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Modeling New Housing Supply in Los Angeles:

Simulations from the Terner Housing Policy Dashboard

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It is widely recognized that California needs to build more housing in order to affordably house its population. However, the policy ideas to encourage new homebuilding are not always informed by data or market-based feasibility. In part, this is because many different and interrelated factors affect what gets built and where. The maximum number of dwelling units on a parcel may not be feasible given limits to floor area ratio, and parking space requirements may actually determine if a project makes financial sense to reach the allowable height. These nuances and intricacies make it difficult to assess which policy changes may have the greatest impact on supply.

Today, the Terner Center & Labs are offering a new paradigm for informing land use decisions at the local level. With the introduction of the Terner Housing Policy Dashboard tool, local elected officials, planning staff and the public will soon have the ability to better understand the likely impacts of different housing policy choices on supply. This new tool builds off of our original Housing Development Dashboard, which focused on a handful of Bay Area cities.[1] The new version, which will be available to partner researchers and city staff, focuses on the state's largest and potentially most complex city: Los Angeles.

As Los Angeles and other cities across California work towards meeting their Regional Housing Needs Allocation (RHNA) and Housing Element goals, they are faced with the challenge of accommodating new levels of housing production that often vastly exceed the level of development in the past. According to the 2021-2029 RHNA allocation, on a per-year basis the City of Los Angeles must plan for nearly 34,000 moderate- and above moderate-income units per year, and roughly 57,000 total units, which is significantly more than the average yearly production during the past 2014-2021 period at roughly 16,500 total units.[2] Accordingly, policymakers need to determine what policy changes can be associated with increasing expected total housing units to the scale of roughly a 240 percent increase.

A crucial first step is to understand the magnitude of each regulatory, market, or policy constraint on housing supply. In this analysis we use the Housing Policy Dashboard to simulate six different prohousing policy scenarios, reflecting the six options outlined by the State's Prohousing Designation Program—a program designed to entice cities to adopt policies that should encourage more homebuilding.[3]

The goal of this analysis is not to prescribe an ideal housing policy regime and zoning code, nor to imply any individual prescription is sufficient to address the housing shortage. It is also not designed to forecast precisely what would happen if Los Angeles were to adopt these policies; market conditions can change more rapidly than the data inputs. With this tool we are simply illustrating the potential of the Dashboard to assess possible policy changes and better measure the level decision makers could adjust a particular policy lever in order to achieve a desired outcome of new housing supply.

In our modeling, no individual policy lever we simulated increased expected units by more than 16 percent from the baseline scenario of current policy conditions. However, each policy lever contributes more housing in different ways, and each has different impacts on where new units are likely to be located with important implications for equity and environmental sustainability. Our analysis makes clear that only a comprehensive solution combining multiple policy levers is likely to get Los Angeles close to its RHNA goals.

How the Tool Works

The Terner Housing Policy Dashboard overlays a real estate pro forma—the calculations that determine whether a new building is financially feasible to build—on top of parcel-level land use and regulatory data. Users can then toggle a broad range of market and policy factors to observe how those changes might impact how much housing gets built. Those parcel-level estimates are aggregated across the city, and by adjusting dozens of inputs, can indicate the citywide impact that a suite of market or policy changes have on development potential.

In partnership with the City of Los Angeles, the Dashboard was built from the parcel level up by running a series of generic rental pro formas for a variety of unit sizes across each plot in the city. These pro formas use data on the parcel's land use allowances, costs of acquiring and building various structures on that parcel, and anticipated revenues and financial returns from potential development. As more thoroughly described in the methodology appendix (Appendix A), our model works by simultaneously simulating the following questions for each of the approximately 850,000 parcels in Los Angeles for which residential development may be allowed:

1. Based on the existing land use regulations and building requirements on each parcel, what structure types and unit counts are allowed? For example, would the parcel allow only a low-rise triplex or would it allow a 500-unit high-rise?

2. For each of these allowed structures, what are the estimated financial results? For example, what would be the returns on a six-unit apartment building compared to a 45-unit building?

3. Based on those financial metrics, which structure and unit count is optimal for each parcel? What would the developer likely seek to build?

4. For the developer's optimal structure on each parcel—using the relationship between these financial metrics and past development outcomes—what is the probability it will be developed, and what is the expected number of units? For example, based on the calculated financials and development outcomes during the past decade across the city, how likely is a 120 units podium project on a given parcel likely to be built in the next ten years?

5. When these expected unit counts are aggregated citywide, how do they change if the inputs that affect steps 1 and 2 are altered?

Through these simulations, we are able to better understand how shifts in policy can be expected to impact homebuildings. However, models are only as accurate as the data they rely on, and it is important to note that the Dashboard cannot fully capture the interaction effect across parcels that may occur if a policy or market shift occurs beyond the bounds of observed past practice. For example, if new housing were to suddenly become more feasible in substantially more places all at the same time, planning applications could swamp city staff capacity or demand for electrical engineers could exceed the total available pool of workers, raising costs or timelines in unanticipated ways. In addition, in another city (or even in a future Los Angeles experiencing a significantly different housing market), policy changes could have significantly different impacts, so readers should be cautious about applying these findings to any other city or housing market without conducting a similar analysis with localized conditions.

Our model only applies to multi-unit rental buildings and does not yet include the creation of for-sale condos, single-family homes for sale or for rent, or affordable housing rental projects built with government funding sources. We are also not modeling multifamily developments on parcels that are currently not zoned for multifamily use. In addition, our pro forma calculates development estimates based on the land use and zoning codes as of the Dashboard's construction in 2020 and does not include forthcoming updates committed to by the City of Los Angeles in its most recent Housing Element update. In future updates to the Dashboard, we plan to add this data. However, even with these limitations, we believe that our model can sufficiently estimate overall development probabilities and activity.

Policy Scenario Simulations

The State of California highlights a number of policies as "Prohousing" through its Prohousing Designation Program.[4] These policies include lower impact fees, streamlining approval processes, and increasing allowable density, among others. The goal of this work was to test policy designs of this type against real conditions in the city of Los Angeles. To do so, we used our Dashboard's generic multifamily rental pro forma to simulate the number of expected units that will be built on each parcel and citywide to establish a baseline and then again for six distinct policy simulations.

