

SUPPLY CONSTRAINTS DO NOT EXPLAIN HOUSE PRICE AND QUANTITY GROWTH ACROSS U.S. CITIES

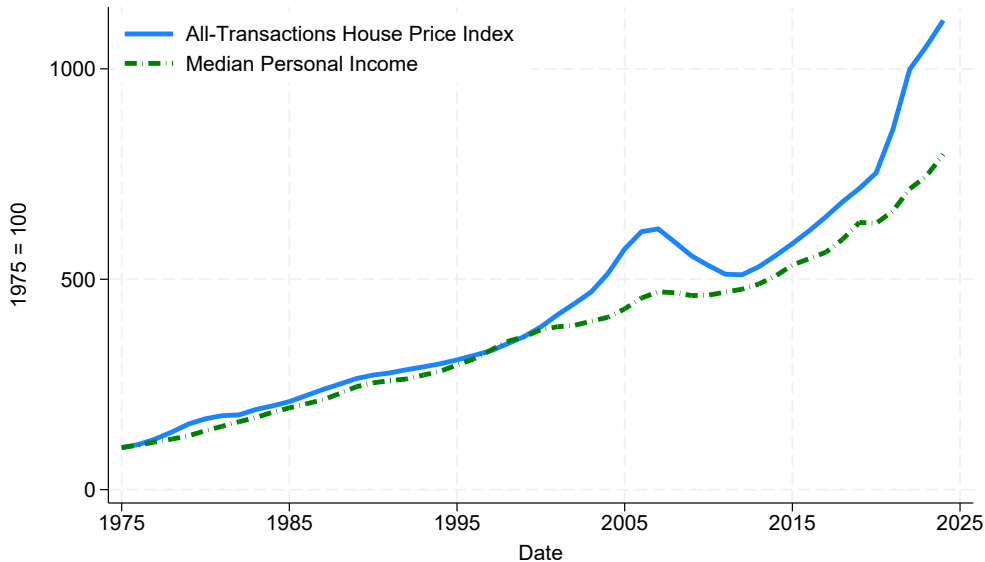
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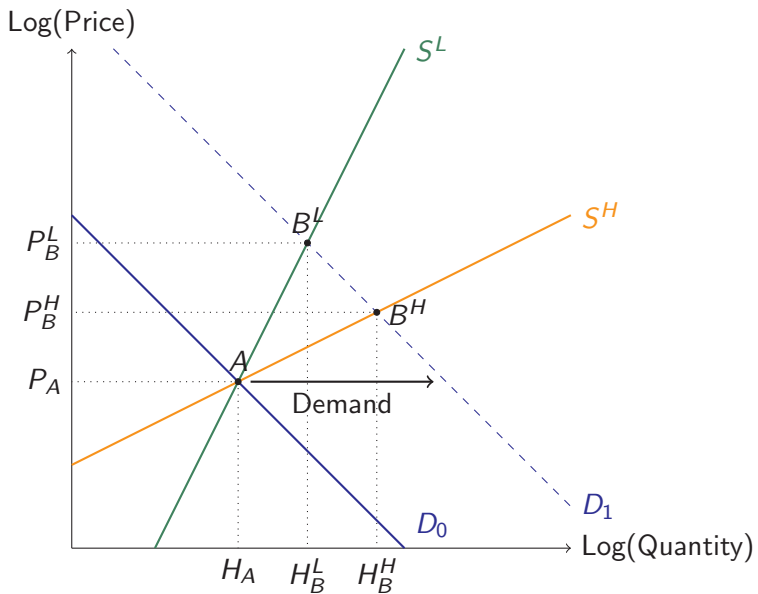
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HOUSING AFFORDABILITY CRISIS



STANDARD VIEW



THIS PAPER

- The standard view:

- ▶ Housing supply elasticities across cities vary due to geographic and regulatory constraints:

$$\hat{H}_i^S = \psi_i \hat{P}_i$$

- ▶ Differences in ψ_i are important in explaining house price growth and quantity growth across cities.

⇒ To improve housing affordability, need to relax housing supply constraints.

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⇒ To improve housing affordability, need to relax housing supply constraints.

- We use data for U.S. cities (MSAs) to evaluate this view:

- ▶ In cities with smaller (measured) ψ_i , does the same change in income growth predict a larger change in house prices and a smaller change in housing quantities?

SUMMARY OF RESULTS

- From 2000 to 2020, the differences in total income growth, per capita income growth, and population growth predict **the same** differences in house price, quantity, and population growth **regardless** of a city's measured housing constraints
 - ▶ Same results for 1980 to 2000 and 1980 to 2020

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- Unobserved shocks to housing supply could generate these results, but only under **very specific conditions** that are **at odds the standard view**.

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 - These results quantify the role of supply constraints under any correlation (causal or non-causal) between income growth and unobserved demand shocks.
 - Unobserved shocks to housing supply could generate these results, but only under very specific conditions that are at odds the standard view.
 - Shocks to housing demand from work from home or from standard Bartik/climate instruments give the same results.
- ⇒ **Supply constraints do not appear to matter in the way we expect!** Fixing the affordability crisis may not be as “simple” as the standard view suggests.

RELATED LITERATURE

- **Constraint measures we use:** Gyourko, Saiz, and Summers 2008; Saiz 2010; Davis, Larson, Oliner, and Shui 2021; Baum-Snow and Han 2024
- **Housing supply**
 - ▶ **Implications for the housing market:** Glaeser, Gyourko, and Saks 2005; Green, Malpezzi, and Mayo 2005; Glaeser and Gyourko 2005; Davis and Palumbo 2008; Gyourko 2009; Kok, Monkkonen, and Quigley 2014; Gyourko and Molloy 2015; Molloy 2020; Gorbach and Keys 2020; Albouy and Stuart 2020; Guren et al. 2021; Gyourko, Hartley, and Krimmel 2021; Saiz 2023; Chodorow-Reich, Guren, and McQuade 2024
 - ▶ **Broader implications:** Saks 2008; Paciorek 2013; Gyourko, Mayer, and Sinai 2013; Ganong and Shoag 2017; Gaubert 2018; Glaeser and Gyourko 2018; Hsieh and Moretti 2019; Been, Ellen, and O'Regan 2019
 - ▶ **Similar results?:** Aura and Davidoff 2008; Davis and Ortalo-Magné 2011; Davidoff 2013; Davidoff 2016; Rodríguez-Pose and Storper 2020; Anenberg and Kung 2020; Howard and Liebersohn 2021; Molloy, Nathanson, and Paciorek 2022; Baum-Snow 2023
- **Local effects of new construction and regulatory changes:** Zahirovich-Herbert and Gibler 2014; Diamond and McQuade 2019; Pennington 2021; Li 2022; Freemark 2023

OUTLINE

- 1 INTRODUCTION
- 2 FRAMEWORK
- 3 EMPIRICAL RESULTS
- 4 WHAT CAN EXPLAIN HOUSE PRICES AND QUANTITIES?
- 5 CONCLUSION
- 6 APPENDIX

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SUPPLY FUNCTION INTUITION

- The basic intuition of our approach comes from the strict logic of the standard log-linear competitive supply equation (Saiz 2010; Saiz 2024).
- Long-run (20+ years) changes in housing supply are a function of the elasticity, price changes, and supply shocks ($\hat{\sigma}_i$):

$$\hat{H}_i^S = \psi_i \hat{P}_i + \hat{\sigma}_i$$

- Imagine there are two kinds of cities, high elasticity (ψ_H) and low elasticity (ψ_L). When can we empirically recover these different elasticities?

RECOVERING THE ELASTICITIES

- Consider an IV model where $\check{P}$ is house price growth instrumented with a variable $\hat{Y}$ that we know is correlated with housing demand (can call it income growth)

$$\hat{H}_i = \kappa_j + \theta_j \check{P}_i + w_i,$$

$$\hat{P}_i = \alpha_j + \beta_j \hat{Y}_i + e_i, \quad i \in \Omega^j, j \in \{H, L\}$$

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$$\theta_j = \psi_j + \frac{\text{Cov}(\hat{\sigma}_i, \hat{Y}_i | i \in \Omega^j)}{\text{Cov}(\hat{P}_i, \hat{Y}_i | i \in \Omega^j)}, \quad i \in \Omega^j, j \in \{H, L\}$$

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- ▶ Supply shocks **more** correlated with income growth in **inelastic** areas $\Rightarrow$ **Problem!**

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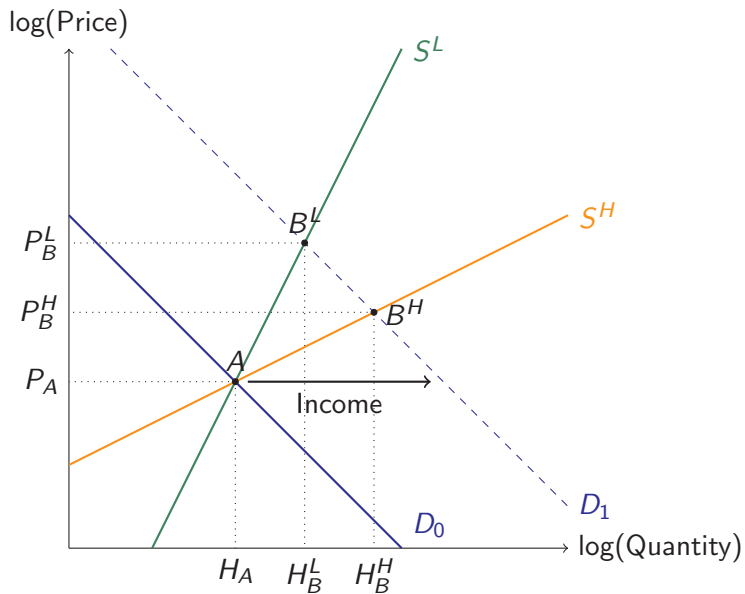
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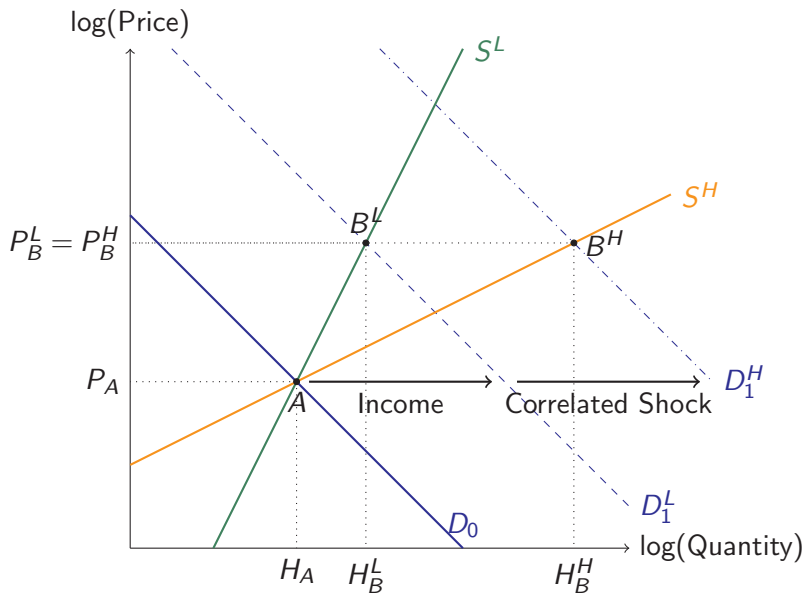
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- ▶ Common correlation between income growth and supply shocks $\Rightarrow$ No problem!
- ▶ Supply shocks more correlated with income growth in inelastic areas $\Rightarrow$ Problem!
- ▶ Must be a specific story, positive correlation between labor demand shocks and housing supply shocks, which contradicts standard view's premise . . . and anyway that's what instruments are for (WFH, Bartiks, etc)

