCO_CH9-24REOPSPZODI; "Zoning Map for City of Simi Valley," 2011, http://webapp.scag.ca.gov/scsmaps/Maps/Ventura/subregion/VCTC/Simi%20Valley/image/Simi_Valley_ZN.pdf.

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