For simplicity and comparability, we ran simulations that attempted to model roughly a 25 percent change[5] in a certain policy (i.e. reduced the ratio of parking spaces per unit by 25 percent or increased the maximum floor area ratio from 3 to 3.75), and apply that change across the entire city. The Dashboard allows dialing these levers up or down by any percentage, but for this analysis we chose to compare a consistent 25 percent change across each variable tested. Other than for comparability across policy prescriptions in this study, there was no other reason for specifically choosing to simulate 25 percent changes, and we acknowledge that the decision for how far to ratchet up various policy levers at times is more art than science.[6] While the Dashboard tool was developed precisely to address the issue that planners cannot always quantify impacts of changing policies by a little versus a lot, this simplified assumption should be taken into account when comparing disparate potential policy options against each other.[7]

The scenarios tested are simpler and more sweeping than city officials would likely consider. In practice, a policy change to increase floor area ratios and heights would likely be implemented in select parts of the city with more exceptions or in tandem with a combination of policies across some of the above categories (like density increases or inclusionary policies). This analysis does not prescribe how to achieve policy changes simulated under each scenario (i.e. we do not offer a recommendation for which reviews to remove to reduce entitlements durations), but shows what the estimated outcomes would be, on average, if policy makers were to focus on reaching this goal of a 25 percent effective reduction in the duration and costs incurred by developers.

Furthermore, these estimates are subject to economic conditions. For example, the sharp increase in interest rates over recent months undoubtedly matters a great deal for the housing market and for developers. To take rising interest rates or other market conditions into account, the Dashboard allows users to address uncertainty around future economic conditions by dialing up or down a broad variety of market factors conveying economic conditions. Those market factors include interest rates, rent growth, and construction costs, among others. The estimates reported here reflect assumptions corresponding to the state of affairs just prior to the pandemic, and users of the Dashboard will need to modify these assumptions as events continue to unfold.

Baseline Scenario and Six Prohousing Policy Prescriptions:

To measure the impact of different policy options, we developed a "baseline scenario" for Los Angeles that predicts what our model expects to be built moving forward using the recent conditions in the city. This baseline provides a reference point to observe the degree to which the policies move the needle. We set the baseline scenario in the model using existing policy and our default market factor assumptions as of 2020.[8] For a full list of assumptions in the baseline scenario that are universally applied to all parcels see appendix B.

We simulated the following six policy prescriptions, representing different prohousing approaches (Table 1):

Table 1. Six Prohousing Policy Prescriptions

Policy Prescription		Policy Change	Prohousing Rationale
A	**Increase allowable density on multifamily parcels**	Increase maximum density by 25 percent across all multifamily parcels citywide.	This policy prescription tests if Los Angeles allowed for more density on all multifamily parcels.
B	**Focus on transit**	Increase all density bonuses[9] granted by the transit-oriented communities (TOC) program by 25 percent, except for parking requirements (simulated as part of another policy prescription).	This policy prescription tests if Los Angeles wanted to further incentivize the development of housing near transit via location-based bonuses.
C	**Lower building fees**	Reduce per construction valuation dollar building permit fees by two tenths of one cent, decrease per dwelling unit fees by $1,000, and reduce per square foot fees by $1.	This policy prescription tests the degree that high input costs of development in the form of fees limit the number of parcels in the city that "pencil out" for redevelopment.[10]
D	**Streamline the process**	Reduce entitlement durations by 25 percent across all structure types[11], reduce assumed entitlement costs by 25 percent across all structure types, and reduce entitlement density compromises[12] by 25 percent across all structure types.[13]	This policy prescription tests the degree entitlement process delays, costs, or compromises reduce unit counts or increase costs to the point fewer parcels pencil out for redevelopment.
E	**Bigger and taller buildings**	Increase the maximum height, floor area ratio by 25 percent, and reduce required setbacks by 25 percent.	This policy prescription tests the degree the overlapping restrictions to the land use envelope decreases the number of housing units constructed. The prescriptions test whether if more units were allowed to be added to projects, more parcels would redevelop and the new structures would contain more homes.
F	**Less parking**	Reduce minimum parking requirements citywide by 25 percent, including within TOC zones.[14]	This policy prescription tests the theory that the cost of parking spaces are a major driver of a project's input costs and can keep otherwise profitable projects from penciling out when they are required.[15]

Findings

A comprehensive solution is needed to affect meaningful increases in supply, and larger impacts are expected from less restrictive land use controls.

The simulations produce annual estimates[16] of expected new units of varying magnitudes, with changes to maximum density and building size each increasing expected units by more than 15 percent from the baseline. Density and building size were followed closely by TOC bonuses and entitlement process reform in terms of expected unit increases.

The scale of the expected unit increases from the baseline for each policy prescription indicates that a comprehensive policy solution is necessary to facilitate large-scale increases in supply. Individual prescriptions in isolation result only in incremental increases. For example, increasing maximum density alone in Policy Prescription A increases the expected unit count by roughly 16 percent from the baseline (Figure 1).

Combining all three policy simulations that most directly impact land use restrictions (prescriptions A, B, and E) results in expected units to increase by nearly 43 percent, and combining all six policy prescriptions increase expected units by over 70 percent from the baseline[17] (Figure 2).

The Housing Policy Dashboard allows us to model combinations of these policies and test how they work in combination because the effect on expected unit counts are not necessarily additive. To test this, we combine the policy simulations into two groups:

- Policies that most directly influence development input costs, such as fee reductions, entitlement process streamlining, and mandatory parking requirements (prescriptions C, D, and F)
- Policies that most directly influence allowable units, such as density limits, TOC density bonuses, building size restrictions (prescriptions A, B, and E)