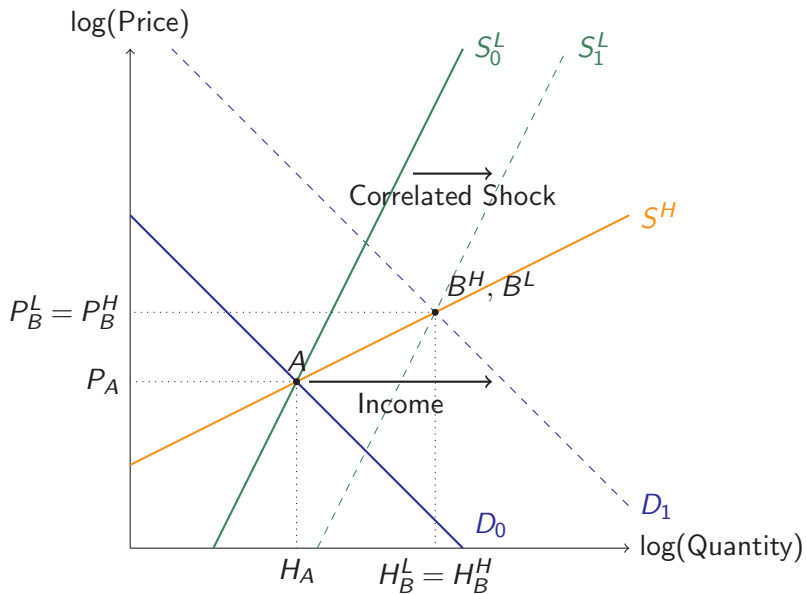
NO SHOCKS



DEMAND SHOCKS



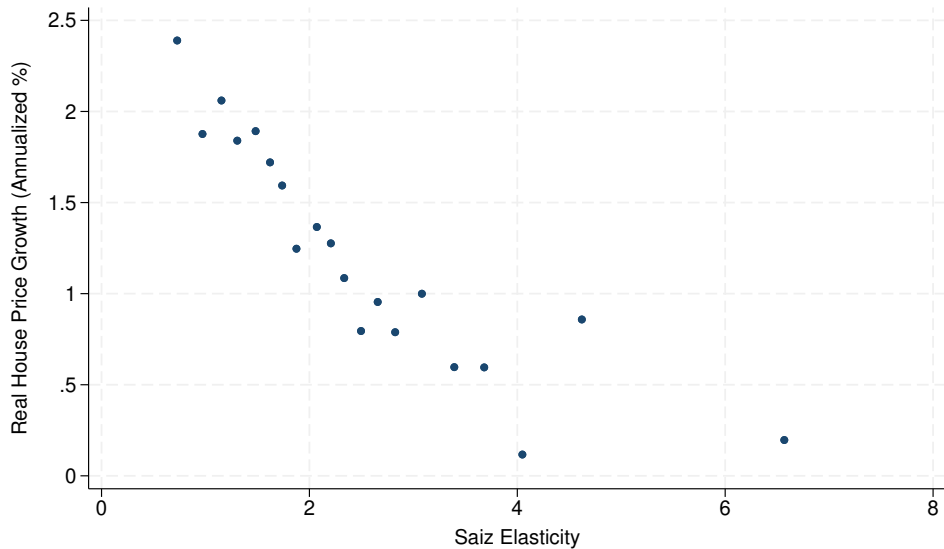
SUPPLY SHOCKS



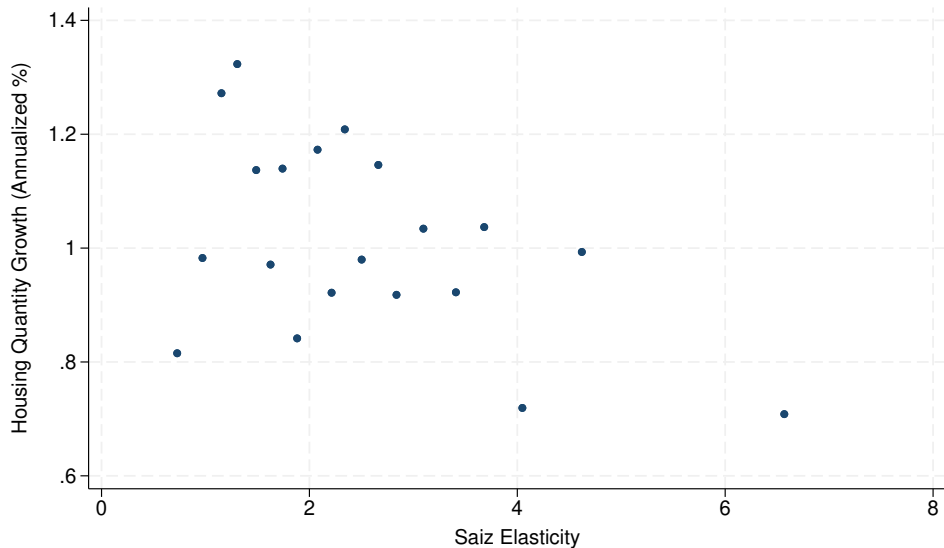
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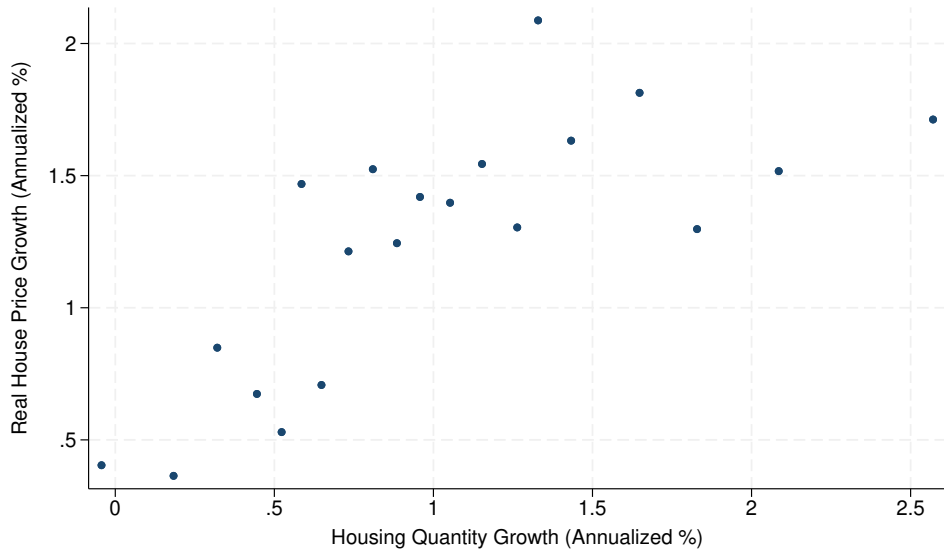
HOUSE PRICE GROWTH (2000-2020) AND SAIZ ELASTICITY



HOUSE QUANTITY GROWTH (2000-2020) AND SAIZ ELASTICITY



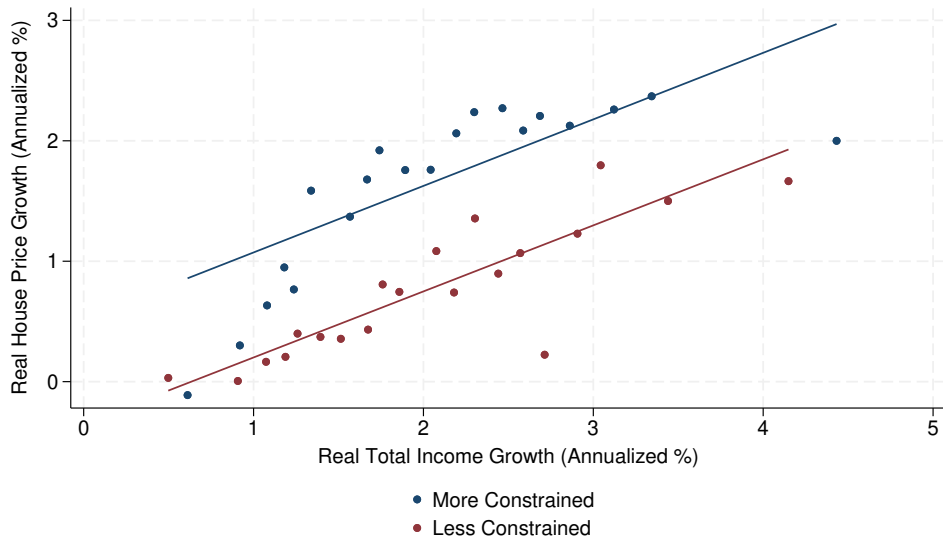
HOUSE PRICE AND QUANTITY GROWTH (2000-2020)



