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Supply Constraints Do Explain House Price and Quantity Growth Across U.S. Cities*

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Abstract

In a widely cited working paper, Louie, Mondragon and Wieland (2025) find that higher income growth predicts the same growth in house prices, housing quantity and population regardless of a city's estimated housing supply elasticity, implying that constrained housing supply is relatively unimportant in explaining differences in rising house prices among U.S. cities. We show that their findings do not hold up—our evidence is that supply constraints do explain new housing supply and house prices across U.S. cities, in line with the literature. Inter alia, we model the effect of supply constraints on new housing supply (proxied by permits), exploiting the variation in annual data and controlling for other factors using year and MSA fixed effects.

Keywords: Housing supply, house prices, housing supply elasticity, housing supply constraints, metropolitan statistical areas.

JEL Codes: R21, R31, C23.

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1. Introduction

The findings of a recent NBER working paper by Louie, Mondragon and Wieland (LMW, 2025)—“Supply Constraints Do Not Explain House Price and Quantity Growth Across U.S. Cities”—are surprising and controversial. They suggest that, from 2000 to 2020, “higher income growth predicts the same growth in house prices, housing quantity and population regardless of a city's estimated housing supply elasticity”. They argue that their findings are very robust since they find the same pattern using different elasticity measures, instrumenting for local housing demand and extending the sample back to 1980.

The LMW paper has sparked discussion among those following housing market research. This is because their findings imply that “constrained housing supply is relatively unimportant in explaining differences in rising house prices among U.S. cities”—an assertion that “challenge[s] the prevailing view of local housing and labor markets and suggest[s] that easing housing supply constraints may not yield the anticipated improvements in housing affordability”.

Despite these contradictions of the literature at large, many cite the LMW findings as refuting the received view of the role of restrictions on housing supply. This has likely added to public pessimism and/or skepticism regarding the efficacy of housing supply increases in lowering rents and house prices, as explored by Elmendorf et al. (2025).

We focus on housing supply and follow LMW by estimating “long difference” 2000 to 2020 reduced form and structural / instrumental variables housing supply equations. We use six different housing supply / constraint measures – the original four measures in LMW and an additional two measures.

In addition, we estimate reduced form and structural models of the flow of new housing supply, proxied by permits, using annual data. We believe that the results from estimating supply equations using annual data, and which include year and MSA fixed effects to control for other drivers of housing supply and demand, are at least as informative as those from long difference equations. Consistent with housing market stock-flow equilibrium, we specify new supply / permits as a function of the level of house prices rather than the rate of change in house prices.

Note that permits are a less noisy measure of new housing supply than housing units, which suffer from non-random measurement error. Finally, we weight all our MSA-level regressions by the size of the MSA population since, at the aggregate level, lower supply restrictions in large metros matter more than higher supply elasticities in smaller metros.

We otherwise stick as closely to the LMW setup as possible. For example, we do not include any dynamics in the estimated housing supply equations, allow time variation in supply responses or include kinks etc. in the supply curves. Our results, unlike those in LMW, show that differences in supply constraints do explain differences in housing supply, and hence house prices, across U.S. cities, in line with the literature.

This paper is organized as follows. Section 2 is an overview of the empirical housing supply literature. Section 3 discusses the data and data limitations. The simple textbook model of the housing market used by LMW is set out in Section 4. The models we estimate are discussed in Section 5. Our empirical results are shown in Section 6 and Section 7 concludes. In the appendix, the well known DiPasquale and Wheaton (1992) four quadrant, stock-flow equilibrium, model is set out. Annual reduced form house price equation results are also presented.

2. Overview of the Housing Supply Literature

The findings in LMW are at odds with the existing literature, which highlights the important role of housing supply elasticities and constraints in explaining differences in house price growth and new housing supply between cities and regions. The large literature shows that the response of house prices to income and other demand shocks varies with the elasticity of supply. Surveys in Gyourko and Molloy (2015), Molloy (2020), Duca et al. (2021), and Saiz (2024) emphasize the repeated evidence that constraints on housing supply impact house prices, while Baum-Snow and Duranton (2025) find supply constraints to be “increasingly binding” since 1980.

These surveys rely on a robust body of earlier work. U.S. focused papers include Glaeser, Gyourko and Saks (2005a), who find that the growing gap between market prices and marginal construction costs follows directly from tight regulation. They later note that zoning restrictions

specifically can lead to increased housing prices (2005b). Additional studies provide similar evidence to support regulation, among other building constraints, as a driver of differing construction costs between cities (Gyourko and Saiz, 2006; Saks, 2008).

Increased regulation has also been shown to spark higher market prices of homes in papers such as Quigley and Raphael (2005) and Glaeser and Gyourko (2018), though some have found this link too weak to assume causality (Quigley and Rosenthal, 2005). Mayer and Somerville (2000) find a reduction in housing starts across metropolitan areas with more restrictive regulations. A smaller pool of research addresses the views of housing supply skeptics, with papers such as Been et al. (2017) and Elmendorf et al. (2025) asserting the importance of supply liberalization in reducing the home prices of an area.

Core to the analysis in this paper is the literature measuring housing supply elasticities between cities and examining their effects. Papers Gyourko, Saiz and Summers (2008), Saiz (2010) and Baum-Snow and Han (2024) establish widely accepted measures of housing supply elasticity and constraint—measures used in both LMW and our analysis below. Green et al. (2005), Paciorek (2013) and Aastveit, Albuquerque and Anundsen (2020, 2023) find a city’s regulatory environment and/or topography to be direct determinants of its housing supply elasticity.

Outside of the U.S., cross-country analysis of OECD countries confirms the reliance of housing supply elasticities on local policies, such as land use regulations, in addition to national geographic and urban characteristics (Caldera and Johansson, 2013; Cavalleri, Cournède and Özsöğüt, 2019). UK papers by Meen outline the importance of structural differences between housing markets on home prices, as opposed to regional growth patterns (Meen, 1999, 2002). Cameron, Muellbauer and Murphy (2006) develop a spatial model of the U.K. housing market. Hilber and Vermeulen (2016) find regulatory constraints in the UK increase an area’s house price-earnings elasticity, like U.S. focused work.

Ball, Meen and Nygaard (2010) find housing supply to be less responsive in Britain than the U.S. or Australia, contrary to intuition, but continue to stress the negative impact of regulatory constraints on housing supply responsiveness. The UK’s low housing supply responsiveness has

been partially attributed to the U.K. planning system by Kate Barker's Review of Land Use Planning (2004). Examining historical differences between the U.S. and UK's housing supply elasticities, Malpezzi and MacLennan (2001) find much larger housing supply elasticities in the U.S. both before and after WWII than were found in the UK.

Analysis concerning other Western countries generally hold with the large literature referenced above. Papers by Vermeulen and Rouwendal (2007) and Vermeulen and Van Ommeren (2009) find links between increased land use regulation and a lack of housing supply responsiveness in the Netherlands. Melser et al. (2022) put forth an estimate of housing supply elasticities across local government areas in Australia, attributing variation between regions to each region's accessibility to the center of the city. Grimes and Aitken (2010) in New Zealand show that regional price dynamics are a function of the region's supply elasticity. In Finland, city size, zoning policy, and geographic constraints are found to be the largest determinants of a city's housing supply elasticity, the same as in the U.S. despite its different population density, among other factors (Oikarinen, Peltola and Valtonen, 2015).

Typically, housing supply issues are mostly associated with advanced countries, but a significant body of work has shown that housing supply constraints also impact emerging economies. Early work includes Malpezzi (1996), which highlights the shared behaviors between the housing markets of different countries, and Malpezzi and Mayo (1997), which, using Malaysia as a case study, finds the costs of regulation and pricing restrictions far outweigh the benefits of subsidies and regulatory exemptions. These works build off the paper Hannah, Bertaud, Malpezzi and Mayo (1989), which also examines Malaysia and highlights the suppression of housing supply following government intervention. Brueckner and Lall (2015) presents a survey of urban economics in developing countries, addressing the role of land use regulation on housing supply outcomes.

Works focused on China also find that regulation impacts housing prices. Wu, Gyourko and Deng (2012) find that the activity of state-owned enterprises contributes to rising land values, which have significantly impacted house price growth in China. Wu, Deng and Liu (2014) develop a house price index for China which accounts for housing markets consisting predominantly of

newly built homes. Wang, Chan and Xu (2012) find that geographic, economic, and regulatory factors are determinants of the price elasticity of housing supply. These findings are echoed in a paper by Huang (2022), which finds declines in housing supply elasticities have been steepest in larger cities. Hong Kong, in particular, has an extremely low housing supply elasticity per Ren, Wong and Chau (2025), who attribute this rigidity to the scarcity of undeveloped land.

Housing deregulation efforts in India have prompted notable studies of the country. Dutta, Gandhi and Subramanian (2022) found that the repeal of Urban Land Ceiling laws limiting the amount of vacant land a private entity could own in each city did not lead to housing supply growth, as confusion and legal disputes over property rights rendered deregulation ineffective. Nagpal and Gandhi (2024) showed that the relaxation of laws previously limiting the amount of floor space that could be developed on a lot resulted in the production of more units.

In Brazil, Lima and Silveira Neto (2019) find that zoning ordinances are associated with higher average rents. They also note that higher housing prices can incentivize low-income households to enter the informal housing market, leading to an increase in slum formation. This observation is corroborated by Cavalcanti, Ferreira and Monge-Naranjo (2024), who further explore how housing constraints in developing countries contribute to the bifurcation of the housing market into formal and slum sectors.

3. Data

We follow LMW and estimate long difference housing supply equations between the two Census years 2000 and 2020. In addition, we estimate supply equations, proxying permits using annual data from 2000 to 2024. As noted above, we did this because we believe the additional variation in annual data helps pin down the cross-metro responsiveness of new housing supply to house prices, once we control for year and MSA fixed effects.

The major issue with using annual data is consistent geo-coding of the MSA data on house prices, permits, housing units and personal income. We map all geographies to match the MSA boundaries between 2017 and 2023. To maintain consistent geocoding, we also map the housing supply elasticity and constraint measures to MSAs.