Figure 1. Percent Change in Expected Units Per Year from Baseline Simulation

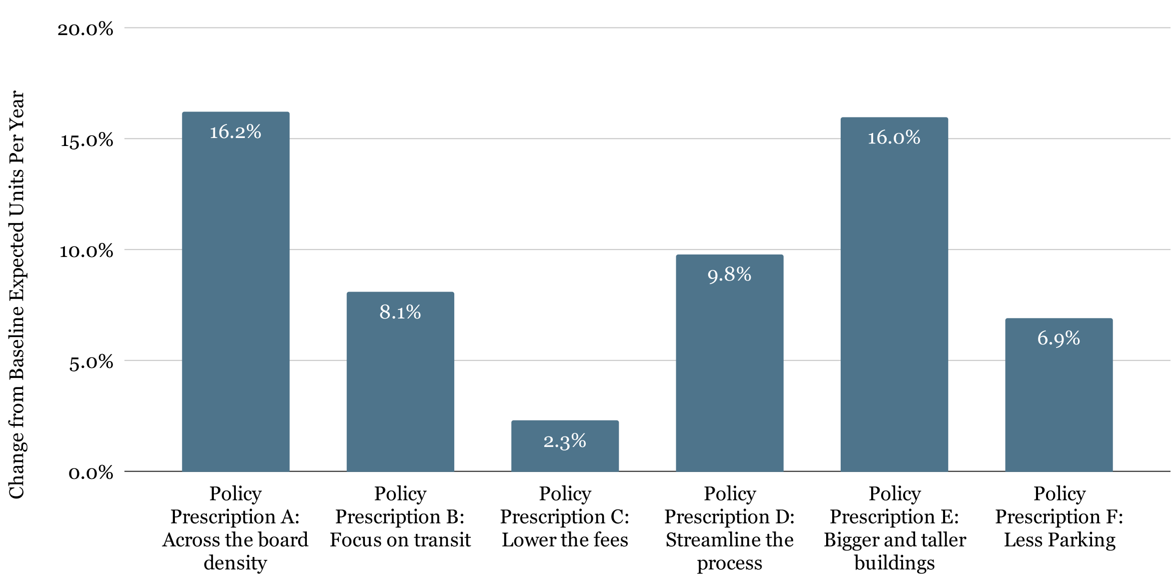
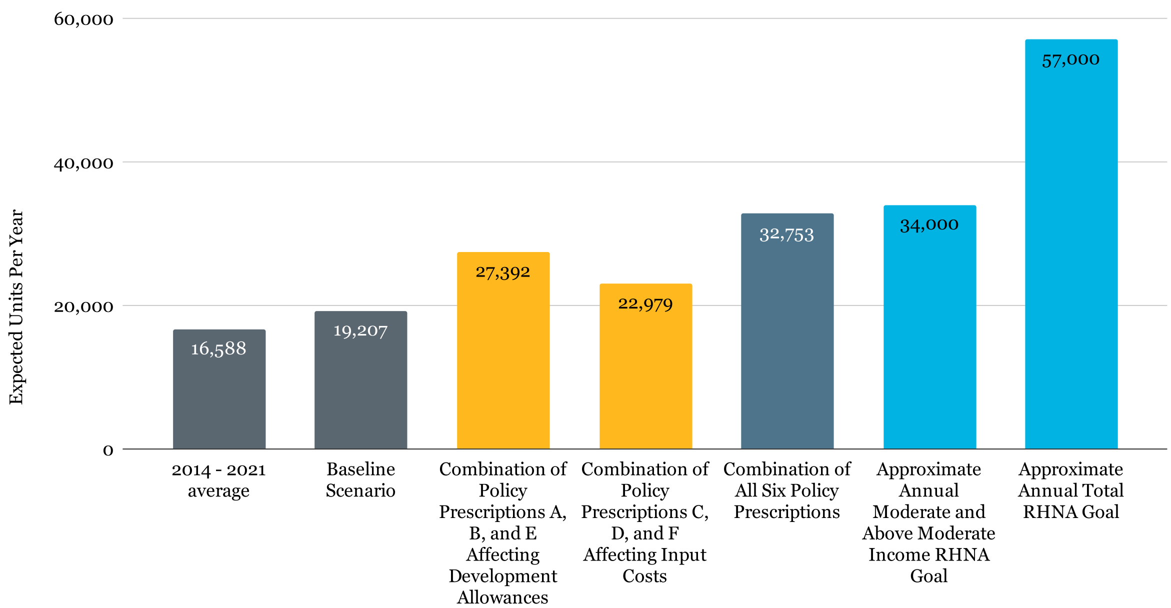


Figure 2. Expected Units Per Year for Each Policy Prescription, Compared to Baseline, 2014-2021 Average, and RHNA Goals



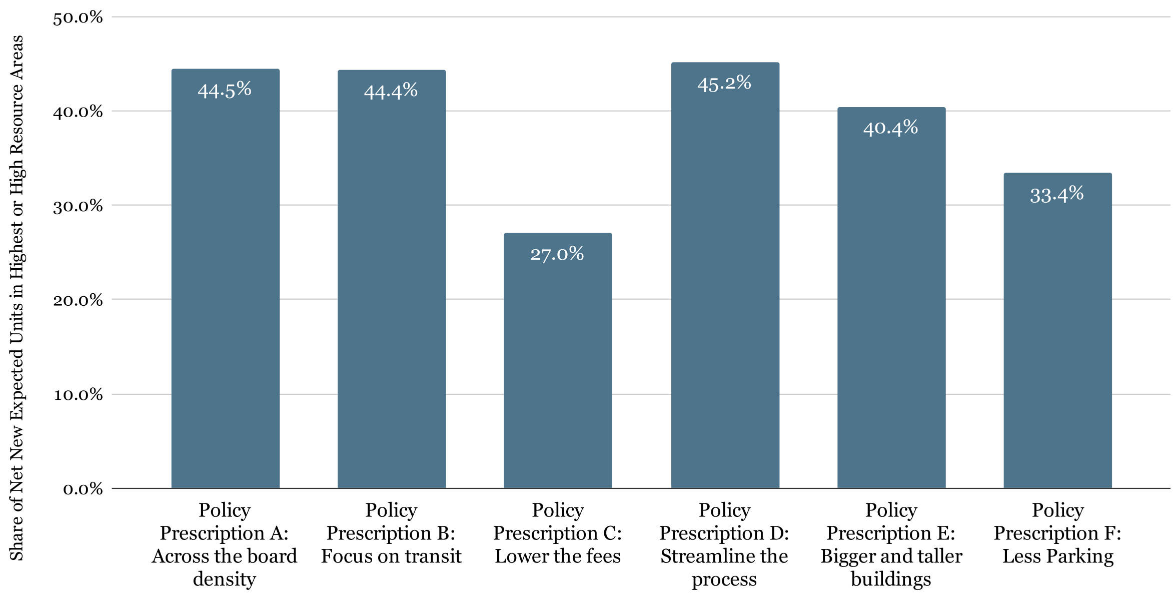
The combination of all six policy changes has an impact much more to the scale with RHNA goals than the individual policy prescriptions alone, signaling that no individual policy change will be sufficient to make up for the city's significant housing shortfall.[18]

The baseline simulation results in about 2,600 units more annually than the observed[19] average between 2014 and 2021.[20] Some of the differences can reasonably be assumed to be a factor of the model capturing economic and policy conditions in 2020 that are more conducive to multifamily rental development than in the 2014-2021 timeframe, whether it be rising rents or new policies increasing density allowances. Some of the gap, however, may also be attributable to additional factors limiting development that are not captured by the Dashboard.

Where can we expect new units to be built under the six policy prescriptions?