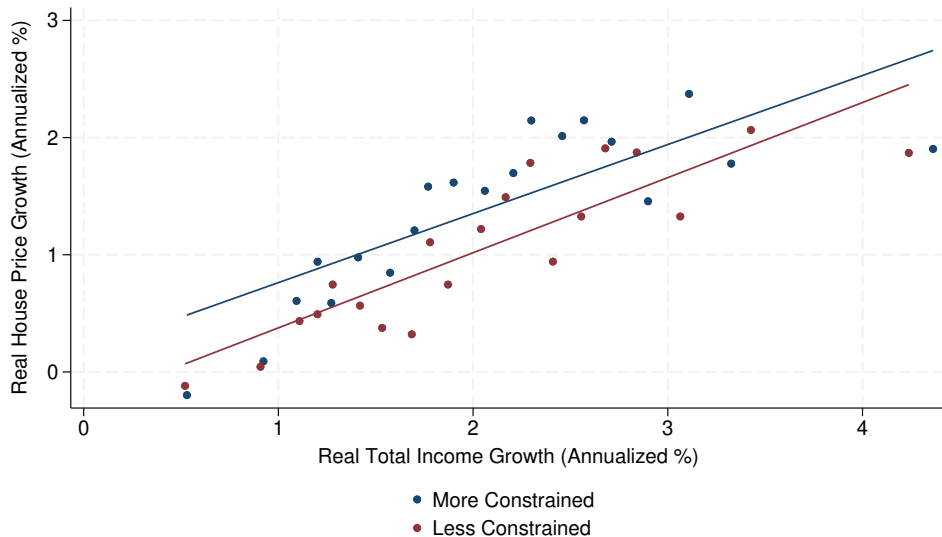
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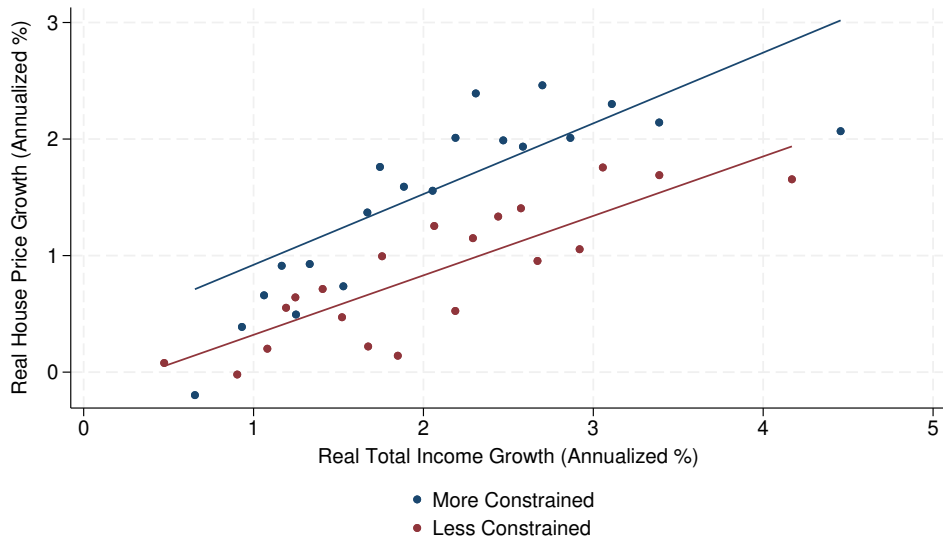
PRICES: SAIZ (2010)



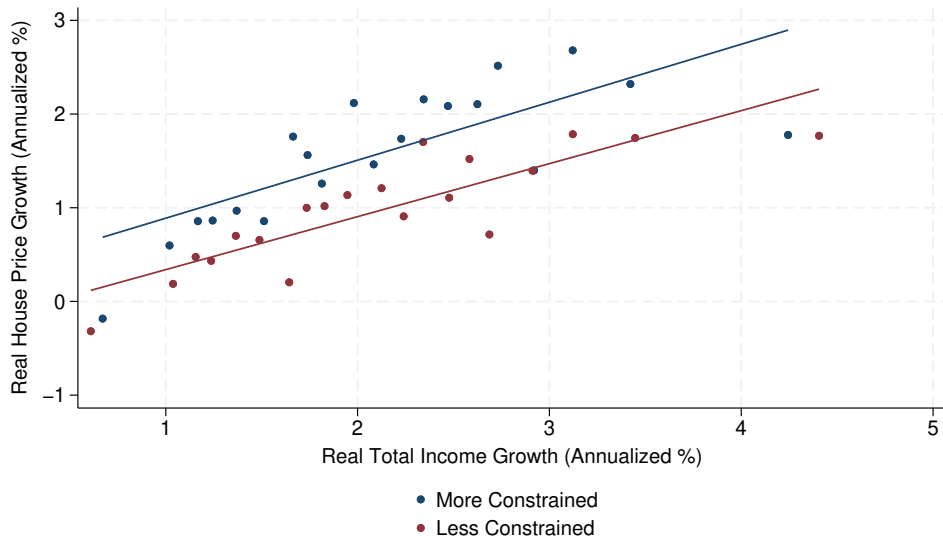
PRICES: BAUM-SNOW AND HAN (2024)



PRICES: GYOURKO, SAIZ, AND SUMMERS (2008)



PRICES: DAVIS, LARSON, OLINER, AND SHUI (2021)



HOUSE PRICE GROWTH (2000-2020)

	(1) Saiz	(2) BS-H	(3) WRLURI	(4) Building
<i>Real House Price Growth (Annualized %)</i>				
Less Constrained $\times$ Income Growth	-0.004 (0.120)	0.052 (0.111)	-0.097 (0.119)	-0.053 (0.113)
Income Growth	0.553*** (0.098)	0.589*** (0.078)	0.607*** (0.094)	0.619*** (0.089)
Less Constrained	-0.868*** (0.262)	-0.438* (0.237)	-0.504* (0.262)	-0.496** (0.246)
R2	0.48	0.34	0.42	0.37
Number of Observations	268	308	268	306

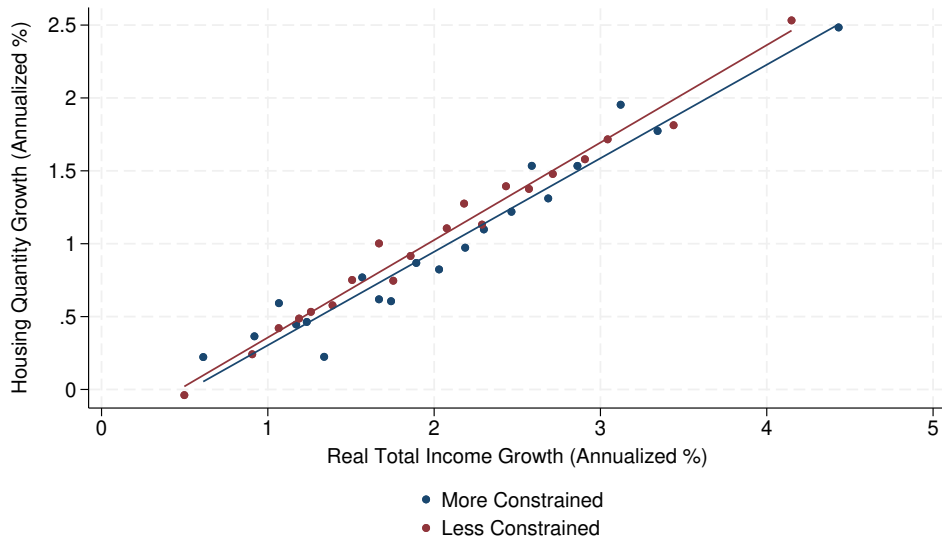
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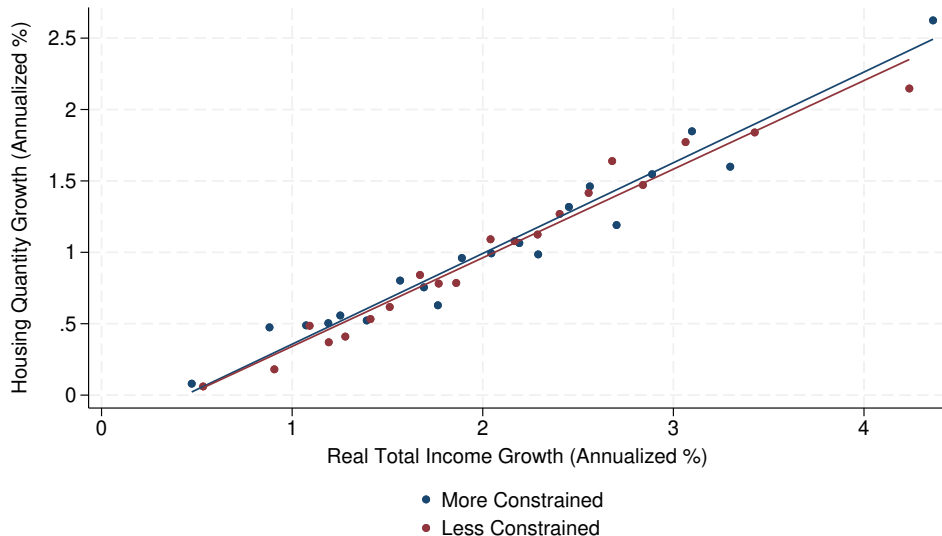
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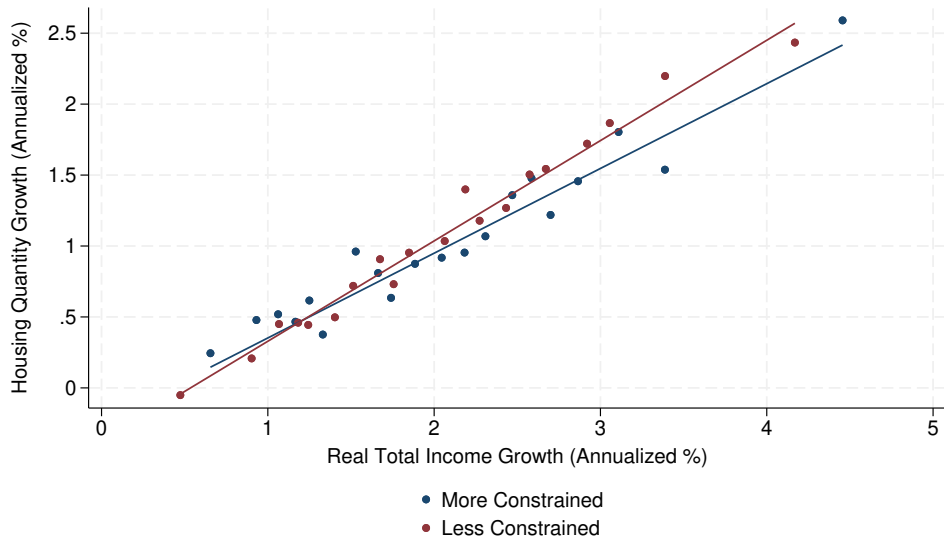
QUANTITIES: SAIZ (2010)