The main data definitions and sources are as follows:

HP	Cotality / CoreLogic single family combined (attached and detached, distress included) house price indices. Metro division indices aggregated to MSA level. Nominal indices are converted to real indices using the national PCE deflator. Source: Cotality, Haver Analytics and Bureau of Economic Analysis (BEA).
Permits	Total permitted units (single family, 2 to 4 units and 5 plus units). Source: Haver Analytics and Census Bureau.
HU	Annual, mid-year county level housing units aggregated to the MSA / metropolitan CBSA level using the county to metro crosswalks for the relevant years. Sources: Haver Analytics and Census Bureau.
Pop	Annual resident population. Source: Haver Analytics and Census Bureau.
Y	Real per capita personal income. Nominal values deflated by national PCE deflator. Source: Haver Analytics and BEA.
CC	RS Means construction cost indices matched to MSAs. Mid-year values are geometric averages of the Jan numbers. Nominal indices are converted to real indices using the national PCE deflator. Source: Gordian / RS Means <i>Square Foot Costs</i> , various years.
PC	PCE deflator. Source: Haver Analytics and BEA.
Disaster Losses	Natural disaster losses aggregated from the county to the metro and annual levels, scaled by lagged metro total personal income. Source: Crosignani and Hiti (2025, NY Fed) and BEA. ¹

House price indices (HPIs) for 13 large MSAs were constructed using data for the underlying metropolitan division HPIs weighted by the value of the housing stock in each division.² Some summary statistics for the “long difference” (2000 to 2020) regressors are set out in **Table 1**.

¹ Recent natural disaster property losses by Connecticut planning region were mapping to the counties using population data from the 2020 Census.

² The 13 MSAs are Atlanta-Sandy Springs-Roswell GA, Boston-Cambridge-Newton MA-NH, Chicago-Naperville-Elgin IL-IN, Dallas-Fort Worth-Arlington TX, Detroit-Warren-Dearborn MI, Los Angeles-Long Beach-Anaheim CA, Miami-Fort Lauderdale-West Palm Beach FL, New York-Newark-Jersey City NY-NJ, Philadelphia-Camden-Wilmington PA-NJ-DE-MD, San Francisco-

(b) Supply Elasticity / Constraint Measures

We use six housing supply elasticity / constraint measures. The first four measures are the same as in LMW:

- Saiz (2010) housing supply elasticities. We update Saiz's older MSA / NECMA areas to match our MSA designations, checking the results against the mapping in Guren et al. (2021).
- Baum-Snow and Han (2024) housing supply elasticities. Originally available at the tract level, we used the Gorback and Keys (2026) MSA mapping.
- Gyourko et al. (2008) Wharton residential land use regulation index (WRLURI), a city level survey-based measure of regulatory constraints. We update the older MSA / NECMA areas to match our MSA designations, again checking the results against the mapping in Guren et al. (2021).
- Davis et al. (2021) land shares, which measure the share of land in property appraisals, i.e., the share not accounted for by the depreciated cost of replacing the structure etc. This measure is available at the MSA level. The intuition is that the land share of property values is higher in areas where supply is more inelastic / constrained.

The two additional measures of housing supply / constraint measures are:

- Lutz and Sand (2023) buildable land share measure, which tracks the share of land within a zip code that can be built upon. We mapped the data from the zip code level to the MSA level using the Geocorr (geographic correspondence) file from the Missouri Census Data Centre (<https://mcdc.missouri.edu/applications/geocorr.html>).

Oakland-Fremont CA, Seattle-Tacoma-Bellevue WA, Tampa-St. Petersburg-Clearwater FL and Washington-Arlington-Alexandria DC-VA-MD-WV. The value of the housing stock was proxied by the product of the number of housing units times the median house value.

- Guren et al. (2020) housing sensitivity measure, which gauges the response of local house prices to regional house price changes. This measure is available at the MSA level. The intuition behind this measure is that, ceteris paribus, MSA house prices respond more to regional house prices shocks in areas where supply is less elastic / more constrained.

Summary statistics and pairwise correlations for the six supply elasticity / constraint measures are set out in **Table 2** and **Table 3**. The six supply elasticity and constraint measures described above are plotted in **Figure 1**. The pairwise correlations between the six measures range from 0.25 to 0.63 in absolute value.

(c) Changes in Housing Units Versus Housing Permits

The Census Bureau's estimates of housing units by metro are somewhat problematic (**Figure 2**). Natural disaster losses appear as low outliers in the data, while high outliers often remain unexplained. Permits appear to be a better, albeit imperfect, measure of housing supply—outlying points in permit data can often be explained by the rezoning and subsequent permitting of large land parcels in the area.

Permits are also the main component of estimated change in housing units at the metro level. The Census Bureau calculates the change in housing units as follows:

$$\Delta Housing\ Units_t = New\ Construction_t + New\ Mobile\ Homes_t - Losses_t$$

$$New\ Construction_t = (Permits_{t-1} * Completion\ Rate_{t-1}) + Non\ Permitted\ Construction_{t-1}$$

$$Losses_t = (Loss\ Rate * Stock_{t-1}) + Disaster\ Losses_t$$

New mobile homes make up only a small portion of the overall change in housing units, averaging roughly 150,000 annual manufactured home shipments from 1994-2024 (Census Bureau Manufactured Housing Survey, 2025). Housing unit changes are therefore primarily reliant on new construction and losses. According to the Census Bureau, approximately 97% of new construction occurs in areas that require permits. Permits should then account for the bulk of the new construction measured.

The result of regressing change in housing units on lagged permits and scaled property damages (**Table 4**), suggests that permits are a good proxy of new housing supply.³ Both permits, representing new construction, and damages, representing total losses, yield highly significant coefficients.

We considered using housing starts or completions to measure housing supply. Unfortunately, official MSA level housing starts and completions data do not exist at the MSA level. However, housing starts data taken at the aggregate U.S. level moves closely together with aggregate U.S. housing permits, indicating that permits are an appropriate alternative to starts (**Figure 3**).

Of course, not all housing permits translate into new housing units. The fraction varies over the business cycle. We argue that the time-varying option value of permits is mostly captured by using year fixed effects. While aggregate permits and real house prices move together over time, the relationship is clearly a loose one (**Figure 4**), so other factors such as changing mortgage rates and lending standards matter as well. Time fixed effects will pick up these common factors as they occur across MSAs.

4. The LMW Modelling Framework

LMW use the standard textbook model of the housing market to motivate their empirical models (**Figure 5**). They focus on the reduced form price and quantity equations from the model and consider several generalizations, including one case where the standard model predictions fail to hold.

(a) The Textbook Model

In the textbook model, the log linearized demand for and supply of housing (services) may be specified as:

³ The lagged right-hand side variables in Table 4 reflect the timing of the variables, e.g., the housing units data are mid-year estimates, and lag between permits and completions is close to a year.

$$\ln H = d_0 - d_p \ln HP + d_y \ln Y + Z_d,$$

$$\ln H = s_0 + s_p \ln HP + Z_s.$$

Here, the housing stock H , real house price HP and real income Y are logged, and Z_d and Z_s are demand and supply shifters or shocks. The corresponding, first differenced, reduced form equations are:

$$\Delta \ln HP = \frac{1}{d_p + s_p} (d_y \Delta \ln Y + \Delta Z_d - \Delta Z_s) = \pi_Y^d \Delta \ln Y + \pi_{Z_d}^d \Delta Z_d + \pi_{Z_s}^d \Delta Z_s,$$

$$\Delta \ln H = \frac{s_p}{d_p + s_p} (d_y \Delta \ln Y + \Delta Z_d) + \frac{d_p}{d_p + s_p} \Delta Z_s = \pi_Y^s \Delta \ln Y + \pi_{Z_d}^s \Delta Z_d + \pi_{Z_s}^s \Delta Z_s.$$

LMW estimate “long difference” versions of these reduced form equations, where the first differences are replaced by the average annual growth rates in $\ln H$, $\ln HP$ and $\ln Y$ between the Census years 2000 and 2020. (We use $\Delta_{20} \ln H$ etc. in our long difference regressions, a trivial change.)

If ΔY , ΔZ_d and ΔZ_s are uncorrelated, then the regression of ΔHP on ΔY will recover $\pi_Y^d = \frac{d_y}{d_p + s_p}$ and the regression of ΔH on ΔY will recover $\pi_Y^s = \frac{s_p d_y}{d_p + s_p}$. If the demand elasticities are common across cities, the impact of higher incomes on house prices will be lower in cities with higher price elasticities of housing supply, and the impact of higher incomes on the housing stock will be higher in cities with higher price elasticities of housing supply. This is shown in **Figure 5**. LMW focus on these simple implications for high and low supply elasticity metros, arguing that the result holds more generally.

(b) Heterogeneity in Correlations and Elasticities

What happens if ΔY and the “shocks” ΔZ_d and ΔZ_s are correlated, or if demand elasticities differ by city? Building on the standard model, the regression coefficients become:

$$\begin{aligned} \hat{\pi}_Y^d &\rightarrow \frac{d_y}{d_p + s_p} + \frac{1}{d_p + s_p} \frac{\text{Cov}(\Delta \ln Y, \Delta Z_d - \Delta Z_s)}{\text{Var}(\Delta \ln Y)} \\ \hat{\pi}_Y^s &\rightarrow \frac{s_p d_y}{d_p + s_p} + \frac{s_p}{d_p + s_p} \frac{\text{Cov}(\Delta \ln Y, \Delta Z_d)}{\text{Var}(\Delta \ln Y)} + \frac{d_p}{d_p + s_p} \frac{\text{Cov}(\Delta \ln Y, \Delta Z_s)}{\text{Var}(\Delta \ln Y)} \end{aligned}$$

If the ΔY , ΔZ_d and ΔZ_s correlations are the same in high and low supply elasticity cities, the impact of higher incomes on house prices will be the same as in the textbook model.

LMW discuss three other forms of heterogeneity. If high supply elasticity cities have stronger correlations between ΔY and ΔZ_d than low supply elasticity cities, then the difference in ΔHP between high and low supply elasticity cities is smaller while the difference in ΔH is larger. We can identify this situation by looking at ΔHP and ΔH jointly. If cities with low supply elasticities have lower income or higher price elasticities of demand than high supply elasticity cities, the difference in ΔHP between high and low supply elasticity cities is smaller while the difference in ΔH is larger. Again, we can identify this by examining ΔHP and ΔH jointly.