Because the Housing Policy Dashboard evaluates development potential on individual parcels the tool allows for important analyses on not just how much housing is produced, but where the housing will be located. For example, as we have demonstrated these different policy changes are associated with different levels of homebuilding increases, the location of those new units is not necessarily the same across policy prescriptions. These discrepancies allow us to compare policy options across additional dimensions and identify which policy changes most disperse or concentrate benefits and impacts of new housing across communities. We can also overlay results with other data sets to, for example, better understand the likelihood of generating rental housing specifically in previously exclusionary, high-opportunity neighborhoods. As illustrated in Figure 3, we observed

Figure 3. Share of Net New Expected Units in High or Highest Resource Areas (TCAC)

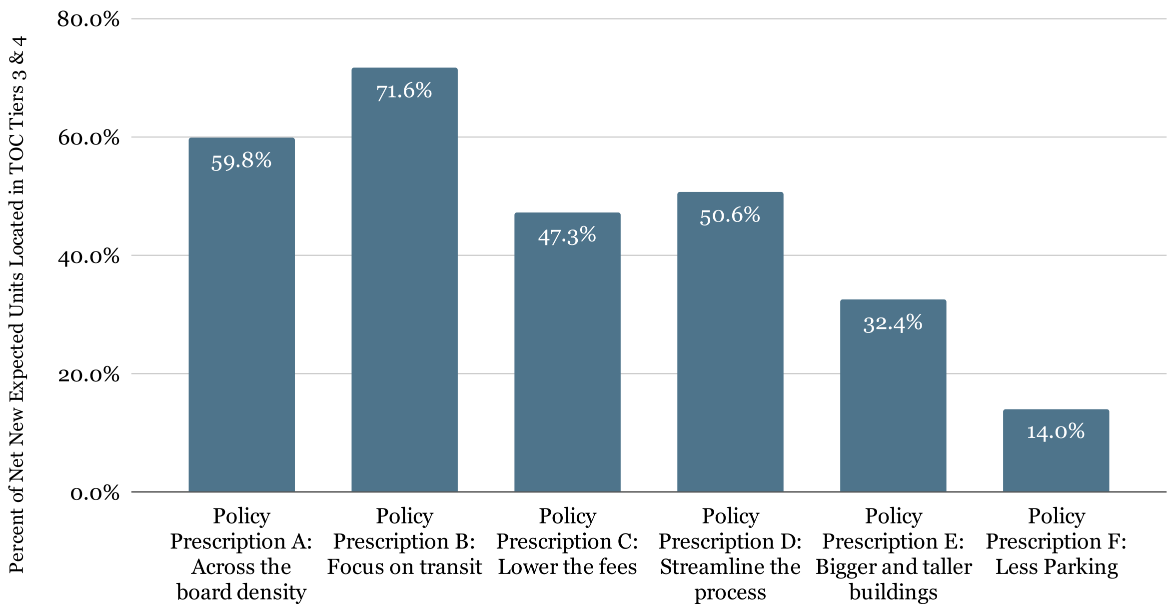


that policy prescriptions involving streamlining the entitlement process, overall increases to density, and transit-oriented density bonuses (prescriptions D, A, and B), produce the largest share of net new units in high-resource areas as designated by California's Tax Credit Allocation Committee (TCAC) Opportunity Area maps.[21]

Unsurprisingly, transit-oriented density bonuses and wholesale density (prescriptions B and A) increases lead to the largest share of expected units with high levels of transit access, as measured by the share of net new units falling within Los Angeles's highest TOC tiers (tiers 3 and 4) (Figure 4). Only 14 percent of the new units generated by focusing on lower parking requirements (prescription F), are expected in areas within the top two TOC tiers. This result is likely due to the fact that the existing TOC bonus program already significantly reduces parking requirements in these areas.

The Dashboard simulations suggest certain policies are more likely to trigger increased density on already feasible parcels (as opposed to making formerly infeasible parcels likely candidates for new development activity). For example, reducing parking requirements (prescription F) seems to have a larger impact on shifting the profitability of a marginal project without necessarily incentivizing a larger project. Conversely, the policy change to encourage overall density (prescription A) is more likely to increase the optimal unit count on parcels compared to increasing the likelihood that the development will happen on a given parcel. Relatedly, increasing overall density (prescription A) significantly shifts the number of parcels upon which the optimal building typology is a more dense structure, meaning that a larger share of parcels are a high-rise building under the policy simulation relative to the baseline,whereas changes to parking requirements (prescription F) have a smaller impact in that regard.

Figure 4. Share of Net New Expected Units in Areas with High Levels of Transit Access (TOC Tiers 3 & 4)



Opportunities for Future Work

Although these are simplified examples, they demonstrate the capabilities of the Dashboard to serve policymakers and the public as a powerful tool to visualize and understand the impact of different policy shifts and likelihood of new supply. But it is important to note the Dashboard is intended to be the starting point of the deliberative planning process to right-size the scope of potential changes, not an "answer" in and of itself.

The Dashboard can provide data to ground important discussions around fundamental questions, such as:

- Which prohousing policies work best to reach the city's goals? And which combination of policies best work together to optimize impact?
- While many prohousing policies involve dialing up or down a level, a dollar amount, or a percentage, what level is necessary to reach the city's goals? For example, should the height limit be four stories or five? Should inclusionary zoning be set at 10 or 15 percent? Where should a city set the dial for the greatest feasibility?
- Does fee reduction as a strategy to spur new development further the city's goals sufficiently to outweigh the loss of revenue, especially when those fees might fund other housing-related programs? Future work should focus on quantifying the amount of revenue lost by reducing fees, how that translates into forgone revenue dollars per expected dwelling unit gained, and whether a lower fee amount on a higher number of units can actually break even with the existing fee structure, or whether there are better ways to raise those revenues that do not require penalizing new development in particular.

- What are policies or programs that can lower some of the market costs impacting development likelihoods, such as modular constructions or financing mechanisms during an inflationary environment?
- In which neighborhoods are certain policies more likely to produce new units relative to other policies? The number of new units associated with a policy change matters, but so does where those units are built with respect to racial and economic equity or environmental sustainability via development which helps to reduce vehicle miles traveled (VMT).

These data help set the stage for a more data-backed discussion of the relative magnitude of policy changes and a quantitative assessment of some tradeoffs. However, a deeper and more detailed analysis of potential policy changes is warranted in future work.

Diving deeper into those policies that look promising may involve simulating more granular policy changes. For example, future work might test whether 20 percent, 22 percent, or 25 percent increases in density have substantially different effects or testing where policy shifts like changes to maximum FAR should really raise proportionally with height limits.

A crucial expansion of this work is increasing the geographic specificity of the simulations to both test impacts of policies implemented to certain areas but not others. Further improvements to the tool will consider generating a model to estimate changes in single-family zoning to allow for multifamily uses, developing a pro forma for owner-occupied housing, modeling projects that combine adjacent parcels, and including additional policy levers created by recent state laws.

We are also actively working to expand the Dashboard to additional jurisdictions in order to simulate the impact of policy changes across various regions and city types, and look forward to working closely with city planners and policymakers to allow them access to these simulations.