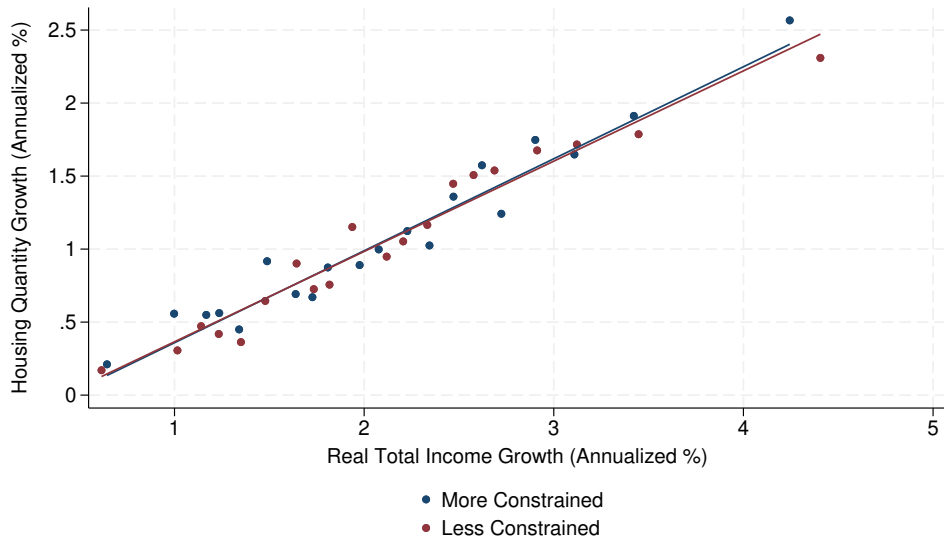
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HOUSE QUANTITY GROWTH (2000-2020)

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<i>Housing Quantities Growth (Annualized %)</i>				
Less Constrained $\times$ Income Growth	0.027 (0.046)	-0.015 (0.048)	0.110** (0.049)	-0.012 (0.050)
Income Growth	0.642*** (0.033)	0.635*** (0.030)	0.597*** (0.034)	0.630*** (0.032)
Less Constrained	0.026 (0.089)	-0.001 (0.090)	-0.133 (0.093)	0.018 (0.095)
R2	0.79	0.77	0.80	0.76
Number of Observations	269	310	269	308

CHANGE IN ROOMS PER PERSON (2000-2020)

	(1) Saiz	(2) BS-H	(3) WRLURI	(4) Building
<i>Change in Average Rooms per Person</i>				
Less Constrained $\times$ Income Growth	0.017 (0.018)	0.003 (0.018)	0.004 (0.018)	-0.013 (0.019)
Income Growth	-0.055*** (0.012)	-0.043*** (0.013)	-0.046*** (0.012)	-0.031** (0.014)
Less Constrained	0.020 (0.040)	0.072* (0.039)	0.070* (0.039)	0.090** (0.041)
R2	0.11	0.11	0.13	0.08
Number of Observations	267	309	267	307

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- What if we use exogenous shocks to housing demand?

PLAUSIBLY EXOGENOUS SHIFTS IN DEMAND

- Our analysis identifies differences in supply elasticities even if changes in total income are endogenous, unless supply shocks are more correlated with labor demand shocks in inelastic cities.
- Restricting ourselves to plausibly exogenous shifts in housing demand addresses this concern.
- Include two distinct exercises:
 - ▶ Pandemic-driven WFH shock (Mondragon and Wieland, 2025), look at housing outcomes from 2019-2024 WFH
 - ▶ Standard instruments for housing demand from the literature (Diamond 2016; Chodorow-Reich, Guren, and McQuade 2024): Bartik, average July humidity, January temperature.

SUPPLY ELASTICITIES - TOTAL INCOME

	(1) Saiz	(2) BS-H	(3) WRLURI	(4) Building
<i>Real House Price Growth (Annualized %)</i>				
More Constrained $\times$ Price Growth	1.161*** (0.216)	1.078*** (0.168)	0.984*** (0.183)	1.018*** (0.170)
Less Constrained $\times$ Price Growth	1.216*** (0.175)	0.965*** (0.133)	1.383*** (0.201)	1.088*** (0.159)
Less Constrained	1.058*** (0.405)	0.447 (0.280)	0.443 (0.356)	0.547* (0.313)
Chi-Squared Test P-value	0.84	0.60	0.14	0.76
F-stat More Constrained	31.63	56.74	41.70	48.41
F-stat Less Constrained	64.92	66.03	48.12	65.23
Number of Observations	268	308	268	306

SUPPLY ELASTICITIES: STANDARD INSTRUMENTS

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<i>Real House Price Growth (Annualized %)</i>				
More Constrained $\times$ Price Growth	0.694*** (0.132)	0.636*** (0.120)	0.479*** (0.098)	0.526*** (0.097)
Less Constrained $\times$ Price Growth	0.513*** (0.126)	0.309*** (0.107)	0.811*** (0.190)	0.452*** (0.107)
Less Constrained	0.741*** (0.242)	0.491** (0.197)	0.044 (0.219)	0.349* (0.179)
Chi-Squared Test P-value	0.32	0.04	0.12	0.60
F-stat More Constrained	15.66	18.58	21.09	17.53
F-stat Less Constrained	17.22	13.29	8.20	19.21
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SO WHAT CAN EXPLAIN THE DATA?

What does housing consumption actually look like?

- A shelter/unit (quantity or u) . . .
- With specific materials, size, location, etc (quality or q).

Both of these margins will be demanded, supplied and **priced**:

$$\hat{u}_i^S = \psi_u \hat{P}_{u,i},$$

$$\hat{q}_i^S = \psi_q \hat{P}_{q,i},$$

$$\hat{P}_i = \hat{P}_{q,i} + \hat{P}_{u,i}.$$

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What does housing consumption actually look like?

- A shelter/unit (quantity or u) . . .
- With specific materials, size, location, etc (quality or q).

Both of these margins will be demanded, supplied and **priced**:

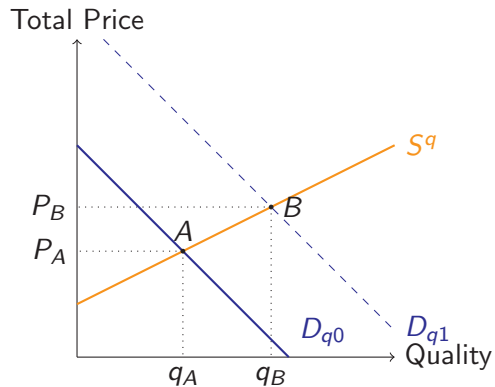
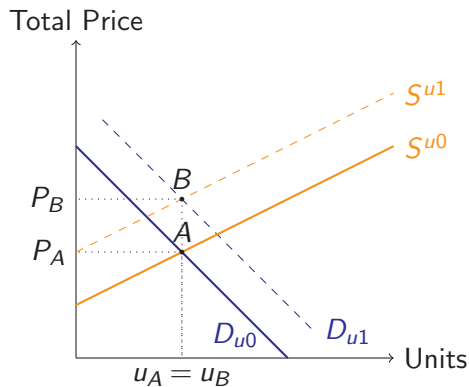
$$\hat{u}_i^S = \psi_u \hat{P}_{u,i},$$

$$\hat{q}_i^S = \psi_q \hat{P}_{q,i},$$

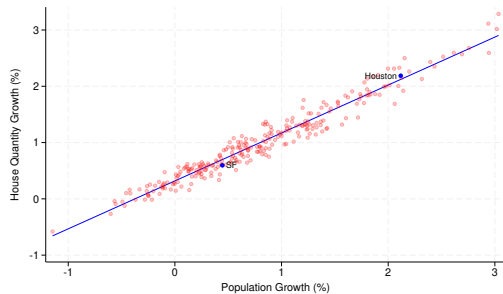
$$\hat{P}_i = \hat{P}_{q,i} + \hat{P}_{u,i}.$$

Why does this matter?

- Changes in quality (or quality valuation) will affect prices but not quantities!
- Quantities will reflect population growth and household formation.
- Recovering supply elasticities (Saiz 2010, Chodorow-Reich, Guren, McQuade 2024, etc) is much more difficult than typically thought.



Supply and demand shift up in the units market!
 (This is just hedonic equilibria ala Rosen 1974)

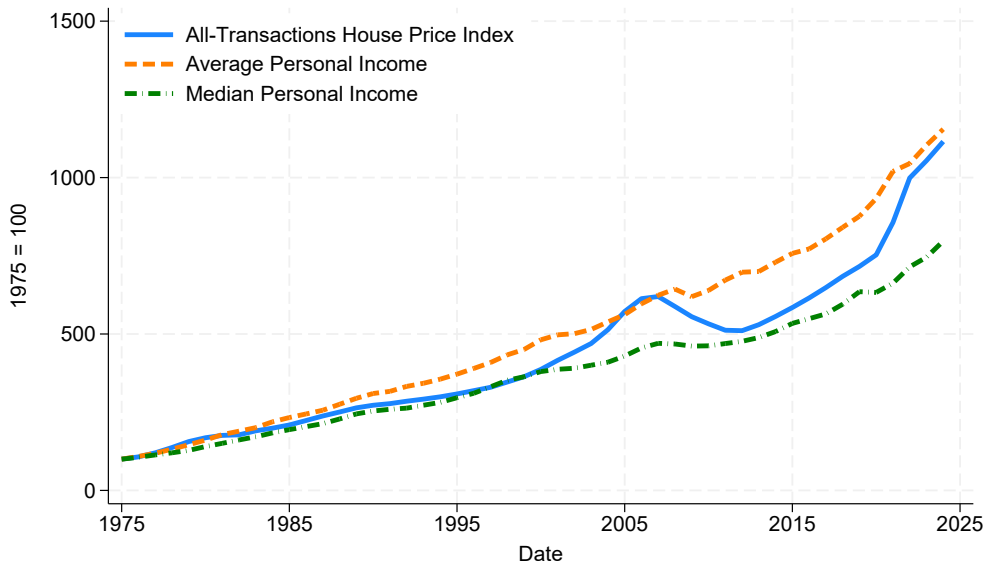


Houston and San Francisco are about where we expect them to be!

