Supply Constraints Do Not Explain House Price and Quantity Growth Across U.S. Cities

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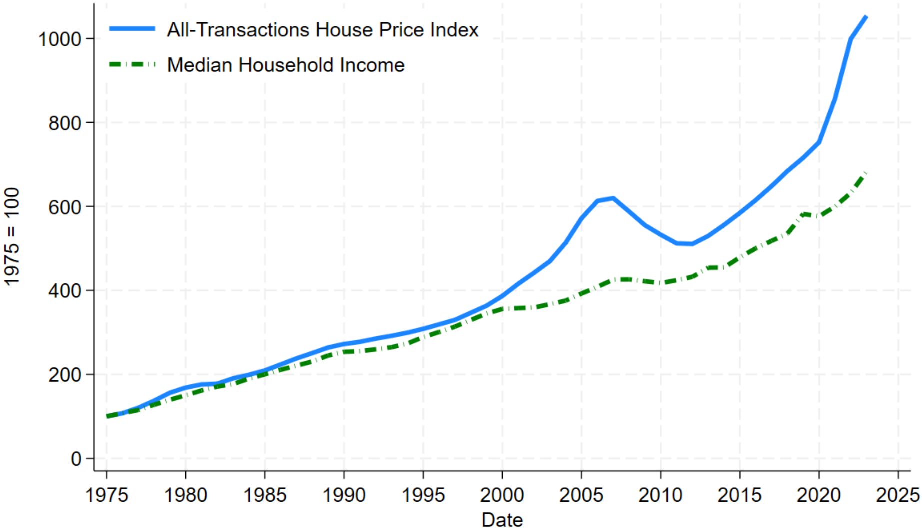
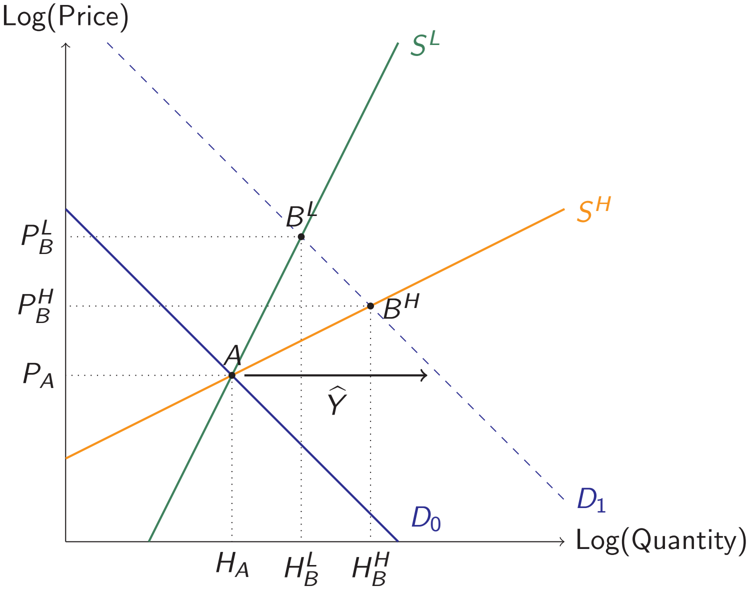
HOUSING AFFORDABILITY CRISIS



Standard View



This Paper

- The standard view:
  - Housing supply elasticities across cities vary due to geographic and regulatory constraints:

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

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

$\Rightarrow$ To improve housing affordability, need to relax housing supply constraints.

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$\Rightarrow$ 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
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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.
- Shocks to housing demand from work from home or from standard Bartik/climate instruments give the same results.