Finally, if low supply elasticity cities have stronger correlations between ΔY and ΔZ_s than high supply elasticity cities, then the differences in ΔHP and ΔH between high and low supply elasticity cities are small. In this case, ΔHP and ΔH would be observably similar between high and low supply elasticity cities. This is the only situation in which the standard textbook model predictions do not hold.

Although the LMW results are consistent with this case, they suggest that this case is very unlikely and indicates a more fundamental issue with the standard view of housing supply constraints. This is the basis for their claim that “differences in supply elasticities do not explain differences in house price growth and quantity growth across cities” (2025).

5. Specification of Housing Supply Equations

In this section, we discuss the specification of the housing supply equations which we estimate – reduced or structural form, and long difference or annual. The specification of the housing supply equations differs depending on the time horizon used. In principle, we prefer the more direct structural form approach over the reduced form one, because simple reduced forms may not capture all the drivers of housing demand.

(a) Long Difference Housing Supply Equations

The long difference reduced form equation, which is estimated by OLS, is as follows:

$$\Delta_{20} \ln H_{mt} = \pi_0 + \pi_1 \Delta_{20} \ln Y_{mt} + \pi_2 (\Delta_{20} \ln Y_{mt} \times Elasticity_m) + v_{mt}$$

where H is housing units, Y is total real personal income, m is the MSA and t is the year 2020.

The parameters π_1 and π_2 are both positive a priori. The *Elasticity* variable is one of the Saiz (2010) elasticity, the Baum-Snow and Han (2024) elasticity or the Lutz and Sand (2023) buildable land share measures, or the negative of the other three supply constraint measures – the Gyourko et al. (2008) WRLURI, the Davis et al. (2021) land share of property value or the Guren et al. (2020) local house price responsiveness measure.

We follow LMW and use log total MSA personal income, instead of log per capita MSA personal income, on the RHS of this equation. Furst (2025) and Wiebe (2025) argue that total personal income may not be exogenous, since changes in population and the housing stock are correlated. LMW's reply is that any endogeneity is very limited.

The long difference, structural form equation is estimated by instrumenting house prices HP by personal income Y . The first stage equations are:

$$\Delta_{20} \ln HP_{mt} = \pi_{10} + \pi_{11} \Delta_{20} \ln Y_{mt} + \pi_{12} (\Delta_{20} \ln Y_{mt} \times Elasticity_m) + v_{1mt}$$

$$(\Delta_{20} \ln HP_{mt} \times Elasticity_m) = \pi_{20} + \pi_{21} \Delta_{20} \ln Y_{mt} + \pi_{22} (\Delta_{20} \ln Y_{mt} \times Elasticity_m) + v_{2mt}$$

and the second stage equation is:

$$\Delta_{20} \ln H_{mt} = \beta_0 + \beta_1 \Delta_{20} \widehat{\ln HP_{mt}} + \beta_2 (\Delta_{20} \widehat{\ln HP_{mt}} \times \widehat{Elasticity_m}) + u_{mt}$$

The parameters of interest are now the supply coefficients β_1 and β_2 . Other possible instrumental approaches here include instrumenting house prices by property crime rates or a Bartik-style shift-share labor demand instrument (Bartik 1991, Bartik 1993, Blanchard and Katz, 1992).

The number of observations in the long difference regressions varies between 267 and 385 MSAs depending on supply elasticity / constraint measure used. We report robust standard

errors when presenting the estimation results. Inter alios, the F-statistics of the first stage equations show that the instruments are strong so, for brevity, we do not report them.

(b) Annual Housing Supply Equations

It is important to carefully distinguish between housing stocks and flows when modelling housing supply at the annual (or higher) frequency, since the housing stock is largely predetermined⁴. The key margin of adjustment is new housing supply. The supply equation – for example, one based on Poterba (1984) or the DiPasquale and Wheaton (1992) four quadrant model⁵ – specifies new supply $S_t \approx \Delta H_t$ as a function of the level of house prices rather than the change in house prices. This suggests that, setting aside the measurement issues with the housing stock, a first differenced version of the long difference housing supply equation is not appropriate when using annual data.

Proxying new supply by permits (e.g., Paciorek, 2013), our annual reduced form supply is:

$$\ln Permits_{mt} = \pi_0 + \pi_1 \ln Y_{mt} + \pi_2 (\ln Y_{mt} \times Elasticity_m) + f_m + f_t + v_{mt}$$

where f_m and f_t denote MSA and year fixed effects. Turning to the structural form, which is estimated by instrumenting house prices by per capita personal income, the first stage equations are:

$$\ln HP_{mt} = \pi_{10} + \pi_{11} \ln Y_{mt} + \pi_{12} (\ln Y_{mt} \times Elasticity_m) + f_{1m} + f_{1t} + v_{1mt}$$

$$(\ln HP_{mt} \times Elasticity_m) = \pi_{20} + \pi_{21} \ln Y_{mt} + \pi_{22} (\ln Y_{mt} \times Elasticity_m) + f_{2m} + f_{2t} + v_{2mt}$$

and the second stage:

$$\ln H_{mt} = \beta_0 + \beta_1 \widehat{\ln HP_{mt}} + \beta_2 (\widehat{\ln HP_{mt}} \times \widehat{Elasticity_m}) + f_m + f_t + u_{mt}$$

⁴ Witte (1963) is an example of an early paper emphasizing stock-flow equilibrium.

⁵ See the Appendix for a sketch of the four-quadrant model.

The parameters of interest here are the supply elasticity and interaction coefficients, π_1, π_2, β_1 , and β_2 , all of which are positive a priori. The real house price HP is instrumented by Y , real per capita personal income. MSA (m) and year (t) fixed effects are also included in these regressions to control for metro specific and common year effects.

The annual housing supply / permits equations are estimated using data for the period 2000 to 2024. The panel is unbalanced, mainly due to differences in the availability of the MSA-level supply elasticity / constraint measures. Driscoll-Kraay (1998) HAC standard errors with one lag are reported since the panel is spatially dependent. Standard weak instruments tests are decisively rejected and are not reported here for brevity.

6. Empirical Results

Our analysis addresses the long difference regression results in Tables III (reduced form housing supply) and IV (structural form) of LMW. We reproduce these as Tables 5 and 9 below. We report our own versions of these two tables, as well as our annual permits / housing supply equations which confirm our findings that supply constraints do explain house price and quantity growth across U.S. cities.

(a) Long Difference Reduced Form Results

LMW's long difference reduced form housing supply estimates are shown in **Table 5**. We follow LMW and use real aggregate personal income growth, rather than per capita personal income growth, as our income growth measure. We also swap the signs on the supply constraint measures, so all the supply elasticity etc. interaction terms should be positive a priori.

Real income growth is the main determinant of the growth in housing units in line with priors etc. However, the interaction of income growth with all four of the measures of supply elasticities / constraints used by LMW are insignificant, contrary to theory and prior research.

Our long difference, reduced form results in **Table 6** are different.⁶ Personal income growth is highly significant, the same as in Table 5, but now the six housing supply interaction terms – income growth interacted with the supply elasticity / constraint measures – are positive and significant at the 10% level, consistent with the priors and the literature.

What accounts for the difference in our results from those in LMW? The differences stem from our use of regressions weighted by MSA population size and, to a lesser extent, our use of the continuous supply elasticity / constraint measures rather than dummy variables for higher elasticities / lower constraints. We believe that our two choices are sensible ones.

(b) Annual Reduced Form Results

Our findings carry over when we switch over to using annual data (**Table 7**). The data period is 2000 to 2024, the latest year for which we have MSA-level personal income data. Here, we proxy new housing supply using permits, use levels of variables and include both MSA and year fixed effects to control for omitted drivers of supply. We prefer to use per capita personal income rather than aggregate personal income as our income measure since the former is a more natural driver of house prices than the latter. Our regression results are population weighted and we report Driscoll-Kraay (1998) heteroscedasticity and autocorrelation (HAC) robust standard errors with one lag. These standard errors are quite conservative – they are much larger than the corresponding OLS or heteroscedasticity robust standard errors.

As expected, real per capita income is an important determinant of housing supply. More importantly, the interactions of personal income with the housing supply elasticity / constraint measures are all positive and highly significant in five out of six cases. This suggests that, other things equal, similar income shocks tend to generate relatively more new housing in cities with a higher elasticity of housing supply or lower supply constraints, consistent with theory and prior research.

⁶ We weight the regressions using population weights and report robust standard errors.

What happens when we try to estimate annual, reduced form supply equations using the data on housing units? It turns out that it is very difficult to do because the change or growth in housing units is (i) very noisy, and this noise is not standard, white noise, measurement error, and (ii) contaminated by natural disaster losses. In **Table 8** we swap log permits for the noisy change in housing units (so the estimated coefficients are not elasticities.). In order to get sensible results, we must omit the observations for 2020 because of the large outliers and errors in the calculation of the change in housing units that year (**Figure 2**, above). As before, real per capita income is an important determinant of housing supply. The interactions of income with the housing supply elasticity / constraint measures are positive and highly significant in four out of six cases.

(c) Long Difference Structural Form Results

We now turn to structural form estimates of housing supply. LMW's long difference "housing supply" equation estimates are reproduced as **Table 9**. House price growth is interacted with dummies for cities that indicate relatively more or less constrained supply. The house price growth and house price growth interaction terms are instrumented using aggregate personal income growth and income growth interacted with the dummies. LMW find no difference in the price elasticities of supply between more and less constrained cities.

Our long difference, structural form, estimates are set out in **Table 10**. Our housing supply elasticity / constraint results are the opposite of those in LMW. We find that all six housing supply elasticity / constraint interaction terms are positive and highly significant.

Can we account for the differences in our results from those in LMW? The answer is a puzzling no. We cannot attribute the difference in results to the use of weighted regressions or continuous supply elasticity / constraint measures, unlike in the long difference reduced form case.

(d) Annual Structural Form Results

Our annual housing supply equation results, using the permits proxy, are presented in **Tables 11 and 12**. We again use the levels of variables and include MSA and year fixed effects. House

prices and the house price elasticity / constraint interactions are instrumented using income and income interactions.⁷ Our income measure is real per capita personal income. The results are population weighted and we report Driscoll-Kraay (1998) HAC standard errors with one lag.