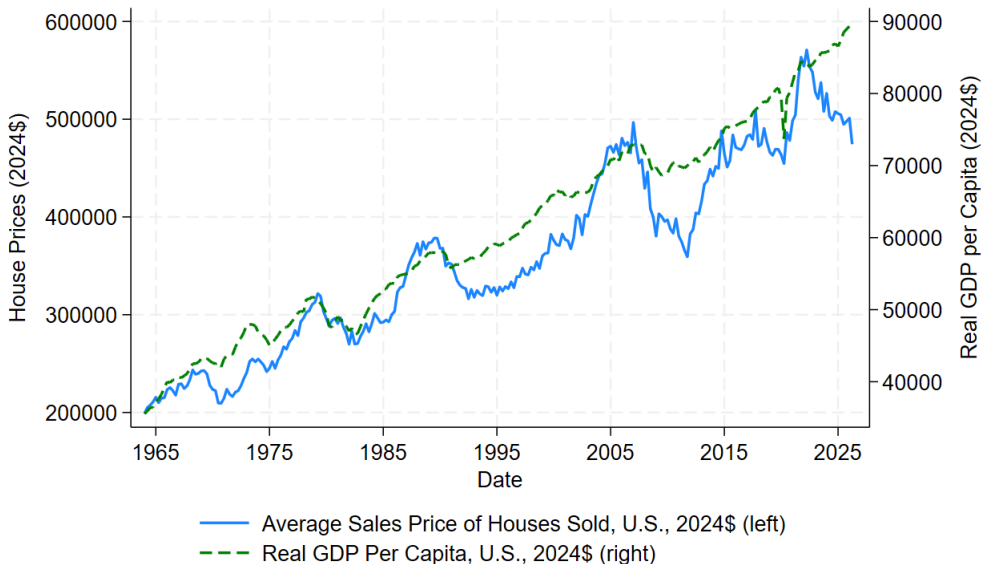
OUTLINE

- 1 INTRODUCTION
- 2 FRAMEWORK
- 3 EMPIRICAL RESULTS
- 4 WHAT CAN EXPLAIN HOUSE PRICES AND QUANTITIES?
- 5 CONCLUSION**
- 6 APPENDIX

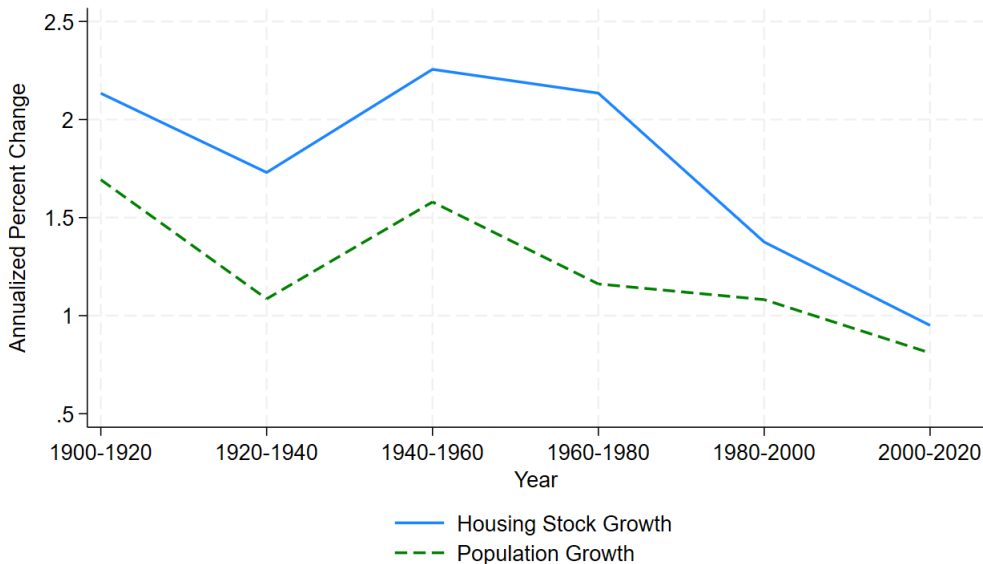
HOUSING AFFORDABILITY CRISIS?



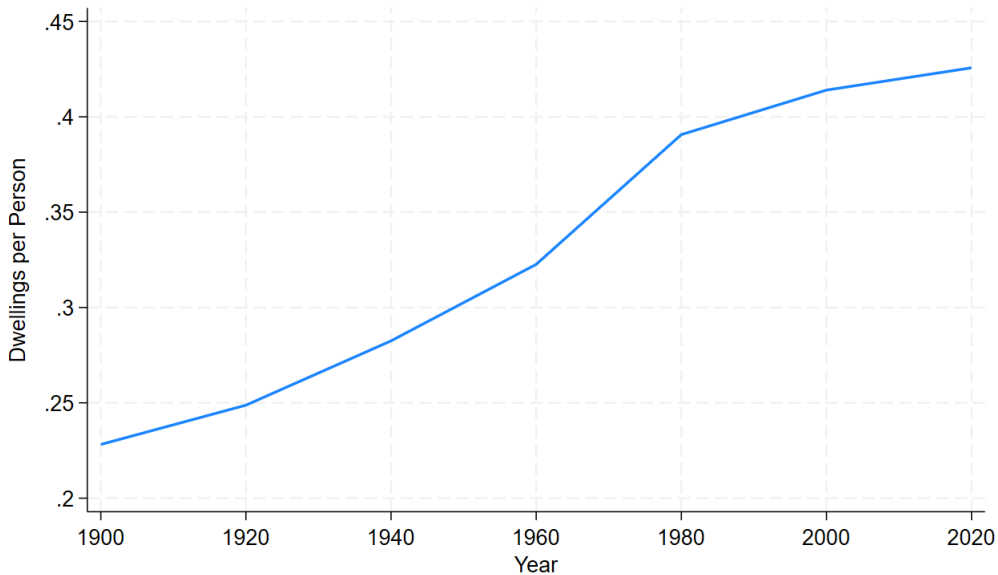
US HOUSE PRICES AND GDP PER CAPITA



US POPULATION AND HOUSING UNITS



US DWELLINGS PER CAPITA



CONCLUSION

- Supply constraints do not explain differences in the growth of house prices and house quantities relative to income growth.
- This is deeply inconsistent with the standard view.
- Suggests that efforts to relax supply constraints are unlikely to have material effects on house prices or quantities (consistent with other evidence).
- But our results bring up more questions:
 - ▶ Is the single-margin framework the right way to think about the housing market? Probably not see Louie Mondragon Najjar Wieland, 2026a.
 - ▶ Is this just about the US? Preliminary work suggests no (Louie Mondragon Najjar Wieland, 2026b).
 - ▶ Maybe what we're seeing are differences in labor supply and the growth process?
- Maybe housing markets are working as we should expect them to work?

Thanks!

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VARIANCE OF SUPPLY SHOCKS

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- If (ceteris paribus) supply shocks are more important in inelastic cities, then supply shocks will be more negatively correlated with per capita income growth (housing supply shocks are labor supply shocks)

MODEL

- Total income in a city is per capita income times the population: $Y_i = y_i N_i$
- Change in housing demand (extensive and intensive) is a function of total income, the price of housing, and demand shifters θ_i :

$$\hat{H}_i^D = \varepsilon_y \hat{Y}_i - \varepsilon_p \hat{P}_i + \hat{\theta}_i$$

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- Prices:

$$\hat{P}_i = \frac{1}{\psi_i + \varepsilon_p} \left(\varepsilon_y \hat{Y}_i + \hat{\theta}_i \right).$$

- Quantities:

$$\hat{H}_i = \frac{1}{1 + \frac{\varepsilon_p}{\psi_i}} \left(\varepsilon_y \hat{Y}_i + \hat{\theta}_i \right).$$

EMPIRICAL IMPLICATIONS FOR PRICES

- We observe total income Y , housing units H , and prices P
- Two kinds of cities: high ψ_H and low ψ_L denoted by j
- What happens if we run a regression of house price growth on income growth:

$$\hat{P}_i = \alpha_j + \beta_j \hat{Y}_i + e_i$$

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$$\beta_j = \frac{\varepsilon_y}{\psi_j + \varepsilon_p} + \frac{1}{\psi_j + \varepsilon_p} \frac{\text{Cov}(\hat{\theta}_i, \hat{Y}_i | i \in \Omega^j)}{\text{Var}(\hat{Y}_i | i \in \Omega^j)}, \quad j \in \{H, L\}.$$

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- Demand shocks **differentially** correlated with income could make elastic places **appear** inelastic (high prices for the same observed change in income)

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- What about if we regress quantity growth on total income growth?

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$$\gamma_j = \frac{\varepsilon_y}{1 + \frac{\varepsilon_p}{\psi_j}} + \frac{1}{1 + \frac{\varepsilon_p}{\psi_j}} \frac{\text{Cov}(\hat{\theta}_i, \hat{Y}_i | i \in \Omega^j)}{\text{Var}(\hat{Y}_i | i \in \Omega^j)}, \quad j \in \{H, L\}.$$

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- Demand shocks **differentially** correlated with income will **amplify** the quantity effect, making elastic places appear even **more elastic** (larger change in quantities for the same observed change in income)

SPATIAL MODEL

$$U_i = (1 - \alpha) \log(c_i) + \alpha \log(h_i).$$

Given a wage w_i and a city-specific cost of housing p_i , the budget constraint is $c_i + p_i h_i = w_i$. This implies that the per capita demand for housing is simply

$$h_i^D = \frac{\alpha w_i}{p_i}.$$

Let total population in city i be L_i . Then aggregate housing demand in that city is equal to

$$H_i^D = h_i^D L_i = \frac{\alpha w_i L_i}{p_i} = \frac{\alpha Y_i}{p_i}$$

where Y_i is total income in city i .