$\Rightarrow$ **Housing supply constraint measures do not matter in the way we expect! Fixing housing affordability may not be as "simple" as we thought.**

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; Gorback 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
  - **Alternative frameworks:** Watson and Ziv 2021; Baker 2024; Titman 1985; Murphy 2018; Murray 2020; Lange and Teulings 2024; McDonald 1981; Thorsnes 1997; Ahlfeldt and McMillen 2018; Combes, Duranton, and Gobillon 2021
- **Local effects of new construction and regulatory changes:** Zahirovich-Herbert and Gibler 2014; Diamond and McQuade 2019; Pennington 2021; Li 2022; Freemark 2023

Outline

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Model Motivation

Purpose of the model:

- Guides how we quantify the importance of housing supply constraints.
- Basic question: can we use non-causal relationships between **long-run** changes in house prices, quantities, and income to quantify the importance of supply constraints?

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Outline:

- Demand-Supply (price theory) model of local housing markets (one margin) with local supply elasticities
- Demand for housing reflects total income: population growth and average income growth.
- Allow **any correlation (causal or non-causal)** between total income growth and unobserved housing supply or demand shocks.

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- **Punchline: The comovement of house prices and quantities with income growth is sufficient to quantify the importance of housing supply constraints**.

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 ($\widehat{\sigma}_i$):

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

- 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 $\widehat{Y}$ that we know is correlated with housing demand (can call it income growth)

$$\widehat{H}_i = \kappa_j + \theta_j \check{P}_i + w_i,$$
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- The IV estimate is

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

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

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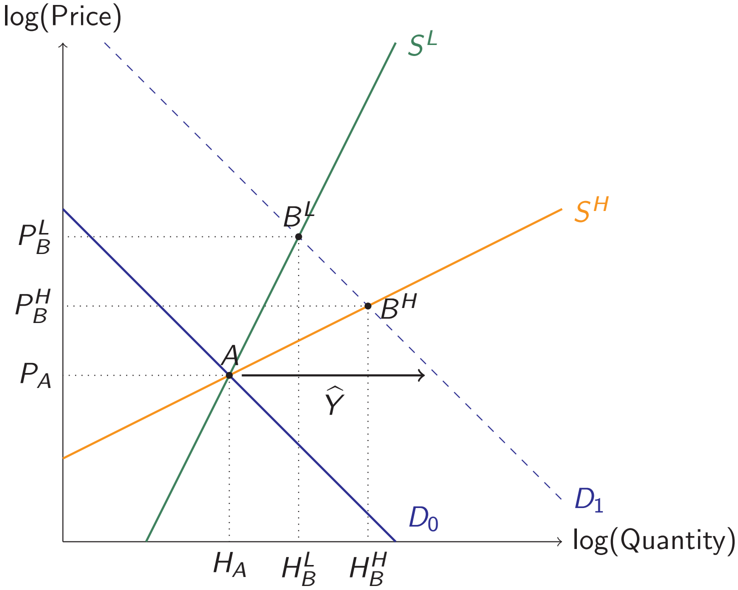
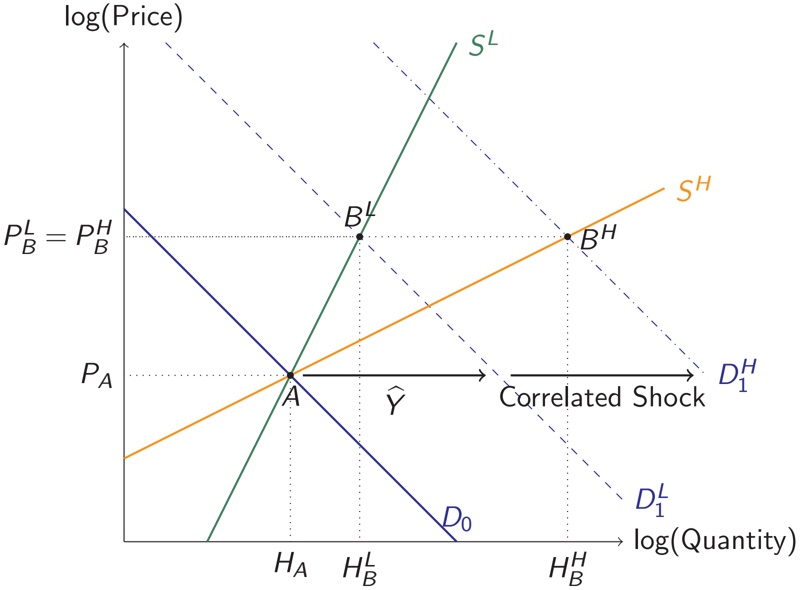
  - Common correlation between income growth and supply shocks $\Rightarrow$ No problem!
  - Supply shocks more correlated with income growth in inelastic areas $\Rightarrow$ Problem!
  - Must be a specific story, positive correlation between labor demand shocks and housing supply shocks, which contradicts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