In **Table 11**, all six supply elasticity / constraint interaction terms are positive and four of the six interactions are statistically significant at the 5% level. We currently have construction cost data from RS Means for about half of the MSAs in our sample, predominantly the larger MSAs. The results of including construction costs in the supply equations are shown in **Table 12**. While it can be difficult to empirically pin down the role of construction costs in housing supply (e.g., Potter and Syverson, 2025), we find highly significant and negative effects. The supply elasticity / constraint interaction terms are all positive, in line with expectations, and now five out of the six terms are significant.

7. Conclusions

Economists do not have a good handle on many housing supply issues (e.g., DiPasquale, 1999, and Broxterman et al., 2020), but the literature has consistently highlighted the role of supply constraints in explaining differences in housing supply across cities and countries. The housing supply findings in LMW (2025) are startling because they are at odds with this literature and our priors. Their findings have also been quite widely cited and are “grist to the mill” of housing supply pessimists and skeptics.⁸

Upon closer examination, we believe the startling findings in LMW do not hold up. We follow LMW by estimating MSA-level, long difference, housing supply equations. However, unlike them, we generally recover economically significant supply elasticity / constraint interactions

⁷ Very similar results were obtained using lagged income and its interactions as instruments.

⁸ On the one hand, there are some grounds for pessimism since several papers suggest that the elasticity of housing supply has declined in the U.S. (e.g., Aastveit et al., 2020, 2023 and Albuquerque et al., 2020). On the other hand, a variety of recent federal, state and local initiatives such as zoning reforms may halt and reverse any decline.

with personal income and house prices, which suggests that supply constraints do indeed explain house price and quantity growth across U.S. cities.

Our conclusions are also supported by our annual housing supply results. We generally find significant supply elasticity / constraint interactions when we estimate annual reduced and structural form housing supply equations, using permits to proxy new supply. We prefer the annual, structural form, results but different readers may prefer other supply estimates.

In conclusion, housing affordability and housing supply are hot topics nowadays, so it is important to evaluate new research that challenges the consensus view that supply constraints are an important determinant of differences in housing supply and house prices across U.S. cities. Our evidence supports this view.

References

- Aastveit, Knut Are, Bruno Albuquerque, and André K. Anundsen (2020). "The declining elasticity of U.S. housing supply". *Centre for Economic Policy Research, VoxEU columns*.
<https://cepr.org/voxeu/columns/declining-elasticity-us-housing-supply>
- Aastveit, Knut Are, Bruno Albuquerque, and André K. Anundsen (2023). "Changing supply elasticities and regional housing booms". *Journal of Money, Credit and Banking*, 55(7), 1749-1783. <https://doi.org/10.1111/jmcb.13009>
- Albuquerque, Bruno, Martin Iseringhausen, and Frederic Opitz (2020). "Monetary policy and US housing expansions: The case of time-varying supply elasticities". *Economics Letters*, 195, 109471. <https://doi.org/10.1016/j.econlet.2020.109471>
- Ball, Michael, Geoffrey Meen, and Christian Nygaard (2010). "Housing supply price elasticities revisited: Evidence from international, national, local and company data". *Journal of Housing Economics*, 19(4), 255-268. <https://doi.org/10.1016/j.jhe.2010.09.004>
- Barker, Kate (2004). *Review of housing supply: delivering stability: securing our future housing needs: final report: recommendations*. London: HM Treasury. Available at:
http://news.bbc.co.uk/nol/shared/bsp/hi/pdfs/17_03_04_barker_review.pdf
- Bartik, Timothy J. (1991). "Boon or boondoggle? The debate over state and local economic development policies". W. E. Upjohn Institute for Employment Research.
https://research.upjohn.org/cgi/viewcontent.cgi?article=1095&context=up_bookchapters
- Bartik, Timothy J. (1993). "Who benefits from local job growth: migrants or the original residents?". *Regional Studies* 27, no. 4 (1993): 297-311.
- Baum-Snow, Nathaniel, and Gilles Duranton (2025). "Housing supply and housing affordability". NBER working paper no. 33694. <https://doi.org/10.3386/w33694>
- Baum-Snow, Nathaniel, and Lu Han (2024). "The microgeography of housing supply". *Journal of Political Economy*, 132(6), 1897–1946. <https://doi.org/10.1086/728110>
- Broxterman, Daniel A., and William D. Larson (2020). "An empirical examination of shift-share instruments". *Journal of Regional Science*, 60(4), 677-711. <https://doi.org/10.1111/jors.12481>
- Broxterman, Daniel A., Yishen Liu, and Anthony M. Yezer (2026). "Why we still don't know much about housing supply elasticity". *Real Estate Economics*, 1-22. <https://doi.org/10.1111/1540-6229.70040>

Caldera, Aida, and Åsa Johansson (2013). "The price responsiveness of housing supply in OECD countries". *Journal of Housing Economics*, 22(3), 231-249.

<https://doi.org/10.1016/j.jhe.2013.05.002>

Crosignani, Matteo, and Martin Hiti (2025). "Losses from natural disasters: county-level data on damages, injuries, and fatalities". *Federal Reserve Bank of New York Staff Reports*, no. 1156.

<https://doi.org/10.59576/sr.1156>

Davidoff, Thomas (2016). "Supply constraints are not valid instrumental variables for home prices because they are correlated with many demand factors". *Critical Finance Review*, 5(2), 177-206.

<https://doi.org/10.1561/104.00000037>

Davis, Morris A., William D. Larson, Stephen D. Oliner, and Jessica Shui (2021). "The price of residential land for counties, ZIP codes, and census tracts in the United States". *Journal of Monetary Economics*, 118, 413–431.

<https://doi.org/10.1016/j.jmoneco.2020.12.005>

Duca, John V., John Muellbauer, and Anthony Murphy (2021). "What drives house price cycles? International experience and policy issues". *Journal of Economic Literature*, 59(3), 773-864.

<https://doi.org/10.1257/jel.20201325>

DiPasquale, Denise (1999). "Why don't we know more about housing supply?". *The Journal of Real Estate Finance and Economics*, 18(1), 9-23.

<https://doi.org/10.1023/A:1007729227419>

DiPasquale, Denise and William C. Wheaton (1992). "The markets for real estate assets and space: A conceptual framework". *Real Estate Economics*, 20(2), 181-198.

<https://doi.org/10.1111/1540-6229.00579>

Driscoll, John C. and Aart C. Kraay (1998). "Consistent covariance matrix estimation with spatially dependent panel data". *The Review of Economics and Statistics*, 80(4), 549–560.

<https://doi.org/10.1162/003465398557825>

Elmendorf, Christopher S., Clayton Nall and Stan Oklobdzija (2025). "The folk economics of housing", *Journal of Economic Perspectives*, 39(3), 45–66.

<https://doi.org/10.1257/jep.20241428>

Furth, Salim, Response to "Supply Constraints do not Explain House Price and Quantity Growth Across U.S. Cities" by Louie, Mondragon, and Wieland (April 08, 2025). Available at SSRN:

<http://dx.doi.org/10.2139/ssrn.5227968>

Glaeser, Edward and Joseph Gyourko (2018). "The economic implications of housing supply", *Journal of Economic Perspectives*, 32(1), 3–30.

<https://doi.org/10.1257/jep.32.1.3>

Glaeser, Edward, Joseph Gyourko, and Raven E. Saks (2005a). “Why is Manhattan so expensive? Regulation and the rise in housing prices”. *The Journal of Law and Economics*, 48(2), 331–369. <https://doi.org/10.1086/429979>

Glaeser, Edward, Joseph Gyourko, and Raven E. Saks (2005b). “Why have housing prices gone up?”. *American Economic Review*, 95(2), 329–333. <https://doi.org/10.1257/000282805774669961>

Glaeser, Edward, Joseph Gyourko, and Raven E. Saks (2006). “Urban growth and housing supply”. *Journal of Economic Geography*, 6(1), 71–89. <https://doi.org/10.1093/jeg/lbi003>

Gorback, Caitlin S. and Benjamin J. Keys (2026). “Global capital and local assets: House prices, quantities, and elasticities”. *The Review of Financial Studies*, 39(8), 2476–2516. <https://doi.org/10.1093/rfs/hhag040>

Green, Richard K., Stephen Malpezzi, and Stephen K. Mayo (2005). “Metropolitan-specific estimates of the price elasticity of supply of housing, and their sources”. *American Economic Review*, 95(2), 334–339. <https://doi.org/10.1257/000282805774670077>

Grimes, Arthur, and Andrew Aitken (2010). “Housing supply, land costs and price adjustment”. *Real Estate Economics*, 38(2), 325–353. <https://doi.org/10.1111/j.1540-6229.2010.00269.x>

Guren, Adam M., Alisdair McKay, Emi Nakamura and Jón Steinsson (2021). “Housing wealth effects: The long view”. *Review of Economic Studies*, 88(2), 669–707. <https://doi.org/10.1093/restud/rdaa018>

Gyourko, Joseph, and Raven Molloy (2015). “Regulation and housing supply”. In *Handbook of regional and urban economics*, vol. 5, 1289–1337. Elsevier. <https://doi.org/10.1016/B978-0-444-59531-7.00019-3>

Gyourko, Joseph, and Albert Saiz (2006). “Construction costs and the supply of housing structure”. *Journal of Regional Science*, 46(4), 661–680. <https://doi.org/10.1111/j.1467-9787.2006.00472.x>

Gyourko, Joseph, Albert Saiz, and Anita Summers (2008). “A new measure of the local regulatory environment for housing markets: The Wharton Residential Land Use Regulatory Index”. *Urban Studies*, 45(3), 693–729. <https://doi.org/10.1177/0042098007087341>

Gyourko, Joseph, Jonathan S. Hartley, and Jacob Krimmel (2021). “The local residential land use regulatory environment across US housing markets: Evidence from a new Wharton index”. *Journal of Urban Economics*, 124, 103337. <https://doi.org/10.1016/j.jue.2021.103337>