The linearized housing demand function for location i is therefore,

$$\hat{H}_i = \underbrace{1}_{=\varepsilon_y} \times \hat{Y}_i - \underbrace{1}_{=\varepsilon_p} \times \hat{p}_i$$

LABOR MARKET AND HOUSING SUPPLY

The total supply of housing is given by the following supply function with city-specific elasticity ψ_i

$$H_i^S = p_i^{\psi_i}.$$

Workers provide one unit of labor, have an outside option that determines elasticity of labor supply

$$L_i^S = \left(\frac{w_i}{p_i^\alpha} \right)^\eta.$$

Output (apart from housing) has the following production function with productivity shocks Z_i

$$Y_i = Z_i L_i^\gamma$$

So the total number of workers or population demanded is given as

$$w_i = Z_i \gamma (L_i^D)^{\gamma-1}.$$

LINEARIZED EQUILIBRIUM

Solving for equilibrium in labor and housing markets and then re-arranging for prices and quantities in terms of total income and per capita income (average wages) gives:

$$\hat{p}_i = \frac{1 + \eta}{1 + \alpha\eta + \psi_i} \hat{w}_i,$$

$$\hat{p}_i = \frac{1}{1 + \psi_i} \hat{Y}_i,$$

$$\hat{H}_i = \psi_i \frac{1 + \eta}{1 + \alpha\eta + \psi_i} \hat{w}_i,$$

$$\hat{H}_i = \psi_i \frac{1}{1 + \psi_i} \hat{Y}_i.$$

Total income growth is entirely appropriate. Unobserved demand and supply shocks will affect these equations in the way we discuss. [Back](#)

HOUSE PRICE GROWTH (2000-2020)

	(1) Saiz	(2) BS-H	(3) WRLURI	(4) Building
<i>Real House Price Growth (Annualized %)</i>				
Less Constrained $\times$ Per Capita Income Growth	0.158 (0.253)	-0.162 (0.248)	-0.218 (0.268)	-0.222 (0.232)
Per Capita Income Growth	0.984*** (0.178)	1.284*** (0.187)	1.139*** (0.163)	1.252*** (0.170)
Less Constrained	-1.120*** (0.335)	-0.263 (0.328)	-0.492 (0.354)	-0.381 (0.312)
R2	0.41	0.27	0.34	0.32
Number of Observations	268	308	268	306

HOUSE PRICE GROWTH (2000-2020)

	(1) Saiz	(2) BS-H	(3) WRLURI	(4) Building
<i>Real House Price Growth (Annualized %)</i>				
Less Constrained $\times$ Population Growth	0.061 (0.130)	0.117 (0.131)	-0.001 (0.137)	0.067 (0.139)
Population Growth	0.460*** (0.102)	0.498*** (0.090)	0.494*** (0.107)	0.483*** (0.110)
Less Constrained	-0.992*** (0.158)	-0.401** (0.158)	-0.788*** (0.168)	-0.677*** (0.166)
R2	0.38	0.20	0.32	0.24
Number of Observations	268	308	268	306

MEDIAN HOME VALUE GROWTH (2000-2020)

	(1) Saiz	(2) BS-H	(3) WRLURI	(4) Building
<i>Real Median House Value Growth (Annualized %)</i>				
Less Constrained $\times$ Income Growth	0.047 (0.120)	-0.089 (0.119)	-0.101 (0.121)	0.068 (0.124)
Income Growth	0.577*** (0.104)	0.715*** (0.094)	0.663*** (0.099)	0.603*** (0.099)
Less Constrained	-0.674*** (0.254)	-0.112 (0.244)	-0.205 (0.258)	-0.500* (0.262)
R2	0.47	0.41	0.43	0.38
Number of Observations	267	309	267	307

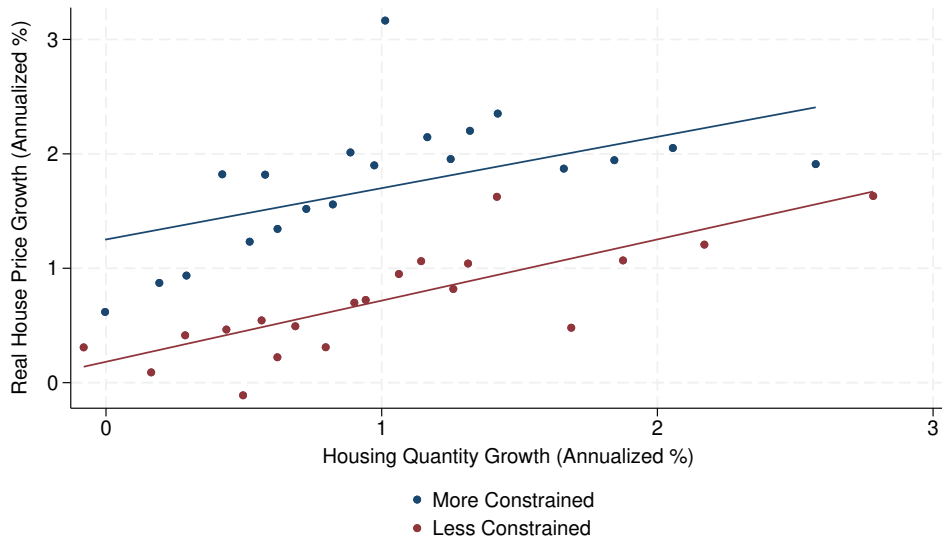
HOUSE PRICE GROWTH (2000-2020)

	(1) Saiz	(2) BS-H	(3) WRLURI	(4) Building
<i>Real House Price Growth (Annualized %)</i>				
Qtl 2 Constraint	-0.468 (0.439)	-0.544 (0.336)	-0.690* (0.372)	-0.552 (0.392)
Qtl 3 Constraint	-1.093*** (0.366)	-0.864** (0.339)	-1.019*** (0.352)	-0.840** (0.393)
Qtl 4 Constraint	-1.185*** (0.399)	-0.566 (0.388)	-0.767** (0.364)	-0.634* (0.358)
Qtl 2 Constraint $\times$ Income Growth	0.008 (0.195)	0.029 (0.159)	0.085 (0.165)	-0.015 (0.184)
Qtl 3 Constraint $\times$ Income Growth	0.078 (0.159)	0.161 (0.165)	0.096 (0.165)	-0.016 (0.178)
Qtl 4 Constraint $\times$ Income Growth	-0.058 (0.174)	-0.020 (0.175)	-0.191 (0.164)	-0.152 (0.171)
Income Growth	0.516*** (0.135)	0.572*** (0.130)	0.532*** (0.127)	0.633*** (0.140)
R2	0.52	0.37	0.47	0.41
Number of Observations	268	308	268	306

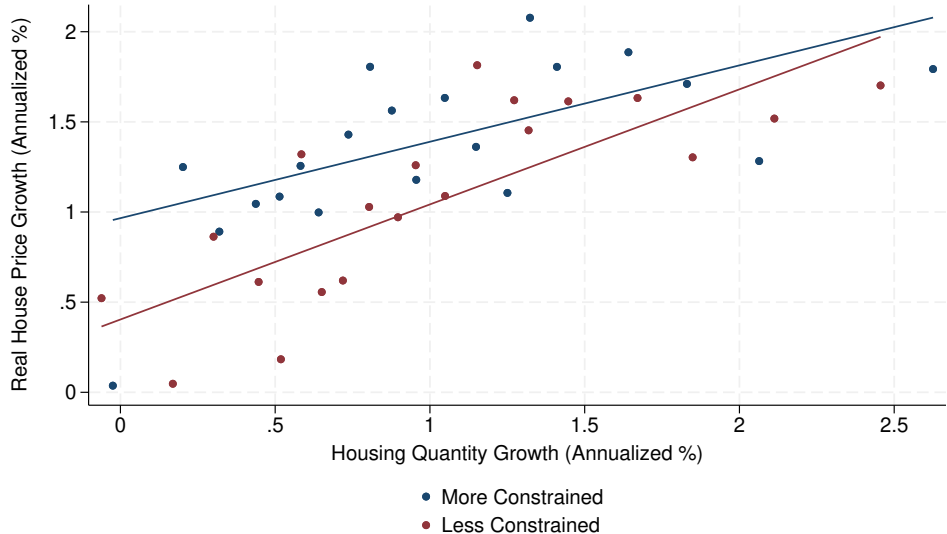
HOUSE PRICE GROWTH W/OUT LOW GROWTH CITIES (2000-2020)

	(1) Saiz	(2) BS-H	(3) WRLURI	(4) Building
<i>Real House Price Growth (Annualized %)</i>				
Less Constrained $\times$ Income Growth	0.375*** (0.119)	0.202 (0.136)	0.148 (0.140)	0.158 (0.131)
Income Growth	0.156** (0.079)	0.354*** (0.089)	0.328*** (0.098)	0.333*** (0.101)
Less Constrained	-1.944*** (0.297)	-0.853** (0.343)	-1.185*** (0.360)	-1.089*** (0.333)
R2	0.45	0.18	0.32	0.26
Number of Observations	197	231	197	239

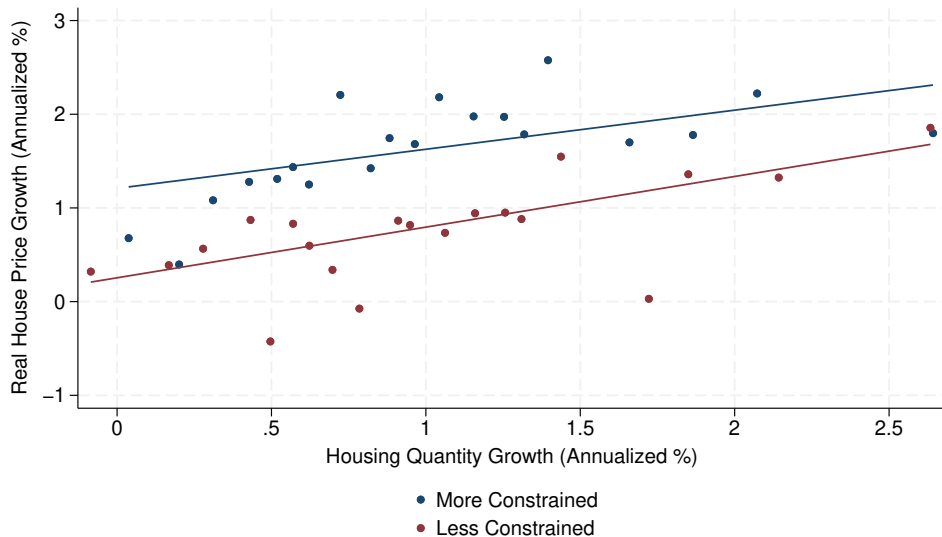
ELASTICITY: SAIZ (2010)