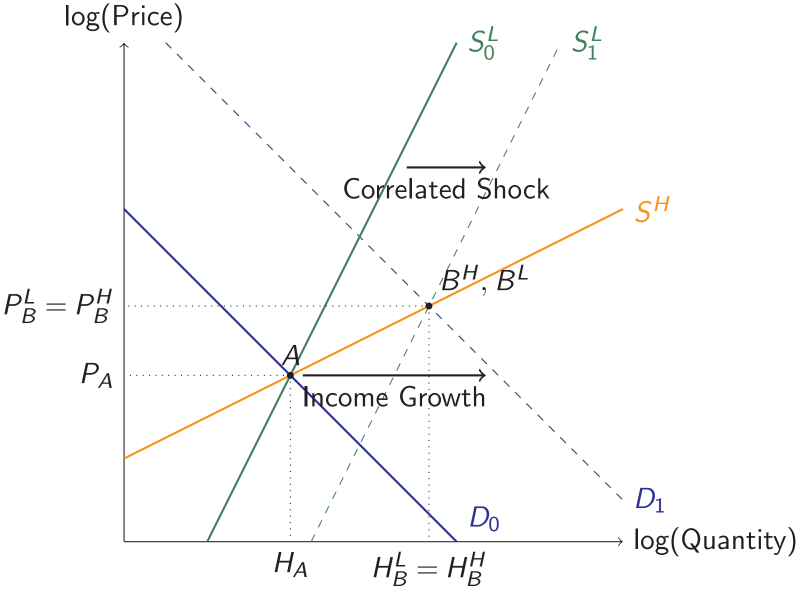
No Shocks


log(Price)
S^L
S^H
B^L
P_B^L
P_B^H
B^H
A
P_A
$\widehat{Y}$
D_1
D_0
log(Quantity)
H_A
H_B^L
H_B^H

Demand Shocks



Supply Shocks



Empirical Strategy

- Regress house price growth and quantity growth on total income growth for more/less constrained cities:

$$\widehat{P}_i = \alpha + \beta_1 \widehat{Y}_i + \beta_2 \mathbb{I}_i(\text{Less Constrained}) + \beta_3 \widehat{Y}_i \times \mathbb{I}_i(\text{Less Constrained}) + e_i$$
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- We expect $\theta_H > \theta_L$.
- **More elastic places should see less price growth and/or more quantity growth as income growth goes up.**

Summary

So what's the big takeaway?

- Correlation of price growth and quantity growth with income growth allows us to quantify the effects of supply constraints.
- Correlation with unobserved demand shocks is not a problem! In fact, the demand side can be completely general.
- Unobserved supply shocks that are **positively** correlated with labor demand shocks in **inelastic** cities would obscure the effects of supply constraints.

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  - What do these constraints mean if constrained cities always experience expansions in housing supply that offset the effects of constraints?

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- But we think this would be quite strange:
  - Supply constraints would not explain differences in house price and quantity growth.
  - What do these constraints mean if constrained cities always experience expansions in housing supply that offset the effects of constraints?
- Regardless, plausibly exogenous variation will take care of that problem anyway.