- Hilber, Christian A. L., and Wouter Vermeulen (2016). "The impact of supply constraints on house prices in England". *The Economic Journal*, 126(591), 358–405. <https://doi.org/10.1111/eoj.12213>
- Huang, Wenbin (2022). "Government land regulations and housing supply elasticity in urban China". *China & World Economy*, 30(4), 122-148. <https://doi.org/10.1111/cwe.12430>
- Louie, Schuyler, John A. Mondragon, and Johannes Wieland (2025). "Supply constraints do not explain house price and quantity growth across U.S. cities". National Bureau of Economic Research working paper no. 33576. <https://doi.org/10.3386/w33576>
- Lutz, Chandler, and Ben Sand (2023). "Highly disaggregated land unavailability". Available at SSRN 3478900. <https://doi.org/10.2139/ssrn.3478900>
- Malpezzi, Stephen, and Duncan Maclennan (2001). "The long-run price elasticity of supply of new residential construction in the United States and the United Kingdom". *Journal of Housing Economics*, 10(3), 278-306. <https://doi.org/10.1006/jhec.2001.0288>
- Mayer, Christopher J., and C. Tsurriel Somerville (2000). "Land use regulation and new construction". *Regional Science and Urban Economics*, 30(6), 639-662. [https://doi.org/10.1016/S0166-0462\(00\)00055-7](https://doi.org/10.1016/S0166-0462(00)00055-7)
- Melser, Daniel, Rachel Ong ViforJ, and Gavin Wood (2022). "Exploring the many housing elasticities of supply: The case of Australia". *Cities*, 128, 103817. <https://doi.org/10.1016/j.cities.2022.103817>
- Molloy, Raven (2020). "The effect of housing supply regulation on housing affordability: A review". *Regional Science and Urban Economics*, 80, 103350. <https://doi.org/10.1016/j.regsciurbeco.2018.03.007>
- Oikarinen, Elias, Risto Peltola, and Eero Valtonen (2015). "Regional variation in the elasticity of supply of housing, and its determinants: The case of a small sparsely populated country". *Regional Science and Urban Economics*, 50, 18-30. <https://doi.org/10.1016/j.regsciurbeco.2014.10.004>
- Paciorek, Andrew (2013). "Supply constraints and housing market dynamics". *Journal of Urban Economics*, 77, 11-26. <https://doi.org/10.1016/j.jue.2013.04.001>
- Poterba, James M. (1984). "Tax subsidies to owner-occupied housing: An asset-market approach". *Quarterly Journal of Economics*, 99(4), 729-752. <https://doi.org/10.2307/1883123>
- Saiz, Albert (2010). "The geographic determinants of housing supply", *The Quarterly Journal of Economics*, 125(3), 1253-1296. <https://doi.org/10.1162/qjec.2010.125.3.1253>

Saiz, Albert (2024). "Long run housing supply: role, determinants, and measurement". MIT Center for Real Estate research paper No. 24/11. <https://doi.org/10.2139/ssrn.4967904>

Saks, Raven E. (2008). "Job creation and housing construction: Constraints on metropolitan area employment growth". *Journal of Urban Economics*, 64(1), 178-195.

<https://doi.org/10.1016/j.jue.2007.12.003>

Vermeulen, Wouter, and Jan Rouwendal (2007). "Housing supply and land use regulation in the Netherlands". Tinbergen Institute, discussion paper no. 07-058/3.

<https://doi.org/10.2139/ssrn.1003955>

Vermeulen, Wouter and Jos van Ommeren (2009). "Does land use planning shape regional economies? A simultaneous analysis of housing supply, internal migration and local employment growth in the Netherlands". *Journal of Housing Economics*, 18(4), 294-310.

<https://doi.org/10.1016/j.jhe.2009.09.002>

Wilson, Ron, and Alexander Din (2018). "Understanding and enhancing the US Department of Housing and Urban Development's ZIP code crosswalk files". *Cityscape*, 20(2), 277-294.

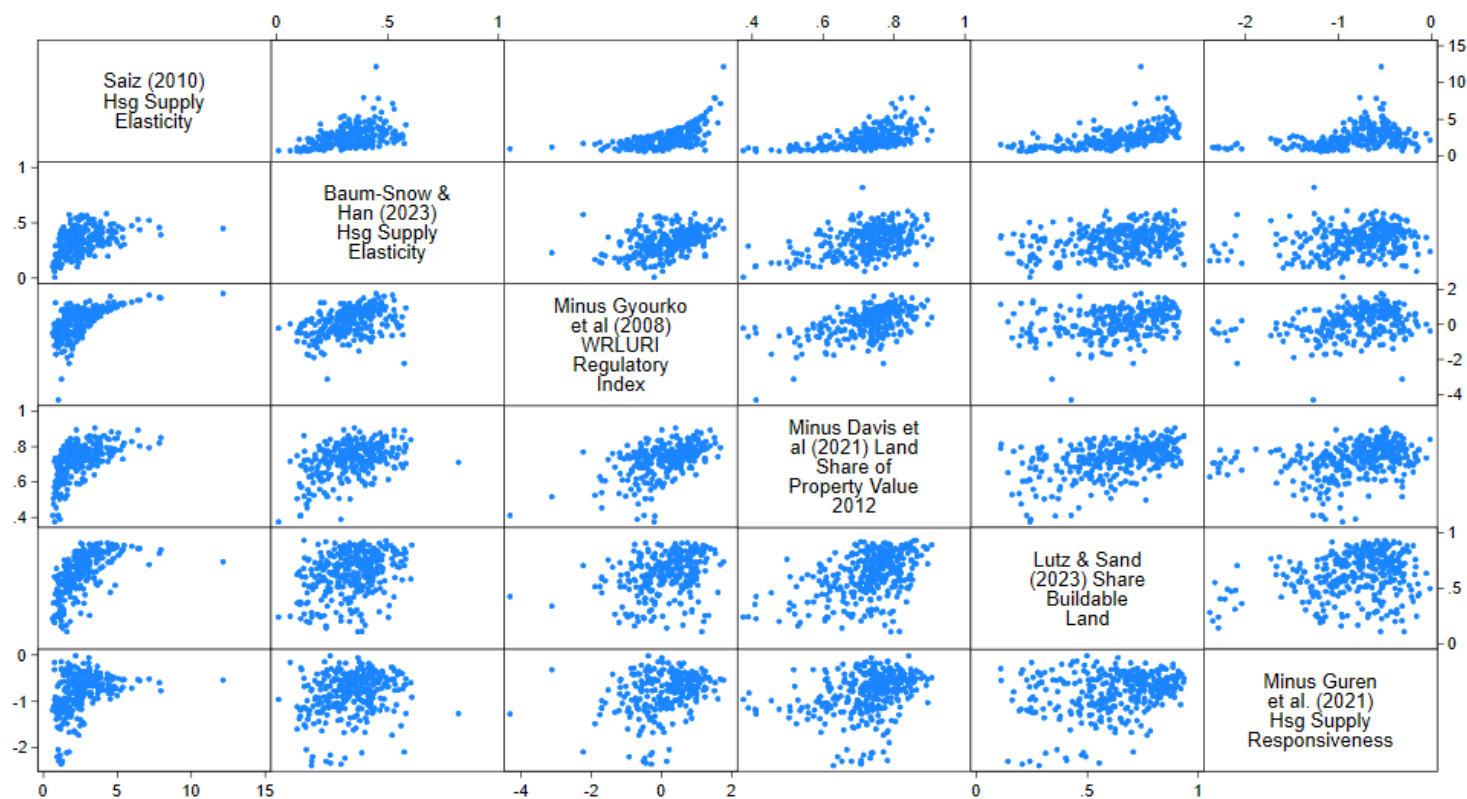
Available at: <https://www.huduser.gov/portal/periodicals/cityscpe/vol20num2/ch16.pdf>

Wiebe, Michael (2025). "Comment on 'Supply constraints do not explain house price and quantity growth across U.S. cities'".

https://michaelwiebe.com/assets/supply_constraints/supply_constraints.pdf

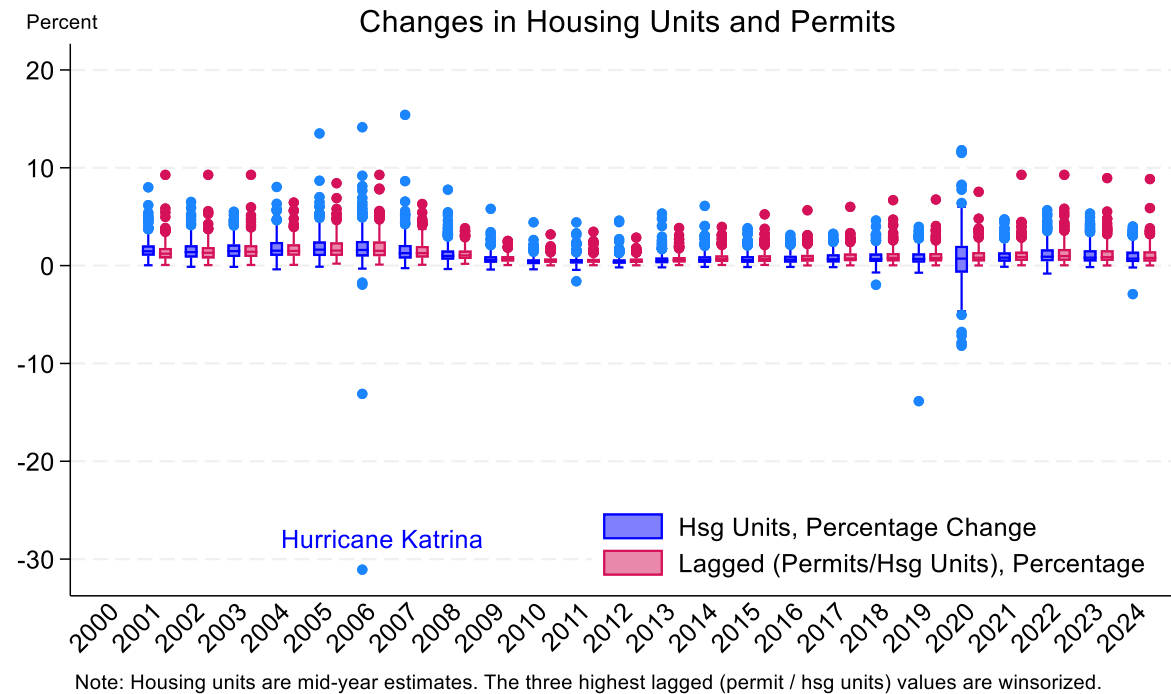
Witte, James G., Jr. (1963). "The microfoundations of the social investment function". *The Journal of Political Economy*, 71(5), 441-456. <https://doi.org/10.1086/258793>