Appendix A. The Dashboard in Detail: Methodology, Limitations, and Ongoing Improvements

The Los Angeles pilot of the Housing Development Dashboard is intended to allow city staff and other researchers to gauge the financial feasibility of multifamily development on every parcel in the City of Los Angeles given current market factors and land use policy. Crucially, the Dashboard is also intended to allow professional planners who have been trained on the tool to toggle the values of different market and policy factors and observe the corresponding changes to financial outcomes.

Data Used

The Dashboard consists of the following elements:

- A data set that includes a record for every city parcel—851,095 in total—with (i) parcel geometry for mapping, (ii) a set of 28 parcel-specific variables, and (iii) 51 universal variables.[22]
- A generic pro forma, which takes as an input a single parcel's data, and outputs for (i) the optimal number of units that could be developed on the parcel, as well as (ii) estimated financial outcomes from the optimal constrained development.
- An econometric model that uses the financial outcomes to estimate each parcel's probability of development.
- MapCraft software, which takes the data and pro forma as inputs, implements the generic pro forma at scale across the entire set of parcels in the data, and reports the pro forma outputs visually on a map. The software accepts input from users who may toggle the values of data inputs away from those dictated in the data set, and updates the pro forma implementation and visual outputs on the map.

Pro Forma Development Modeling

The estimates of building quantities and likelihoods are aggregated from the parcel up to the entire city by running millions of simulated "development math" generic rental pro forma calculations in tandem. The model simultaneously considers:

1. **Based on existing zoning and regulations, what structure types and unit counts are allowed?**

For 60 different potential numbers of units, ranging from two to 1,000 (with sensible gaps), the Dashboard model indicates whether that number of units falls within the policy constraints or not, considering land use policies such as height limits, setbacks, floor area ratio (FAR) limits, density limits, maximum lot coverage, maximum square footage, and maximum dwelling units. It also considers the state density bonus, and the City of Los Angeles' TOC bonuses.

2. **For each of these allowed structures, what are the estimated financials?**

Next the model estimates construction costs for the same 60 different potential numbers of units. It considers three different types of construction: low-rise, mid-rise (e.g. wraparound or podium-plus) and high-rise. For each building type, it assumes a fixed marginal cost per square foot, and a maximum density that can be achieved by that building type. The model then estimates the average net operating income per unit for all the potential building configurations. The worksheet adjusts recent market rents obtained from HUD to account for premiums on new construction and building sizes.[23] The model also accounts for the share and discount of below market-rate units, and relies on assumptions with respect to operating expenses (see Appendix B for baseline assumptions).

For the same 60 different building configurations the model then calculates three financial outcomes: The residual land value to land value[24] ratio (RLVLV), and the net present value (NPV), and NPV per equity dollar. In addition to the construction costs and operating revenues, the financial outcomes also depend on the assumed cap rate at disposition, on the typical loan to cost ratio that dictates the necessary investor equity, on investors' preferred returns, and on the duration of construction, as well as the cost of acquiring the land for development. Here the Dashboard also incorporates some assumption-driven modeling of the entitlement process.

3. Based on financials, which structure and unit count is optimal?

The Dashboard model then selects the number of dwelling units—among the 60 different options—that (i) yields the best financial outcomes, and (ii) is allowed per land use policy (including the entitlement density compromise).

The Dashboard makes this selection with a utility function that takes a bundle of different financial outcomes as inputs and then outputs a single number per bundle that can be used to rank bundles as preferable to one another. In this case, a symmetric constant returns-to-scale Cobb-Douglas utility function is used, which reflects a preference over bundles that is "multiplicative" in nature (i.e., it considers bundles with moderately good values for all financial outcomes as preferable to those that score highly on some financial metrics but badly on others). The optimal number of units—the one with the highest value of utility—is chosen.

4. For the optimal structure, using the relationship between these financial metrics and past development outcomes, what is the probability of development and the expected number of units?

To determine the probabilities of development associated with the optimal unit count derived for each parcel, the Dashboard's underlying pro forma is applied using land use, policy and economic inputs circa 2010. The financial outcomes from the 2010 inputs are compared with actual permitting during the following 10 years, and a bivariate logarithmic regression was used to create predicted development probabilities from each of the financial outcomes. In other words, the relationship was statistically established between, e.g., a NPV of x and probability of redevelopment of y percent. The bivariate models for each of the three financial outputs were combined in a manner that accounts for the most predictive financial metric as well as the lowest probability of the three.

Importantly, any systematic changes in development restrictions between 2010 and 2020 (in addition to spot rezonings at the request of a developer) may alter the probability of development not captured by a model using policy and land use inputs circa

2010. Also, construction patterns were not uniform during the decade the model was trained on, and training a probability model on different base years may yield different estimates. However, our ten-year timeframe captures both the high and low ends of the development cycle, and because of the overwhelmingly clear relationship between each of the financial outcomes (conditional on 2010 inputs) and the development outcomes, we believe the Dashboard's estimate of expected units are directionally correct and a reasonable approximation of magnitude.

A series of validation tests find the predictive power of the pro forma's financial metrics on permitting meet benchmarks for acceptable statistical significance and forecasting discrimination.

Those coefficients determined by analyzing data from 2010 are then applied to the parcel-level financial results from the current Dashboard with present-day inputs, and to produce development probabilities. These probabilities are then multiplied by the optimal unit count to estimate expected unit counts. As the user adjusts the inputs to the Dashboard (and impacts the financial results for each parcel) probabilities and expected units counts shift.

Benefits of Pro Forma Approach

Policymakers and researchers have long strived to measure the associations between different regulatory constraints and economic factors and the likelihood of development. However, purely empirical approaches are generally unable to capture the interdependence of multiple policy and/or economic conditions, typically considering only the impact of one specific factor at a time while holding all other conditions fixed.

Additionally, because certain inputs into the development decision process are difficult to measure, empirical research is prone to over-emphasizing the importance of factors that can be easily observed, which can be misleading. For example, construction costs and permitting fees are notoriously difficult to estimate and are also highly variable. Despite their substantial role in development math, this has likely reduced the frequency with which construction costs and permitting fees are studied, as well as the fidelity of findings regarding them. In other cases, holistic measures of the stringency of land use policy such as the Wharton Residential Land Use Regulation Index (WRLURI) have produced general insights that cannot be directly associated with specific land use policies.[25] As a result, studies using the WRLURI are most useful in demonstrating the fact that land use policy matters, rather than quantifying how much specific policies matter or providing a means of considering prescriptive counterfactuals.

The Dashboard is able to improve upon purely statistical approaches because it estimates the effect of multiple interacting policy changes and introduces economic theory. The way in which the pro forma analysis maps from data on parcel traits and market and policy factors to financial outcomes of development is essentially a theoretical construct, but it is then merged into an empirical-theoretic blend as these factors become the inputs in determining the probability of development based on observed outcomes. Our empirical tests have found a significant, highly predictive[26] relationship between financial outcomes predicted by the pro forma and subsequent observed development. The approach also allows the construction of a transparent predictive model that can be used at scale to generate forecasts based on counterfactual scenarios (i.e. circumstances in which market and policy factors have been toggled away from their actual observed values) and illustrate those predictions using the Dashboard.