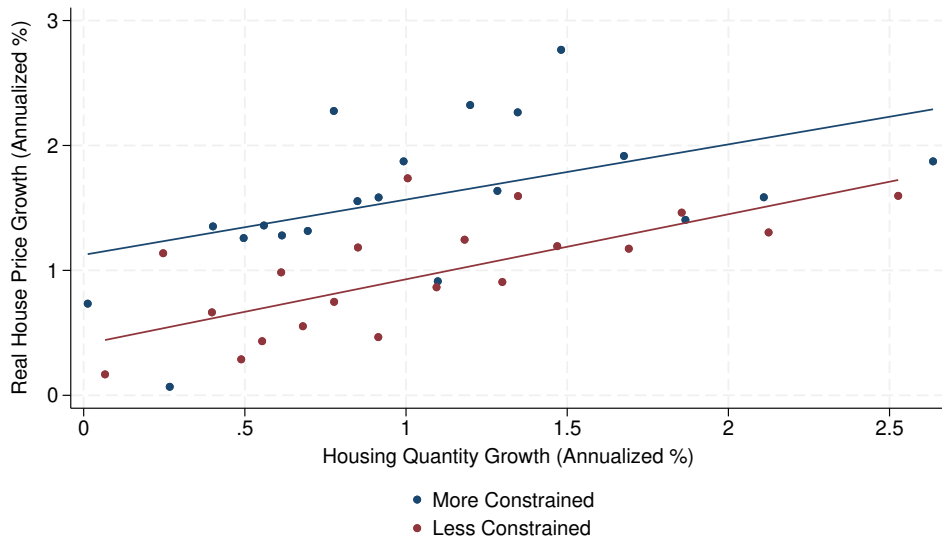
ELASTICITY: BAUM-SNOW AND HAN (2024)



ELASTICITY: GYOURKO, SAIZ, AND SUMMERS (2008)



ELASTICITY: DAVIS, LARSON, OLINER AND SHUI (2021)



HOUSE QUANTITY GROWTH (2000-2020)

	(1) Saiz	(2) BS-H	(3) WRLURI	(4) Building
<i>Housing Quantities Growth (Annualized %)</i>				
Less Constrained $\times$ Per Capita Income Growth	0.308 (0.226)	-0.030 (0.193)	0.189 (0.232)	0.110 (0.187)
Per Capita Income Growth	0.093 (0.183)	0.309** (0.148)	0.140 (0.152)	0.212 (0.137)
Less Constrained	-0.459 (0.283)	-0.084 (0.244)	-0.333 (0.285)	-0.207 (0.240)
R2	0.03	0.04	0.03	0.03
Number of Observations	269	310	269	308

HOUSE QUANTITY GROWTH (2000-2020)

	(1) Saiz	(2) BS-H	(3) WRLURI	(4) Building
<i>Housing Quantities Growth (Annualized %)</i>				
Less Constrained $\times$ Population Growth	0.033 (0.025)	-0.019 (0.024)	0.031 (0.027)	-0.008 (0.025)
Population Growth	0.840*** (0.017)	0.876*** (0.019)	0.838*** (0.021)	0.867*** (0.020)
Less Constrained	0.025 (0.023)	0.057*** (0.022)	0.022 (0.024)	0.018 (0.024)
R2	0.95	0.95	0.95	0.94
Number of Observations	269	310	269	308

POPULATION GROWTH (2000-2020)

	(1) Saiz	(2) BS-H	(3) WRLURI	(4) Building
<i>Population Growth (Annualized %)</i>				
Less Constrained $\times$ Income Growth	0.002 (0.052)	0.001 (0.051)	0.091* (0.053)	0.005 (0.054)
Income Growth	0.755*** (0.041)	0.717*** (0.034)	0.709*** (0.037)	0.710*** (0.038)
Less Constrained	0.027 (0.104)	-0.088 (0.098)	-0.137 (0.104)	-0.032 (0.104)
R2	0.81	0.80	0.82	0.78
Number of Observations	269	310	269	308

HOUSE QUANTITY GROWTH (2000-2020)

	(1) Saiz	(2) BS-H	(3) WRLURI	(4) Building
<i>Housing Quantities Growth (Annualized %)</i>				
Qtl 2 Constraint	-0.031 (0.140)	-0.025 (0.116)	-0.053 (0.156)	-0.138 (0.120)
Qtl 3 Constraint	-0.008 (0.130)	0.035 (0.141)	-0.188 (0.168)	0.074 (0.111)
Qtl 4 Constraint	0.067 (0.108)	-0.068 (0.107)	-0.193 (0.152)	-0.111 (0.152)
Qtl 2 Constraint $\times$ Income Growth	0.050 (0.070)	0.034 (0.060)	0.073 (0.075)	0.168*** (0.058)
Qtl 3 Constraint $\times$ Income Growth	0.067 (0.065)	0.002 (0.076)	0.160* (0.087)	0.033 (0.054)
Qtl 4 Constraint $\times$ Income Growth	0.014 (0.052)	0.006 (0.056)	0.156** (0.075)	0.088 (0.089)
Income Growth	0.624*** (0.038)	0.617*** (0.038)	0.549*** (0.066)	0.552*** (0.038)
R2	0.80	0.78	0.80	0.79
Number of Observations	269	310	269	308

HOUSE QUANTITY W/OUT LOW GROWTH CITIES (2000-2020)

	(1) Saiz	(2) BS-H	(3) WRLURI	(4) Building
<i>Housing Quantities Growth (Annualized %)</i>				
Less Constrained $\times$ Income Growth	-0.050 (0.070)	-0.090 (0.072)	0.067 (0.071)	-0.096 (0.071)
Income Growth	0.698*** (0.050)	0.680*** (0.041)	0.635*** (0.045)	0.688*** (0.046)
Less Constrained	0.242 (0.156)	0.212 (0.162)	-0.012 (0.161)	0.259 (0.158)
R2	0.71	0.68	0.72	0.69
Number of Observations	197	231	197	239

HOUSE PRICE GROWTH (2000-2020)

	(1) Saiz	(2) BS-H	(3) WRLURI	(4) Building
<i>Real House Price Growth (Annualized %)</i>				
Elasticity Measure	-0.278*** (0.070)	-1.660*** (0.298)	-0.479*** (0.061)	-3.936*** (0.443)
Income Growth	0.532*** (0.056)	0.611*** (0.055)	0.542*** (0.054)	0.594*** (0.055)
Share of SF-Houston Gap	0.0754	0.0148	0.0883	0.1808
R2	0.45	0.37	0.44	0.43
Number of Observations	268	308	268	306

HOUSE PRICE GROWTH (2012-2020)

	(1) Saiz	(2) BS-H	(3) WRLURI	(4) Building
<i>Real House Price Growth (Annualized %)</i>				
Elasticity Measure	-0.170** (0.066)	-1.751*** (0.474)	-0.300*** (0.115)	-1.826** (0.748)
Income Growth	1.112*** (0.083)	1.161*** (0.071)	1.122*** (0.084)	1.153*** (0.076)
Share of SF-Houston Gap	0.0112	0.0037	0.0135	0.0216
R2	0.58	0.59	0.58	0.57
Number of Observations	268	308	268	306

HOUSE QUANTITY GROWTH (2000-2020)

	(1) Saiz	(2) BS-H	(3) WRLURI	(4) Building
<i>Housing Quantity Growth (Annualized %)</i>				
Elasticity Measure	0.023 (0.014)	-0.015 (0.124)	0.057*** (0.021)	0.481*** (0.181)
Income Growth	0.656*** (0.024)	0.628*** (0.025)	0.658*** (0.024)	0.627*** (0.026)
Share of SF-Houston Gap	0.0002	-0.0000	0.0003	0.0007
R2	0.79	0.77	0.79	0.77
Number of Observations	269	310	269	308

HOUSE PRICE GROWTH (1980-2000)

	(1) Saiz	(2) BS-H	(3) WRLURI	(4) Building
<i>Real House Price Growth (Annualized %)</i>				
Less Constrained $\times$ Income Growth	-0.092 (0.120)	0.071 (0.112)	-0.076 (0.116)	-0.133 (0.117)
Income Growth	0.058 (0.092)	0.078 (0.093)	0.056 (0.093)	0.148* (0.090)
Less Constrained	-0.229 (0.400)	-0.538 (0.359)	-0.346 (0.381)	-0.108 (0.383)
R2	0.04	0.04	0.05	0.06
Number of Observations	268	308	268	306

HOUSE PRICE GROWTH (1980-2020)

	(1) Saiz	(2) BS-H	(3) WRLURI	(4) Building
<i>Real House Price Growth (Annualized %)</i>				
Less Constrained $\times$ Income Growth	-0.083 (0.093)	0.121 (0.088)	-0.035 (0.092)	-0.091 (0.093)
Income Growth	0.222*** (0.073)	0.212*** (0.066)	0.211*** (0.072)	0.266*** (0.073)
Less Constrained	-0.465* (0.258)	-0.597** (0.234)	-0.548** (0.249)	-0.292 (0.256)
R2	0.23	0.14	0.21	0.17
Number of Observations	268	308	268	306

MEDIAN HOME VALUE GROWTH (1980-2020)

	(1) Saiz	(2) BS-H	(3) WRLURI	(4) Building
<i>Real Median House Value Growth (Annualized %)</i>				
Less Constrained $\times$ Income Growth	0.084 (0.072)	0.110 (0.074)	0.077 (0.076)	-0.011 (0.075)
Income Growth	0.265*** (0.062)	0.292*** (0.060)	0.271*** (0.063)	0.307*** (0.062)
Less Constrained	-0.673*** (0.196)	-0.517*** (0.190)	-0.579*** (0.199)	-0.385* (0.205)
R2	0.41	0.33	0.38	0.35
Number of Observations	267	309	267	307

HOUSE QUANTITY GROWTH (1980-2020)

	(1) Saiz	(2) BS-H	(3) WRLURI	(4) Building
<i>Housing Quantities Growth (Annualized %)</i>				
Less Constrained $\times$ Income Growth	-0.002 (0.035)	0.017 (0.037)	0.025 (0.039)	0.050 (0.039)
Income Growth	0.732*** (0.031)	0.714*** (0.030)	0.716*** (0.029)	0.707*** (0.025)
Less Constrained	0.148* (0.083)	0.091 (0.085)	0.078 (0.088)	0.010 (0.092)
R2	0.88	0.87	0.88	0.86
Number of Observations	268	309	268	307

WEIRD (SIMPLE) MODEL

Start with a stripped down model to get the intuition

- There are no differences in income across cities, every person consumes a single unit of housing (no intensive/quality margin, no changes in household formation)
- Total income in a city is given by the per capita income and the population: $Y_i = yN_i$

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- Housing supply is a function of the elasticity: $\hat{H}_i^S = \psi_i \hat{P}_i$
- Housing market equilibrium: $\hat{H}_i = \hat{H}_i^S = \hat{H}_i^D = \hat{N}_i$
- Market moved around by “exogenous” shifts in population growth

EMPIRICAL IMPLICATIONS FOR PRICES

Let's think about running regressions if this model is true

- We observe population N , housing units H , and prices P
- Two kinds of cities: high ψ_H and low ψ_L elasticity denoted by j
- What if we regress house price growth on population growth?

$$\hat{P}_i = \alpha_j + \beta_j \hat{N}_i + e_i$$

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- Looking at price will be sufficient for figuring out how supply elasticities matter since quantity (population) is exogenous.