Figure 1: Housing Supply and Constraint Measures



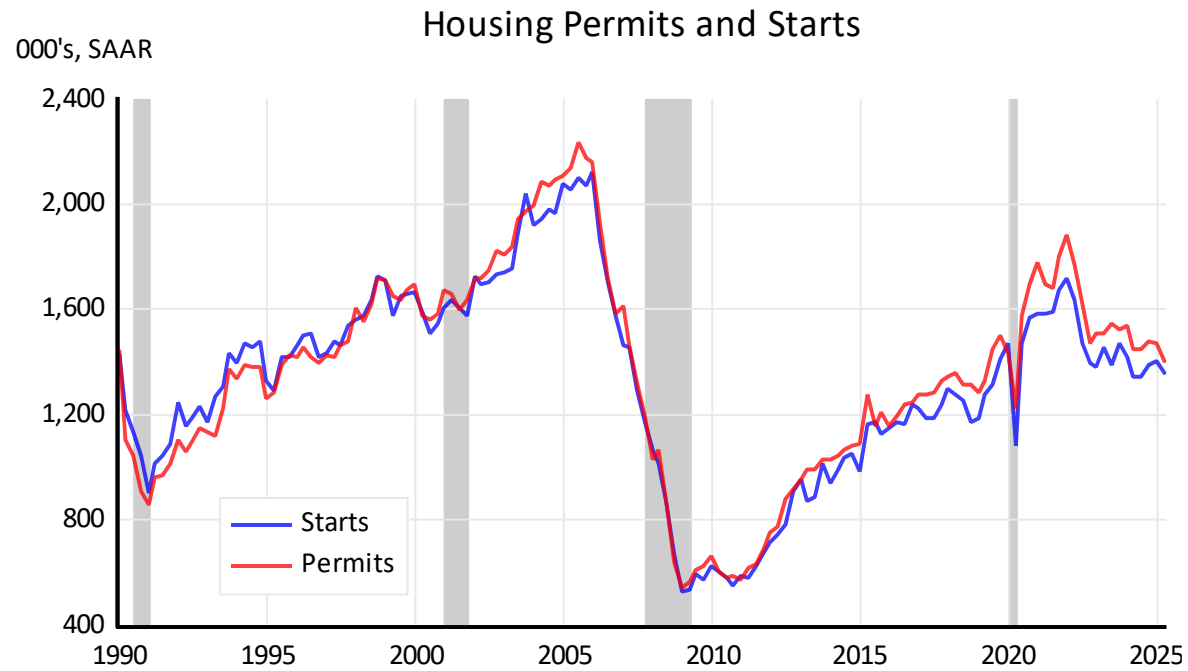
Sources: Saiz (2010), Baum-Snow and Han (2024), Gyourko et al. (2008), Davis et al. (2021), Lutz and Sand (2023), Guren et al. (2021), Gorbach and Keys (2026) and authors calculation. See Section 3.

Figure 2: The Relationship Between Permits and Changes in Housing Units – Box and Whisker Plots, 2000-2024



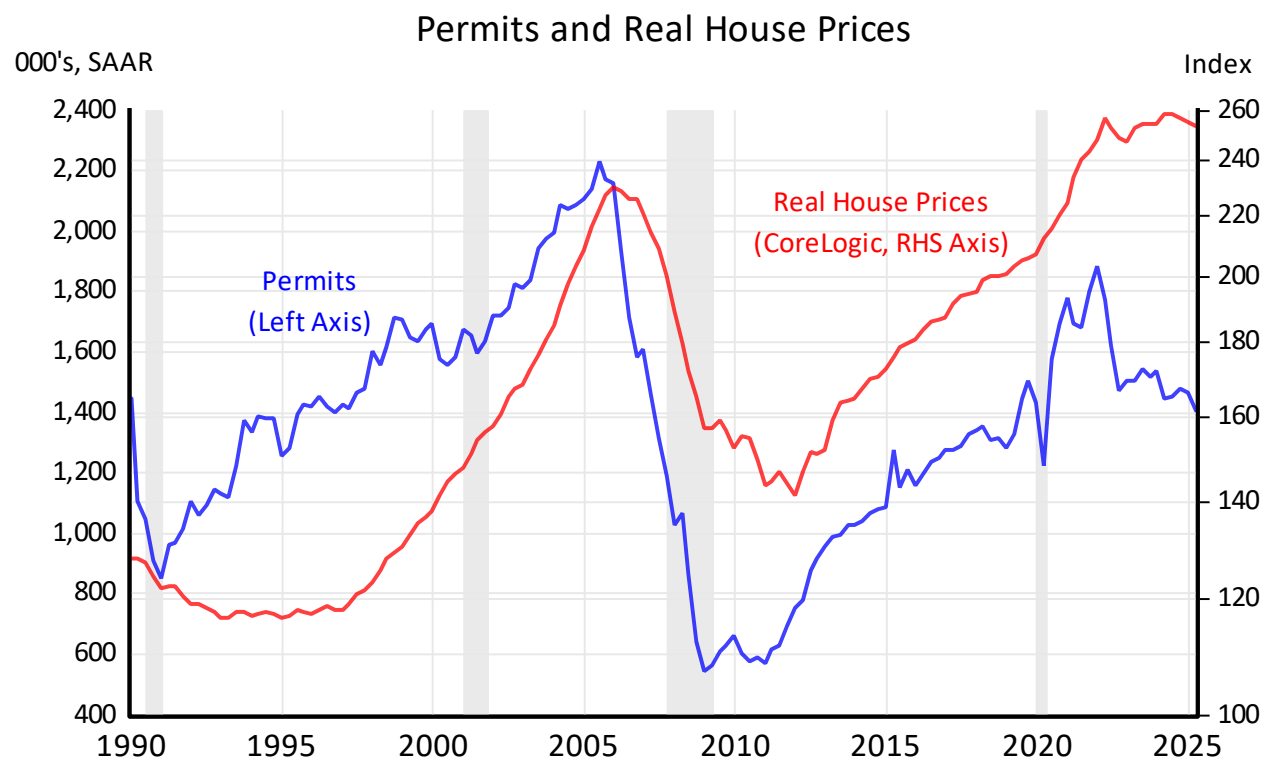
Notes: The housing unit variable is the percentage change in housing units. The permits variable is the lagged ratio of permits to housing units expressed as a percentage. Housing units are mid-year estimates. The three highest permit values are winsorized. In the box and whisker plots, the box represents the inter-quartile range, the line adjacent values and the isolated dots non-adjacent values or outliers. Sources: Haver Analytics and Census Bureau, and authors calculations.

Figure 3: The Close Link Between Housing Permits and Housing Starts



Notes: Aggregate U.S. housing starts and permits. NBER dated recessions are shaded grey. Source: Haver Analytics and Census Bureau.

Figure 4: The Loose Link Between Real House Prices and the New Supply of Housing, Proxied by Permits



Notes: The house price index is the Cotality single family combined index. Real house prices are calculated using the personal consumption expenditure (PCE) deflator. NBER dated recessions are shaded grey. Sources: Haver Analytics, Census Bureau, Bureau of Economic Affairs and Cotality (formerly CoreLogic).

Figure 5: The Textbook Model of House Prices Showing the Differential Effect of Income Growth on House Prices and Quantities in High and Low Supply Elasticity Areas

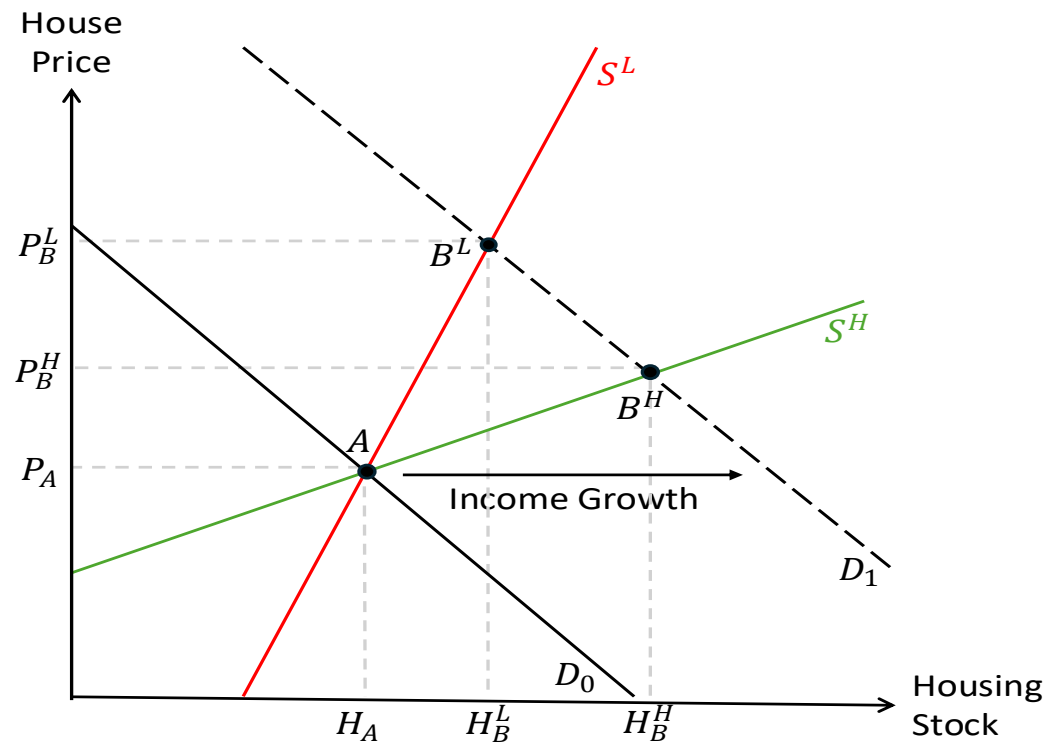


Table 1: Long Differenced Variables, 2000 to 2024 – Summary Statistics (Population Weighted)

Variable	N	Mean	SD	Percentiles				
				P5	P25	P50	P75	P95
$\Delta_{20}\ln H$, Housing Units	396	0.223	0.134	0.056	0.117	0.198	0.293	0.446
$\Delta_{20}\ln HP$, Real House Prices	400	0.397	0.212	0.030	0.241	0.411	0.536	0.795
$\Delta_{20}\ln Y$, Real Personal Income	399	0.493	0.170	0.227	0.376	0.492	0.611	0.735
$\Delta_{20}\ln(Y/POP)$, Real Per Capita Personal Income	399	0.301	0.080	0.190	0.245	0.288	0.346	0.435

Sources: See Section 3.