Demand Side | "Weird" Model | Local Labor Market Model | Quality Model

Outline

Data Sources

- Use MSAs as the geographic unit of analysis to match Saiz (2010)
- Constraint measures (all scaled so that larger values should be more elastic):
  - Supply elasticity from Saiz (2010)
  - Unit supply elasticity from Baum-Snow & Han (2024)
  - Regulatory index of land use (WRLURI) from Gyourko, Saiz, and Summers (2008)
  - Land share of value from Davis, Larson, Oliner, and Shui (2021)
- Income and population: BEA county-level personal income estimates
- Housing costs:
  - Corelogic county-level house price index
  - Median home value and rent from the ACS
- Housing quantity:
  - Housing units from the Census
  - Average rooms per person from the ACS
  - Permits from the Building Permits Survey
- Exposure to remote work from the ACS (Mondragon and Wieland, 2025)
- Primary analysis sample is from 2000 to 2020, but we also look at 1980 to 2000 and 1980 to 2020

Summary Statistics

	Observations	Mean	SD	25th Pct	50th Pct	75th Pct
2000-2020						
Real House Price Growth (Annualized %)	321	1.23	1.04	0.46	1.18	1.98
Real Median House Value Growth (Annualized %)	321	1.44	1.00	0.77	1.36	2.22
Real Rent Growth (Annualized %)	321	0.95	0.64	0.50	0.90	1.45
Real Total Income Growth (Annualized %)	323	2.06	0.91	1.32	1.98	2.64
House Quantity Growth (Annualized %)	323	1.01	0.65	0.54	0.91	1.37
Population Growth (Annualized %)	323	0.81	0.74	0.26	0.71	1.26
Change in Average Rooms per Person	321	0.33	0.17	0.22	0.34	0.44

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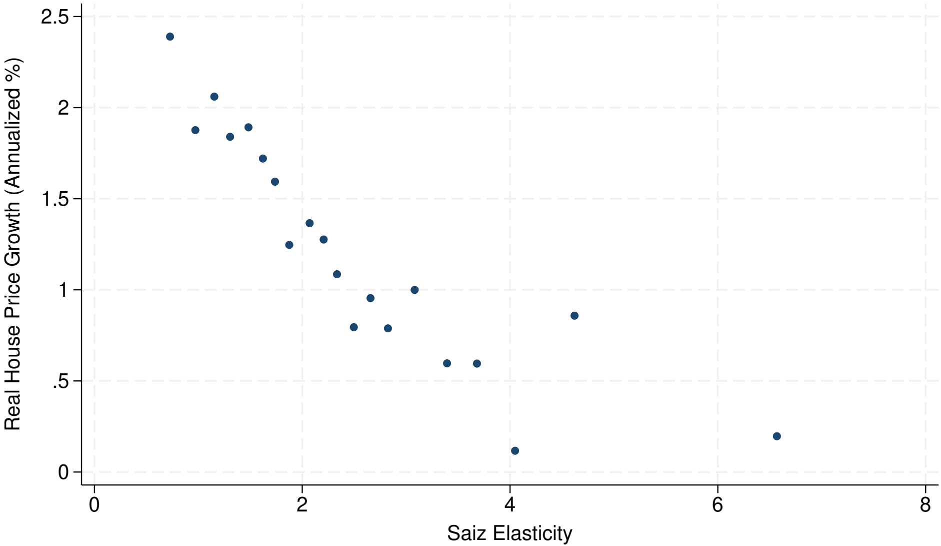
House Price Growth (2000-2020) and Saiz Elasticity