INTERCEPT DECOMPOSITION

We can use our demand-supply model to back out our supply shocks as a functions of empirical estimates and average supply elasticities:

$$E[\hat{\sigma}_{iYH}] = \underbrace{\gamma_2 + \delta}_{\text{actual quantity growth}} - \underbrace{\psi_H(\beta_2 + \alpha)}_{\text{quantity growth implied by price growth}},$$
$$E[\hat{\sigma}_{iYL}] = \delta - \psi_L \alpha.$$

where

$$\hat{P}_i = \alpha + \beta_1 \hat{Y}_i + \beta_2 \mathbb{I}_i(\text{Less Constrained}) + \beta_3 \hat{Y}_i \times \mathbb{I}_i(\text{Less Constrained}) + e_i,$$
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- Average housing quantity growth in aggregate (and in both groups) is about 1%!

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- Alternative: some places experience larger increases in the demand for housing **quality**

MODEL WITH QUALITY

- We assumed the growth in income and growth in population have the same average effect on the intensive and extensive margins of housing demand
- This is likely too strong:
 - ▶ Population growth likely has a larger effect on the demand for units
 - ▶ Income growth likely has a larger effect on the demand for quality
- Differences in the composition of growth can lead to very different implications for housing quantities and prices, **especially if we do not perfectly measure changes in housing quality**

- Assume that total housing H has a quality component q and a units component u so that $H_i = q_i u_i$

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- We expand the demand side into demand for quality and quantity of housing, which depend on income and population growth differently

$$\hat{q}_i + \hat{u}_i = \varepsilon_y \hat{y}_i + \varepsilon_N \hat{N}_i - \varepsilon_P \hat{P}_i + \theta_i,$$

$$\hat{q}_i = \varepsilon_y \hat{y}_i - \varepsilon_{P_q} \hat{P}_{q,i} + \theta_{q,i},$$

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- Supply side has a parallel structure

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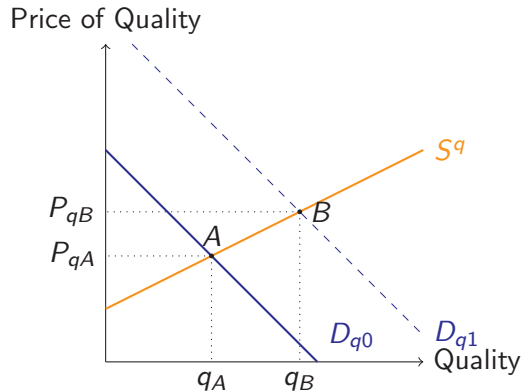
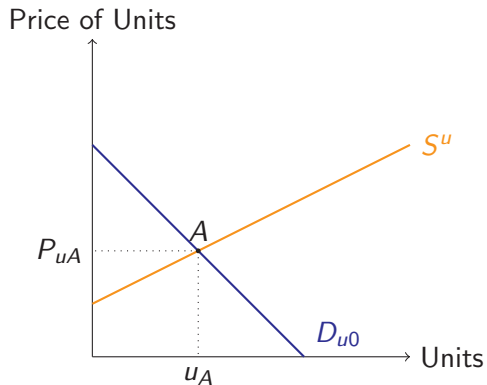
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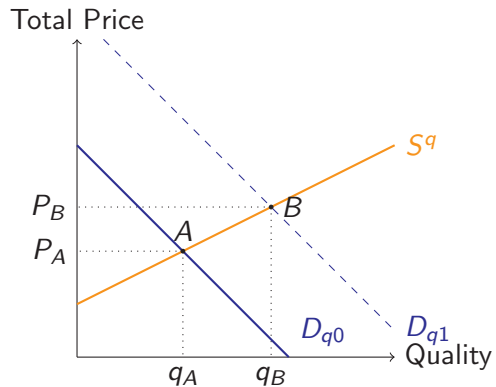
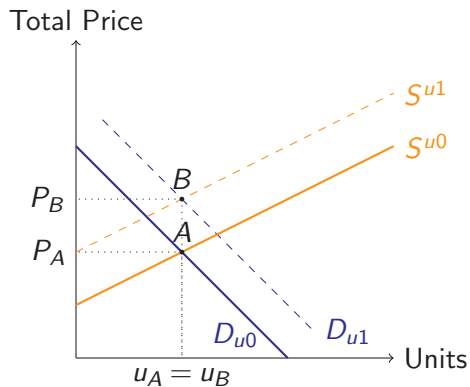
$$\hat{u}_i = \psi_{u,i} \hat{P}_{u,i} + \sigma_{u,i}.$$

- What happens if there is an increase in income ($\hat{y}$), holding population growth constant?

PERFECT MEASUREMENT OF QUALITY



Prices increase, but not when held at constant quality



Supply and demand shift up in the units market!
 (This is just hedonic equilibria ala Rosen 1974)

DISCUSSION

- Imperfect adjustments for changes in housing quality will look like upward shifts in the supply and demand schedules for housing units
- Is it plausible that increases in income are causing changes in housing quality? Here is what Corelogic does to try and keep housing quality constant:

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 - ③ They drop outliers.
- These criteria are almost certainly inadequate for holding quality constant (McMillen and Thorsnes, 2006)
- This also does not grapple with changes in the composition and valuation of amenities that may be correlated with income growth (Bayer et al, 2007; Handbury, 2013; Billings, 2015; Diamond, 2016)

WORK FROM HOME SHOCK

- We argue that our analysis works even if changes in total income are endogenous, but what if we use a plausibly exogenous shift in housing demand?

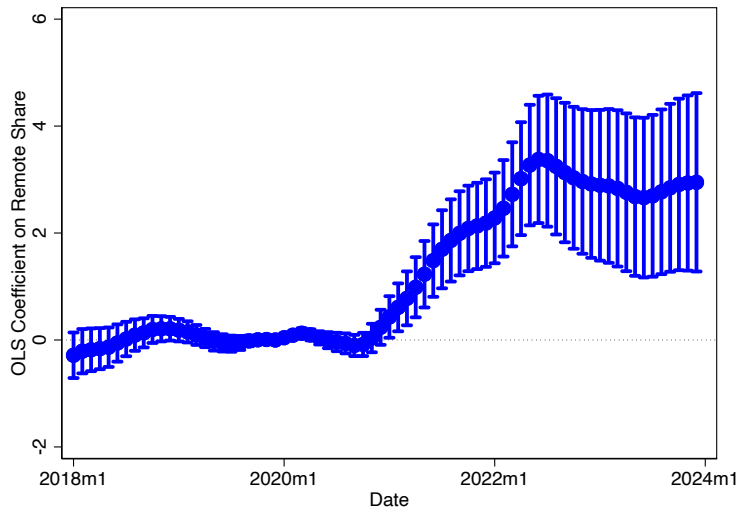
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 - ▶ Workers who shifted to WFH increased their demand for housing
 - ▶ Cities amenable to remote work saw large inflows of remote workers
- Plausibly exogenous
- Does the WFH shock have different effects on house prices and housing quantities (permits) in more- and less-elastic cities

WFH EXPOSURE AND PRICES (MONDRAGON AND WIELAND, 2025)



TOTAL INCOME GROWTH (2019-2023)

	Saiz		BS-H		WRLURI		Building	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
<i>Total Income Growth (Annualized %)</i>								
WFH Shock × Less Constrained		0.082 (0.115)		0.146 (0.098)		0.325*** (0.115)		0.024 (0.104)
WFH Shock	0.437*** (0.056)	0.455*** (0.083)	0.407*** (0.050)	0.366*** (0.078)	0.437*** (0.056)	0.357*** (0.078)	0.381*** (0.048)	0.408*** (0.074)
Less Constrained		-0.017 (0.460)		-0.290 (0.388)		-0.812* (0.443)		0.132 (0.404)
R2	0.25	0.26	0.22	0.24	0.25	0.30	0.20	0.21
Number of Observations	269	269	310	310	269	269	308	308

HOUSE PRICE GROWTH (2019-2023)

	Saiz		BS-H		WRLURI		Building	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
<i>House Price Growth (Annualized %)</i>								
WFH Shock × Less Constrained		0.122 (0.228)		0.110 (0.213)		0.633*** (0.232)		0.203 (0.229)
WFH Shock	0.344*** (0.116)	0.252 (0.161)	0.401*** (0.108)	0.401** (0.162)	0.344*** (0.116)	0.086 (0.162)	0.449*** (0.107)	0.375** (0.157)
Less Constrained		-0.770 (0.917)		0.081 (0.825)		-2.382*** (0.893)		-0.751 (0.902)
R2	0.05	0.05	0.06	0.07	0.05	0.08	0.08	0.08
Number of Observations	268	268	308	308	268	268	306	306

PERMIT GROWTH (2019-2023)

	Saiz		BS-H		WRLURI		Building	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
<i>Cumulative Permit Growth (Annualized %)</i>								
WFH Shock × Less Constrained		0.747 (0.793)		0.886 (0.710)		0.168 (0.708)		1.331 (0.834)
WFH Shock	1.006*** (0.373)	0.951* (0.501)	0.842** (0.368)	0.623 (0.468)	1.006*** (0.373)	1.096* (0.566)	0.841** (0.387)	0.873* (0.522)
Less Constrained		-1.547 (3.069)		-1.447 (2.889)		0.602 (2.964)		-1.715 (3.375)
R2	0.04	0.05	0.02	0.04	0.04	0.04	0.02	0.06
Number of Observations	269	269	310	310	269	269	308	308