Table 2: Supply Elasticity / Constraint Measures - Summary Statistics

Measure	N	Mean	SD	Percentiles				
				P5	P25	P50	P75	P95
Unweighted								
Saiz (2010)	272	2.550	1.422	0.877	1.568	2.276	3.209	4.911
Baum-Snow & Han (2024)	318	0.340	0.121	0.131	0.258	0.350	0.424	0.534
WRLURI, Gyourko et al. (2008)	272	-0.114	0.820	-1.220	-0.758	-0.216	0.409	1.189
Davis et al. (2023)	390	0.266	0.091	0.151	0.205	0.252	0.303	0.444
Lutz & Sand (2023)	353	0.629	0.193	0.248	0.514	0.660	0.783	0.889
Guren et al. (2019)	380	0.796	0.446	0.274	0.492	0.691	1.030	1.623
2010 Population Weighted								
Saiz (2010)	272	1.778	1.049	0.627	0.877	1.606	2.378	3.677
Baum-Snow & Han (2024)	318	0.234	0.113	0.108	0.140	0.206	0.308	0.441
WRLURI, Gyourko et al. (2008)	272	0.167	0.695	-0.913	-0.339	0.193	0.638	1.517
Davis et al. (2023)	390	0.331	0.115	0.185	0.256	0.280	0.406	0.589
Lutz & Sand (2023)	353	0.561	0.191	0.226	0.374	0.603	0.704	0.828
Guren et al. (2019)	380	0.995	0.466	0.345	0.652	0.973	1.197	2.039

Sources: See Section 3.

Table 3: Supply Elasticity / Constraint Measures - Pairwise Correlations

	Saiz	Baum-Snow & Han	(Minus) WRLURI	(Minus) Davis et al.	Lutz & Sand	(Minus) Guren et al.
Unweighted						
Saiz (2010)	1.00					
Baum-Snow & Han (2024)	0.47	1.00				
(Minus) WRLURI, Gyourko et al. (2008)	0.63	0.41	1.00			
(Minus) Davis et al. (2023)	0.52	0.44	0.54	1.00		
Lutz & Sand (2023)	0.60	0.33	0.31	0.45	1.00	
(Minus) Guren et al. (2019)	0.35	0.24	0.32	0.34	0.27	1.00
2010 Population Weighted						
Saiz (2010)	1.00					
Baum-Snow & Han (2024)	0.62	1.00				
(Minus) WRLURI, Gyourko et al. (2008)	0.61	0.43	1.00			
(Minus) Davis et al. (2023)	0.64	0.57	0.55	1.00		
Lutz & Sand (2023)	0.71	0.50	0.40	0.69	1.00	
(Minus) Guren et al. (2019)	0.47	0.36	0.31	0.34	0.45	1.00

Source: See Section 3.

Table 4: Change in Housing Units, Permits and Disaster Losses, 2000-2024

	Δ Housing Units
Lagged Permits	0.917*** (0.013)
Lagged Scaled Property Damages	-7.326*** (1.647)
MSA Fixed Effects	Yes
Year Fixed Effects	Yes
N	8053
Adj R ²	0.81
Adj R ² Within	0.39

Notes: *** p-value < 0.01, ** p-value < 0.05, * p-value < 0.1. OLS regression using annual data from 2000 to 2024. Standard errors are shown in parentheses. Natural disaster property damages are scaled by total personal income. The timing of the right-hand side variables reflects the fact that the housing unit data are mid-year estimates.

Table 5: LMW (2025) Long Difference Reduced Form Housing Supply

HOUSE QUANTITY GROWTH (2000-2020)				
	(1) Saiz	(2) BS-H	(3) WRLURI	(4) Building
<i>Panel A. Housing Quantities Growth (Annualized %)</i>				
Less Constrained $\times$ Income Growth	0.015 (0.048)	-0.029 (0.050)	0.100** (0.050)	-0.023 (0.053)
Income Growth	0.649*** (0.034)	0.642*** (0.030)	0.604*** (0.034)	0.636*** (0.033)
Less Constrained	0.044 (0.092)	0.028 (0.095)	-0.118 (0.096)	0.042 (0.102)
R2	0.79	0.77	0.80	0.76
Number of Observations	269	310	269	308

Notes: Quantity refers to housing units and income to total personal income. The column (2) and (4) estimates use the Baum-Snow and Han (2024) housing supply elasticities and the negative of the Davis et al. (2021) land share measures respectively. More and less constrained areas are defined relative to the mean housing supply elasticity or constraint measure. Source: Upper panel of Table III in LMW (2025).

Table 6: Long Difference Reduced Form Housing Supply (Housing Units), 2000-2020

Dependent Variable = $\Delta_{20}\ln H$ (log housing units)	1	2	3	4	5	6
$\Delta_{20}\ln Y$ (log real personal income)	0.600 *** (0.052)	0.621 *** (0.015)	0.710 *** (0.040)	0.855 *** (0.049)	0.473 *** (0.051)	0.727 *** (0.040)
$\Delta_{20}\ln Y \times$ Saiz Elasticity	0.052 *** (0.015)					
$\Delta_{20}\ln Y \times$ Baum-Snow & Han Elasticity		0.259 * (0.137)				
$\Delta_{20}\ln Y \times$ (Minus) WRLURI			0.073 *** (0.017)			
$\Delta_{20}\ln Y \times$ (Minus) Davis et al. Land Share of Property Value				0.587 ** (0.110)		
$\Delta_{20}\ln Y \times$ Lutz & Sand Buildable Land Share					0.345 *** (0.063)	
$\Delta_{20}\ln Y \times$ (Minus) Guren et al. House Price Sensitivity						0.038 *** (0.011)
N	267	323	267	385	347	375
SE	0.06	0.07	0.06	0.06	0.06	0.07
Adjusted R^2	0.78	0.75	0.78	0.80	0.81	0.74

*** p<.01, ** p<.05, * p<.1. Notes: Data for 2000 and 2020. Income is real total personal income, not real per capita personal income. The estimates are population weighted OLS estimates with robust standard errors shown in parentheses.

Table 7: Annual Reduced Form Housing Permits, 2000-2024

Dependent Variable = log permits	1	2	3	4	5	6
$\ln Y$ (log real per capita personal income)	2.086 *** (0.549)	2.089 *** (0.655)	2.468 *** (0.490)	3.477 *** (0.452)	1,768 *** (0.541)	2.440 *** (0.529)
$\ln Y \times \text{Saiz Elasticity}$	0.231 ** (0.091)					
$\ln Y \times \text{Baum-Snow \& Han}$		1.596 ** (1.187)				
$\ln Y \times (\text{Minus}) \text{ WRLURI}$			0.254 *** (0.070)			
$\ln Y \times (\text{Minus}) \text{ Davis et al.}$ Land Share of Property Value				2.624 *** (0.925)		
$\ln Y \times \text{Lutz \& Sand Buildable}$ Land Share					1.559 *** (0.344)	
$\ln Y \times (\text{Minus}) \text{ Guren et al.}$ House Price Sensitivity						0.087 (0.209)
MSA Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
N	6448	7470	6448	8549	8195	8521
SE	0.37	0.37	0.37	0.37	0.38	0.38
R^2	0.06	0.07	0.06	0.07	0.07	0.06

Notes: *** p<.01, ** p<.05, * p<.1. Annual data 2000-2024. Income is real per capita personal income. The estimates are population weighted OLS estimates with Driscoll-Kraay (1998) HAC standard errors using one lag.

Table 8: Annual Reduced Form Housing Supply (Change in Housing Units), 2000-2024 Excluding 2020

Dependent Variable = Δ housing units/1000	1	2	3	4	5	6
$\ln Y$ (ln real per capita personal income)	39.050 *** (5.122)	38.220 *** (5.635)	47.839 *** (6.641)	51.098 *** (11.201)	32.650 *** (5.023)	55.656 *** (9.975)
$\ln Y \times$ Saiz Elasticity	6.325 *** (1.614)					
$\ln Y \times$ Baum-Snow & Han		24.312 (25.780)				
$\ln Y \times$ (Minus) WRLURI			5.372 *** (0.970)			
$\ln Y \times$ (Minus) Davis et al. Land Share of Property Value				23.020 * (12.314)		
$\ln Y \times$ Lutz & Sand Buildable Land Share					24.431 *** (5.705)	
$\ln Y \times$ (Minus) Guren et al. House Price Sensitivity						14.173 ** (5.272)
Scaled Property Damages Lagged	-0.653 *** (0.187)	-0.593 *** (0.199)	-0.653 *** (0.188)	-0.570 *** (0.197)	-0.579 *** (0.198)	-0.569 *** (0.198)
MSA Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
N	6177	7235	6177	8891	8017	8661
SE	6.44	6.36	6.46	6.48	6.50	6.45
R^2	0.13	0.10	0.12	0.10	0.11	0.11

*** p<.01, ** p<.05, * p<.1. Notes: Annual data 2000-2024, excluding 2020. The change in housing units is in 000s. The estimates are population weighted OLS estimates with Driscoll-Kraay (1998) HAC standard errors using one lag.

Table 9: LMW (2025) Long Difference Structural Form Housing Supply

	(1) Saiz	(2) BS-H	(3) WRLURI	(4) Building
<i>Panel A</i>	<i>Growth (Annualized %)</i>			
More Constrained $\times$ Price Growth	1.117*** (0.204)	1.087*** (0.170)	1.023*** (0.191)	1.009*** (0.165)
Less Constrained $\times$ Price Growth	1.220*** (0.169)	0.924*** (0.122)	1.308*** (0.177)	1.039*** (0.153)
Less Constrained	0.933** (0.380)	0.519* (0.274)	0.555 (0.355)	0.566* (0.301)
Chi-Squared Test P-value	0.70	0.43	0.27	0.89
CD F-stat	54.04	58.23	53.82	63.99
Number of Observations	268	308	268	306

Notes: Instrumental variable estimates using real personal income growth to instrument real house price growth. Quantity is the percentage change in housing units. Column (2) and (4) use the Baum-Snow and Han (2024) housing supply elasticities and the negative of the Davis et al. (2021) land share of house price measures respectively. More and less constrained areas are defined relative to the mean housing supply elasticity or constraint measure. Source: Upper panel of Table IV in LMW (2025).