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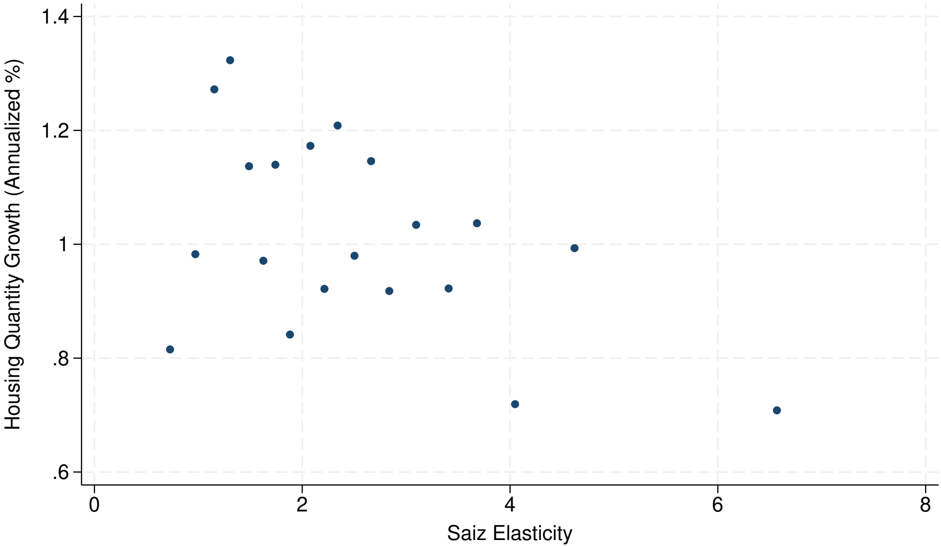
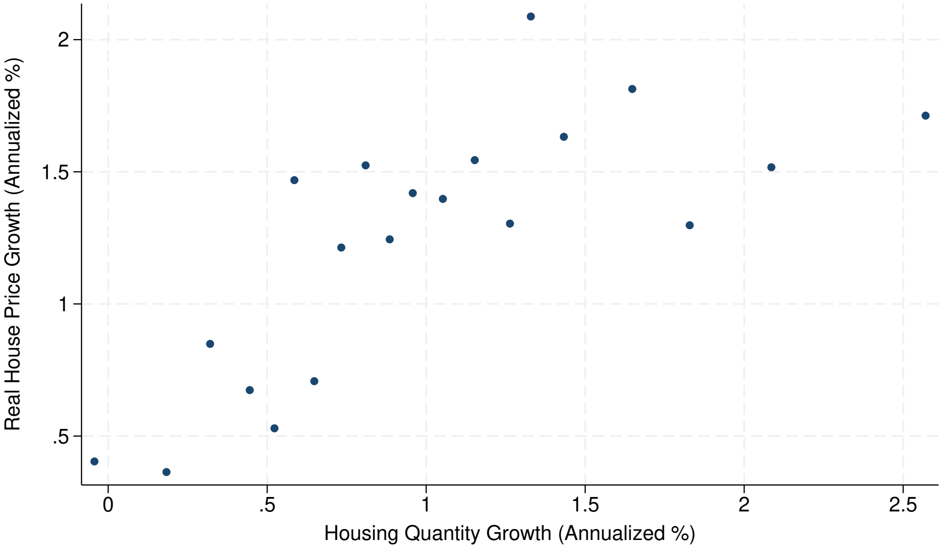


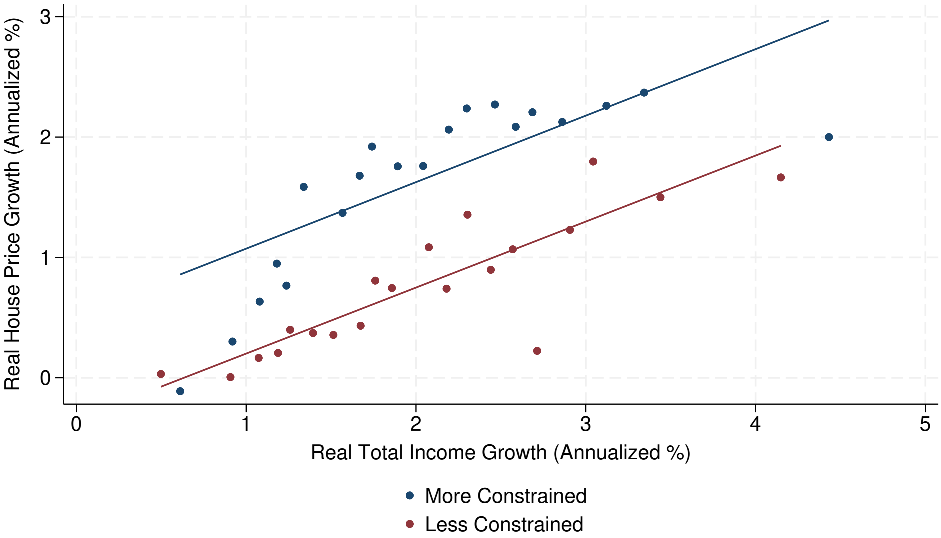
House Price and Quantity Growth (2000-2020)