Limitations to Pro Forma Approach

In addition to challenges previously mentioned with rapidly evolving economic conditions, external validity, and an inability to capture general equilibrium effects from significant changes to building feasibility, the section explores some key limitations to this type of modeling, including interpretation of expected unit counts, generalized policy changes, data limitations, and updated baseline assumptions.

When using expected unit counts as the primary unit of measurement, one must be careful in how they interpret a single parcel's estimate. Take, for example, a parcel where the optimal structure type is 200 units and the financials from the structure place the parcel among the highest-likelihood to redevelop. Given the overall low odds of any development, the expected unit count is reduced to 30. But in practice a developer who does decide to build a 200-unit structure will either build the full 200 on the parcel or not at all. Therefore, the expected unit counts work well to compare rates of increase from the baseline across the entire city and across policies because the calculation smooths out the idiosyncratic factors influencing whether specific parcels are likely to redevelop despite their high financial results (for example, the heirs of an inherited home are enmeshed in the lengthy argument about selling to a developer). But it is also likely to undercount the level of units in a particular parcel or block group. As demonstrated, however, the baseline simulation's sum of expected units is roughly in line with the magnitude of new units annually produced.

As previously stated, a key limitation of the Dashboard is its inability to capture general equilibrium effects. Meaning, the Dashboard runs large numbers of parcel-specific pro formas in parallel, without capturing the interaction across parcels. For example, if market or regulatory factors were to be toggled such that development is more likely across the board, that could result in greater competition over limited planning or construction resources, raising entitlement duration and construction costs or timelines in a way that would find no expression in the Dashboard.

Also worth noting is that the current structure of the Dashboard requires all simulated regulatory changes to be uniform across the city, when in practice a developer would likely adjust their pro forma according to where in the city the parcel is located. This is an area for improvement in future iterations of the Dashboard. For example, the baseline assumption of including 25 percent low-income below market-rate units was assumed in order for projects to qualify for the TOC bonuses. The Dashboard demonstrates including enough below market-rate units to qualify for these bonuses improves financial performance across parcels and block groups, and therefore is the likely pathway for a profit-maximizing developer. However, because the same 25 percent of included below market-rate units must be assumed citywide and for non-TOC zones as well, that is likely an unrealistic assumption for those parcels that results in undercounting expected units in areas ineligible for TOC density bonus. However, we believe when creating citywide assumptions it is more realistic to assume developers will match the requirements of the city's largest bonus program when it's demonstrated as advantageous on net, than to assume a lower BMR share citywide.

Another limitation is that the empirical relationship between financial outcomes derived from the pro forma and the development likelihoods may have reduced external validity when applied to different times or places. Because the model was trained on data within Los Angeles, the latter is less of a concern for this particular report about Los Angeles, however, any algorithm estimated with historical data is necessarily impacted by macroeconomic conditions in that period. Since the macroeconomic conditions in the future may be different, this could influence predictions, even if the relative likelihood of permitting across parcels is valid. For example, the training period linking financial metrics to development outcomes from 2010-2020 began shortly after a steep recession. The total number of permits issued early in the decade was significantly lower than the number of permits issued towards the end of the decade. While the use of an entire decade of training data lowers the risk of selecting an unrepresentative portion of the business cycle, the risk remains that economic conditions will be substantially different in the future.

The model is limited to the parcels for which the profitability analysis can be conducted. This precludes, for example, parcels with missing data or parcels whose observed regulatory restrictions do not currently allow multifamily development, but which could be rezoned. In particular, parcels zoned for single-family homes are not assessed for the profitability of multifamily construction, though ultimately some of these parcels are indeed converted. Also omitted from our analysis are developments that become feasible when the potential for lot assembly is considered, e.g. when two adjacent parcels are acquired and merged into one development. As a result, the model potentially underestimates the feasibility of larger, highrise development. The pro forma also does not currently consider commercial space within a project.

Because the predicted probability of development is designed to depend only on the pro forma-based financial outcomes, it ignores the influence of parcel traits that may influence development in ways that are not captured by the pro forma analysis. For example, the presence or absence of an existing structure on the parcel is considered only through its influence on land value, and neighborhoods are not used as an explicit factor beyond ZIP code-level rent price estimates. While that likely renders the predictions less precise than they would be in a Los Angeles-specific model that incorporated these data, it makes the prediction algorithm more general. Indeed, the use of the pro forma analysis as an exclusive lens is a feature, not a bug, and is likely crucial for extending the Dashboard beyond the City of Los Angeles.

Relatedly, our model assumes that development decisions are made to maximize financial returns in a manner that may not align with people's actual behavior. For example, a policy may lower the required share of parking spaces in a development, yet the developer may still decide to include more parking spaces than required.

And finally, the baseline assumptions within the model often reflect our best reasonable assumptions, yet different inputs could significantly affect the outcome. For example, if in practice a smaller share of developments were downsized via compromises during the entitlement process than our baseline model assumes, then the effect of removing all compromises in our simulation would have a lower effect.

Appendix B. Default Pro Forma Assumptions Applied Globally to All Parcels

Variable	Value
Marginal construction cost per square foot, low-rise (wood) (default)	$178
Marginal construction cost per square foot, mid-rise (wrap around or podium plus) (default)	$236
Marginal construction cost per square foot, high-rise (steel & concrete) (default)	$276
Maximum density for low-rise construction (du per acre)	30
Maximum density for mid-rise construction (du per acre)	100
Maximum density for high-rise construction (du per acre)	400
Max buildable slope (percent)	30
Parking space gross square footage, surface lot	330
Parking space gross square footage, non-surface	400
Parking space cost, surface lot (default)	$6600
Parking space cost, above ground garage (default)	$35500
Parking space cost per square foot, underground garage (default)	$57500
Average gross square footage of recently built (>=2010) dwelling units in 5+ unit multifamily buildings in the city (default)	1100
New construction premium	0.28007822
Premium for 1 unit structures	0.1534
Premium for 2-4 unit structures	-0.06407197
Premium for 5-19 unit structures	-0.06501018
Premium for 20-49 unit structures	-0.08821588
Premium for 50+ unit structures	-0.08283956
Vacancy rate (default)	0.05
Affordable rent threshold (Moderate; 110 percent AMI; 2bd)	$1845
Affordable rent threshold (Low; 80 percent AMI; 2bd)	$1006
Affordable rent threshold (Very low; 50 percent AMI; 2bd)	$839
Affordable rent threshold (Extremely low; 30 percent AMI; 2bd)	$503
Affordable rent share for linkage (per sq ft) fee exemption (Moderate) (default)	0.4
Affordable rent share for linkage (per sq ft) fee exemption (Low) (default)	0.2
Affordable rent share for linkage (per sq ft) fee exemption (Very low) (default)	0.11
Affordable rent share for linkage (per sq ft) fee exemption (Extremely low) (default)	0.08