Table 10: Long Difference Structural Form Housing Supply (Housing Units), 2000-2020

Dependent Variable = $\Delta_{20} \ln H$ (Log Housing Units)	1	2	3	4	5	6
$\Delta_{20} \ln HP$ (log real house price)	0.243 ** (0.098)	0.511 *** (0.190)	1.186 *** (0.202)	1.997 *** (0.291)	0.011 *** (0.088)	1.651 *** (0.372)
$\Delta_{20} \ln HP \times$ Saiz Elasticity	0.471 *** (0.075)					
$\Delta_{20} \ln HP \times$ Baum-Snow & Han Elasticity		2.357 *** (0.601)				
$\Delta_{20} \ln HP \times$ (Minus) WRLURI			0.514 *** (0.102)			
$\Delta_{20} \ln HP \times$ (Minus) Davis et al. Land Share of Property Value				2.856 *** (0.405)		
$\Delta_{20} \ln HP \times$ Lutz & Sand Buildable Land Share					1.793 *** (0.242)	
$\Delta_{20} \ln HP \times$ (Minus) Guren et al. House Price Sensitivity						0.417 *** (0.137)
N	267	313	267	385	347	375
SE	0.17	0.22	0.21	0.18	0.16	0.26

Notes: *** p<.01, ** p<.05, * p<.1. Data for 2000 and 2020. Population weighted OLS estimates with robust standard errors. House prices are instrumented using total personal income.

Table 11: Annual Structural Form New Housing Supply (Permits), 2000-2024

Dependent Variable = $\ln Permits$	1	2	3	4	5	6
$\ln HP$ (log real HP)	1.558 *** (0.298)	1.651 *** (0.410)	2.038 *** (0.388)	2.548 *** (0.447)	1.304 *** (0.301)	1.995 *** (0.470)
$\ln HP \times$ Saiz Elasticity	0.300 ** (0.146)					
$\ln HP \times$ Baum-Snow & Han Elasticity		1.327 (0.881)				
$\ln HP \times$ (Minus) WRLURI			0.354 ** (0.164)			
$\ln HP \times$ (Minus) Davis et al. Land Share of Property Value				1.639 ** (0.773)		
$\ln HP \times$ Lutz & Sand Buildable Land Share					1.441 ** (0.572)	
$\ln HP \times$ (Minus) Guren et al. House Price Sensitivity						0.119 (0.192)
MSA Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
N	6448	7470	6448	8246	8195	8521
SE	0.35	0.36	0.35	0.36	0.36	0.36
R^2	0.15	0.15	0.15	0.15	0.14	0.14

Notes: *** p<.01, ** p<.05, * p<.1. Annual data 2000-2024. Population weighted IV estimates with Driscoll-Kraay (1998) HAC standard errors using one lag. House prices are instrumented using per capita personal income.

Table 12: Annual Structural Form New Housing Supply (Permits) With Construction Costs, 2000-2024

Dependent Variable = <i>ln Permits</i>	1		2		3		4		5		6	
<i>ln HP</i> (log real house prices)	1.675	***	1.542	***	2.248	***	2.559	***	1.294	***	2.233	***
	(0.258)		(0.331)		(0.357)		(0.427)		(0.285)		(0.418)	
<i>ln HP</i> × Saiz Elasticity	0.351	**										
	(0.158)											
<i>ln HP</i> × Baum-Snow & Han Elasticity			2.616	***								
			(0.735)									
<i>ln HP</i> × (Minus) WRLURI					0.379	**						
					(0.184)							
<i>ln HP</i> × (Minus) Davis et al. Land Share of Property Value							1.482	*				
							(0.777)					
<i>ln HP</i> × Lutz & Sand Buildable Land Share									1.707	***		
									(0.578)			
<i>ln HP</i> × (Minus) Guren et al. House Price Sensitivity											0.216	
											(0.175)	
<i>Ln Construction Costs</i> (log real RS Means cost index)	-1.737	***	-1.751	***	-1.659	***	-1.435	***	-1.613	***	-1.453	***
	(0.321)		(0.358)		(0.312)		(0.336)		(0.335)		(0.320)	
MSA Fixed Effects	Yes		Yes		Yes		Yes		Yes		Yes	
Year Fixed Effects	Yes		Yes		Yes		Yes		Yes		Yes	
N	3709		4034		3709		4076		4009		4070	
SE	0.30		0.30		0.30		0.30		0.30		0.30	
<i>R</i> ²	0.15		0.16		0.15		0.16		0.15		0.12	

Notes: *** p<.01, ** p<.05, * p<.1. Annual data 2000-2024. Population weighted IV estimates with Driscoll-Kraay (1998) HAC standard errors using one lag. House prices are instrumented using per capita personal income.

Appendix

(1) Housing market stock-flow equilibrium in the DiPasquale-Wheaton four quadrant model

The well-known DiPasquale Wheaton four-quadrant model in **Figure A1**. In the model, housing is an investment and the stock-flow equilibrium is simultaneously determined in four markets - the space, asset valuation, construction / supply and stock adjustment markets – represented by the four quadrants. Stock equilibrium is shown in the NE (space) quadrant and flow equilibrium is shown in the SW (construction) quadrant. Construction (supply) depends on the level of prices.

Ceteris paribus, an increase in demand for housing raises rents, house prices, construction / supply and the housing stock. Increases (decreases) in the demand for housing generate higher (lower) house prices. In turn, the change in prices generates higher (lower) construction, tracing out the supply curve.

(2) Reduced form house price results

Table A1 reproduces the long difference, reduced form, house price equations in LMW (2025). The noteworthy feature of their results is that all the interactions with the housing supply elasticities etc. are statistically insignificant, contrary to priors. Our long difference and annual reduced form estimates, set out in **Tables A2 and A3**, tell a different story.

Consider the long difference reduced form results in **Table A2**. Note that the column (4) results – using the Davis et al. (2021) land share of property values – should be ignored since the income term is incorrectly signed. The other five supply elasticity / constraint interaction terms are correctly signed and highly significant. In the annual regression (**Table A3**), five of the six interaction terms are significant - the exception being the Guren et al. (2021) house price responsiveness measure. Ceteris paribus, cities with more elastic the reduced form house price results suggest that MSAs with more elastic supply / fewer supply constraints experience lower house price increases when real incomes increase.

Table A1: LMW (2025) Long Difference Reduced Form House Price Equations

TABLE II HOUSE PRICE GROWTH (2000-2020)				
	(1) Saiz	(2) BS-H	(3) WRLURI	(4) Building
<i>Panel A. Real House Price Growth (Annualized %)</i>				
Less Constrained $\times$ Income Growth	-0.038 (0.122)	0.070 (0.111)	-0.053 (0.118)	-0.043 (0.116)
Income Growth	0.581*** (0.104)	0.591*** (0.080)	0.591*** (0.093)	0.630*** (0.089)
Less Constrained	-0.759*** (0.273)	-0.498** (0.240)	-0.580** (0.262)	-0.501* (0.257)
R2	0.47	0.35	0.42	0.37
Number of Observations	268	308	268	306

Notes: The column (2) and (4) estimates use the Baum-Snow and Han (2024) housing supply elasticities and the negative of the Davis et al. (2021) land share measures respectively. More and less constrained areas are defined relative to the mean housing supply elasticity or constraint measure. Source: Upper panel of Table II in LMW (2025)

Table A2: Long Difference Reduced Form House Prices, 2000 - 2020

Dependent Variable = $\Delta_{20} \ln HP$ (log real house prices)	1	2	3	4	5	6
$\Delta_{20} \ln Y$ (log real personal income)	1.114 *** (0.119)	1.015 *** (0.153)	0.604 *** (0.090)	-0.070 (0.108)	1.366 *** (0.150)	0.349 *** (0.116)
$\Delta_{20} \ln Y \times$ Saiz Elasticity	-0.242 *** (0.037)					
$\Delta_{20} \ln Y \times$ Baum-Snow & Han Elasticity		-1.384 *** (0.354)				
$\Delta_{20} \ln Y \times$ (Minus) WRLURI			-0.297 *** (0.044)			
$\Delta_{20} \ln Y \times$ (Minus) Davis et al. Land Share of Property Value				-2.320 ** (0.258)		
$\Delta_{20} \ln Y \times$ Lutz & Sand Buildable Land Share					-1.204 *** (0.187)	
$\Delta_{20} \ln Y \times$ (Minus) Guren et al. House Price Sensitivity						-0.238 *** (0.053)
N	271	317	271	389	351	379
SE	0.14	0.16	0.16	0.13	0.14	0.18
Adjusted R^2	0.56	0.38	0.44	0.60	0.58	0.30

*** p<.01, ** p<.05, * p<.1. Notes: Data for 2000 and 2020. Income is real total personal income, not real per capita personal income. The estimates are population weighted OLS estimates with robust standard errors shown in parentheses.

Table A3: Annual Reduced Form House Price Equations, 2000-2024

Dependent Variable = $\ln HP$ (log real house prices)	1	2	3	4	5	6
$\ln Y$ (log real personal income)	1.096 *** (0.077)	1.026 *** (0.075)	0.859 *** (0.069)	0.547 *** (0.168)	1.202 *** (0.099)	0.794 *** (0.116)
$\ln Y \times$ Saiz Elasticity	-0.116 ** (0.043)					
$\ln Y \times$ Baum-Snow & Han Elasticity		-0.649 ** (0.235)				
$\ln Y \times$ (Minus) WRLURI			-0.131 ** (0.055)			
$\ln Y \times$ (Minus) Davis et al. Land Share of Property Value				-0.935 ** (0.394)		
$\ln Y \times$ Lutz & Sand Buildable Land Share					-0.587 *** (0.203)	
$\ln Y \times$ (Minus) Guren et al. House Price Sensitivity						-0.060 (0.071)
MSA Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
N	6798	7948	6798	9748	8798	9498
SE	0.09	0.09	0.09	0.09	0.08	0.09
R ²	0.36	0.33	0.34	0.35	0.37	0.32

Notes: *** p<.01, ** p<.05, * p<.1. Income is real total personal income, not real per-capita personal income. Population weighted IV estimates with Driscoll-Kraay (1998) HAC standard errors using one lag.