Affordable rent share for TOC Tier 1 (Low) (default)	0.2
Affordable rent share for TOC Tier 1 (Very low) (default)	0.11
Affordable rent share for TOC Tier 1 (Extremely low) (default)	0.08
Affordable rent share for TOC Tier 2 (Low) (default)	0.21
Affordable rent share for TOC Tier 2 (Very low) (default)	0.12
Affordable rent share for TOC Tier 2 (Extremely low) (default)	0.09
Affordable rent share for TOC Tier 3 (Low) (default)	0.23
Affordable rent share for TOC Tier 3 (Very low) (default)	0.07
Affordable rent share for TOC Tier 3 (Extremely low) (default)	0.1
Affordable rent share for TOC Tier 4 (Low) (default)	0.25
Affordable rent share for TOC Tier 4 (Very low) (default)	0.15
Affordable rent share for TOC Tier 4 (Extremely low) (default)	0.11
Low Income below-market-rate share of dwelling units (default)	0.25
Regulatory fee per square foot (independent of unit count) (default)	$3.79
Regulatory fees per dwelling unit (default)	$7171
Regulatory fees per construction valuation dollar (default)	$0.009999999776
Lump sum regulatory fees (default)	$0
Annual appreciation in rent (default)	0.04
Operating expenses as share of revenue (default)	0.3
Months to construct low-rise (default)	14
Months to construct mid-rise (default)	21
Months to construct high-rise (default)	30
Absorption rate (units per month) (default)	30
Stable months at sale (default)	18
Loan to cost ratio (default)	0.65
Loan interest, annual (default)	0.045
Cap rate at time of sale (default)	0.04
Preferred rate of return (default)	0.1
Entitlement timeline, months, 2-4 units (default)	6
Entitlement timeline, months, 5-49 units (default)	12
Entitlement timeline, months, 50+ units (default)	18
Entitlement added cost, percent, 2-4 units (default)	0.01
Entitlement added cost, percent, 5-49 units (default)	0.03
Entitlement added cost, percent, 50+ units (default)	0.05
Entitlement unit reduction, percent, 2-4 units (default)	0.00
Entitlement unit reduction, percent, 5-49 units (default)	0.15
Entitlement unit reduction, percent, 50+ units (default)	0.30

Appendix C. Simplified Treatment of Regulatory Fees

Regulatory fees: Regulatory fees were incorporated differently depending on the way in which they are apportioned (e.g. as a lump sum fee, or in proportion to the number of dwellings) the square footage or the construction cost.

Per square foot fees:

- **Affordable Housing Linkage Fee (AHLF):** The City of Los Angeles does not have Inclusionary Zoning (IZ) requirements. Instead, it charges developers a fee per square foot, which is waived if the development complies with IZ-like requirements with respect to below market-rate share and discount.

  Information on the share of BMR units needed for exemption was included in the set of data inputs.

  The rate of the linkage fee depends on the number of units in the development, and on the "market area type" in which the parcel is located, which is derived from its assignment to a CPA. Information on the rates, on these dependencies, and on the mapping from CPAs to market area types were all obtained from here (per city staff guidance).

- **Per square foot building permit fees (school fee):** There are multiple types of building permit fees that apply in the city. One of them, the school fee, is proportional to square footage. Information on its rate circa 2020 was drawn from here (per city staff guidance).

Per dwelling fees:

- **Park fees:** Park fees are the main per dwelling unit fee. Rates differ between residential subdivision (i.e. condo) and non-residential subdivision projects (i.e. multifamily rental). The pro forma as-is addresses rental developments, so only the non-residential subdivision figure was used. City staff offered guidance on what park fee rates to use.[27]

- **Per dwelling building permit fees (dwelling unit construction tax and residential development tax):** There are multiple types of building permit fees that apply in the city. Two of them, the dwelling unit construction tax and the residential development tax, are proportional to the dwelling count. Information on its rate circa 2020 was drawn from here (per city staff guidance).

Per construction dollar fees:

- **Per construction valuation dollar building permit fees (numerous):** There are multiple types of building permit fees that apply in the city. Most of them are determined in proportion to the dollar valuation of construction associated with a development. These include the building permit fee per se, the plan check fee, an EQ instrumentation fee, a planning fee, as well as a development services center surcharge, a system development surcharge, a state green building surcharge, an energy surcharge and a disabled access surcharge.

  Information on these fees was inferred from the city's building permit fee calculator site, here (per city staff guidance). However, these fees do not vary linearly with project valuations, and in the absence of a clear schedule, their magnitude was backed out from the above calculator. Specifically, fees with energy and disability surcharges were obtained for new residential buildings along a sequence of dollar valuations. The marginal fee per valuation dollar decreases from just under 1.2 cents per dollar at a $1m valuation, and plateaus at about 0.9 cents per dollar (as high as at a $1b valuation).

Endnotes

1. Galante, C. (2016). "Putting the Tool to Work: Takeaways from the Housing Development Dashboard." Terner Center for Housing Innovation, UC Berkeley. Retrieved from: https://ternercenter.berkeley.edu/research-and-policy/dashboard-takeaways/.

2. City of Los Angeles. "What to Know about: RHNA, Site Selection, and Rezoning." Retrieved from: https://planning.lacity.org/odocument/9feed-c9d-07b6-479f-8ad9-84e93192c97a/What_to_Know_about__RHNA,_Site_Selection,_and_Rezoning_-_Updated.pdf; City of Los Angeles. (2020). Annual Housing Element Progress Report. Retrieved from: https://planning.lacity.org/odocument/e7ecf035-0003-4474-995b-b7a1a9f3cef8/Los_Angeles_2021_APR_-_Summary.pdf.

3. These policy prescriptions from the State, aimed at adding housing supply, include "streamlining housing development at the project level," "density bonus programs which exceed statutory requirements," "significant reduction of development impact fees," "modification of development standards and other applicable zoning provisions," and more. See: California Department of Housing and Community Development. Prohousing Designation Program. Retrieved from: https://www.hcd.ca.gov/planning-and-community-development/prohousing-designation-program.

4. California Code of Regulations Title 25. Housing and Community Development Division 1. Chapter 6. Subchapter 6.6 Sections 6600 through 6607, Consecutive. Prohousing Designation Program. Retrieved from: https://www.hcd.ca.gov/community-development/prohousing/docs/Prohousing-Regulation-Text.pdf.

5. While some policies can be adjusted exactly 25 percent, i.e a 25 percent reduction in floor area ratio, entitlement durations were rounded to the nearest month and fees were reduced by round numbers that are approximately 25 percent of the average fees.

6. We did however test these policy changes at increasing intervals, and unsurprisingly the expected unit counts increased as the policy prescriptions were shifted up. For example a 25 percent increase in maximum density increased the expected unit count from the baseline simulation by 16.2 percent, a 50 percent increase in density increased expected units by 25.5 percent, a 75 percent increase in density increased expected units by 35.4 percent and a 100 percent increase in maximum density increased expected units by 43.8 percent.

7. For example, in measuring a policy that increases the maximum density of a parcel, deciding whether to test a 25 percent increase or a 30 percent increase is somewhat arbitrary, and city officials may not have a good reason to select one specific amount over another. And it is reasonable to question whether a 25 percent reduction in entitlement times and costs is, in practice, a similar scale policy proposition to a 25 percent increase in maximum density citywide.

8. This analysis does not include legislation passed during the 2022 session which may further increase expected unit count estimates, such as a changes to parking minimums (AB 2097) or streamlining residential development on commercially zoned land (AB 2011).

9. These density bonuses are: density bonus, FAR bonus, height bonus, and setback reduction.

10. Terner Center's previous work on impact fees notes that these fees can be a significant driver of overall project costs, which in practice may reduce the total number of units built. In our model we incorporate a large number of fees into 3 fee categories: per dwelling fees, per square foot fees, and per construction dollar building permit fees. See: Terner Center for Housing Innovation, UC Berkeley. (2020). "Improving Impact Fees in California: Rethinking the Nexus Study Requirement." Retrieved from: https://ternercenter.berkeley.edu/wp-content/uploads/2020/12/Nexus_Studies_November_2020.pdf.

11. Durations must be rounded to the nearest whole month.The baseline entitlement durations are assumed to be 6 months for buildings with 2-4 units, 12 months for buildings with 5-49 units, and 18 months for buildings with 50+ units.

12. The entitlement process is assumed to have the effect of reducing developments' density above and beyond the joint effect of explicit land use policies on the building envelope. That assumption reflects the results of prolonged and potentially embattled entitlement processes, including any legal action that accompanies them. For 2-4 unit buildings, the entitlement density compromise is assumed to have no effect on the number of dwellings. For 5-49 unit buildings it is assumed to reduce the unit count by 15 percent, and for 50+ unit buildings by 30 percent.

13. For 2-4 unit buildings the entitlement process is assumed to add 1 percent to the total construction cost (which excludes the cost of land). For 5-49 unit buildings it is assumed to add 3 percent to that cost, and for 50+ unit buildings 5 percent.

14. Projects qualifying for TOC bonuses already receive a reduction in required parking spaces and this simulation further reduces that requirement by the same amount as the citywide reduction.

15. A key limitation is that a developer may still choose to include parking units beyond a required minimum if that developer believes parking as an amenity could attract higher revenues for their property. For this analysis we assume a functional decrease in parking by 25 percent, however it remains unclear whether changes to policy of that magnitude translate directly into reductions of that scale. More work is necessary to understand the relationship between minimum parking requirements and any amount typically added by developers above that limit. We also do not account for very recent statewide legislation involving parking requirements.

16. Total expected units across are parcels divided by 10 to reflect the 10 year probability of development window.

17. As the expected unit count climbs higher beyond the baseline, the general equilibrium limitations of this modeling approach become increasingly relevant, including limits to the existing construction workforce or other potential bottlenecks. As tens of thousands of new rental units hit the market, that may have an impact on vacancy rates and prices, which may in turn reduce the financial likelihood of future projects developing.

18. Our model suggests fairly large-scale policy shifts may be required under existing conditions for expected unit production to leap from roughly 20,000 per year to roughly 57,000, a nearly 200 percent increase, per year as RHNA requires. One method could be changing one of these policy levers by a lot, rather than changing six, somewhat disparate, policies each in a smaller way. For example, tripling the TOC bonuses (while eliminating parking requirements in TOC zones) would increase expected unit counts by 86 percent per year. Increasing these policy levers in tandem to a larger degree continue to significantly increase projections. Increasing all six Policy Prescriptions by 50 percent results in nearly 52,000 estimated rental units per year, a nearly 170 percent increase from the baseline projection.

19. City of Los Angeles. (2020). Annual Housing Element Progress Report. Retrieved from: https://planning.lacity.org/odocument/e7ecf035-0003-4474-995b-b7a1a9f-3cef8/Los_Angeles_2021_APR_-_Summary.pdf.

20. The model doesn't consider for-sale multifamily housing, which currently comprises a very small fraction (less than 10 percent) of multifamily units built in the U.S. If the model did consider for-sale multifamily development, it is likely that some such development would substitute estimated for-rent development, making the contribution to overall new unit production even more limited.

21. The TCAC opportunity maps identify areas in every region of the state whose characteristics have been shown by research to support positive economic, educational, and health outcomes for low-income families—particularly long-term outcomes for children.

22. The data were compiled by MetroSight from a variety of sources with guidance from Los Angeles Planning Department staff and in some cases with help from MapCraft Labs.

23. Based on new construction and building size premiums estimated (by MetroSight) for Los Angeles County from the most recent American Community Survey (ACS).

24. Despite the naming of the RLVLV ratio, the denominator land value represents the estimated cost of purchasing the property, both land and improvements. The estimates currently applied correspond more closely to the property's value given its existing use than its value given the financial best use. While future iterations of the Dashboard may revisit how the RLVLV ratio is determined, the current method yields a remarkably clear empirical relationship with development outcomes.

25. Gyourko, J., Hartley, J., & Krimmel, J. (2019). "The Local Residential Land Use Regulatory Environment Across U.S. Housing Markets: Evidence from a New Wharton Index." (No. w26573). National Bureau of Economic Research. Retrieved from: https://real-faculty.wharton.upenn.edu/wp-content/uploads/~gyourko/WRLURI/GyourkoHartleyKrimmel_NBERw26573.pdf.

26. The slope coefficients in each of three bivariate linear regressions of development indicators on each of the financial metrics were all statistically significant at a 99.9 percent confidence level.

27. City of Los Angeles. (2020). Park Fees. Retrieved from: https://www.laparks.org/sites/default/files/planning/Rates and Fees - Revised 05.20.pdf.

ABOUT THE TERNER CENTER

The Terner Center formulates bold strategies to house families from all walks of life in vibrant, sustainable, and affordable homes and communities. Our focus is on generating constructive, practical strategies for public policy makers and innovative tools for private sector partners to achieve better results for families and communities.
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