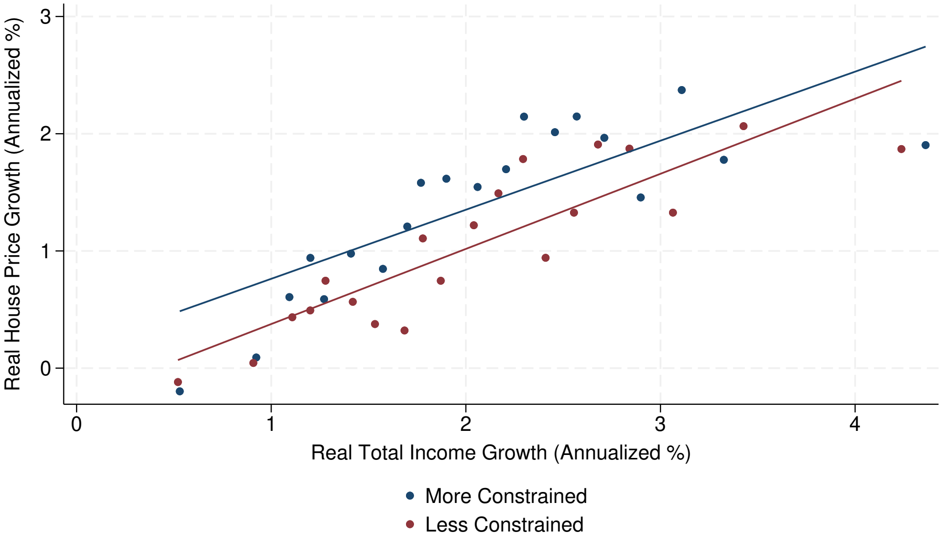
Questions

- Do changes in total income growth predict less price growth in less constrained cities?

Prices: Saiz (2010)



Prices: Baum-Snow and Han (2024)



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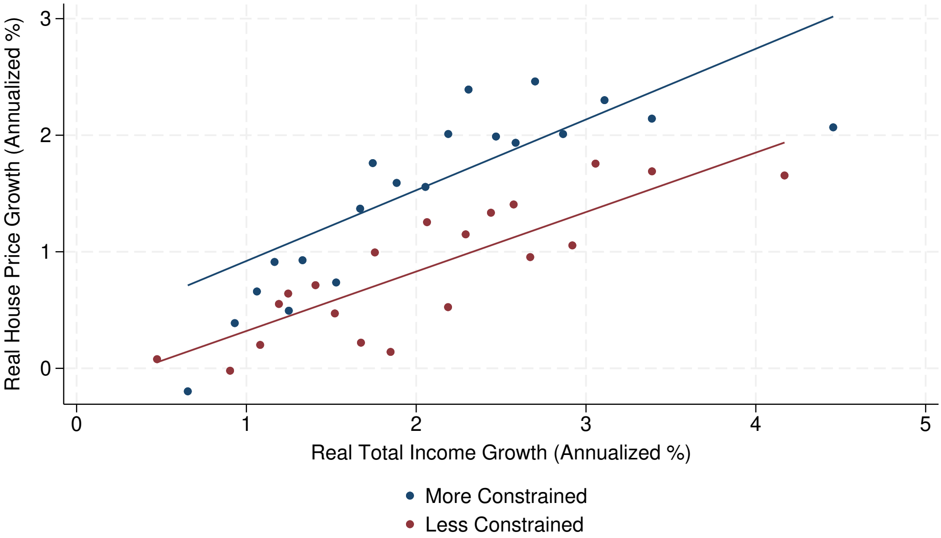

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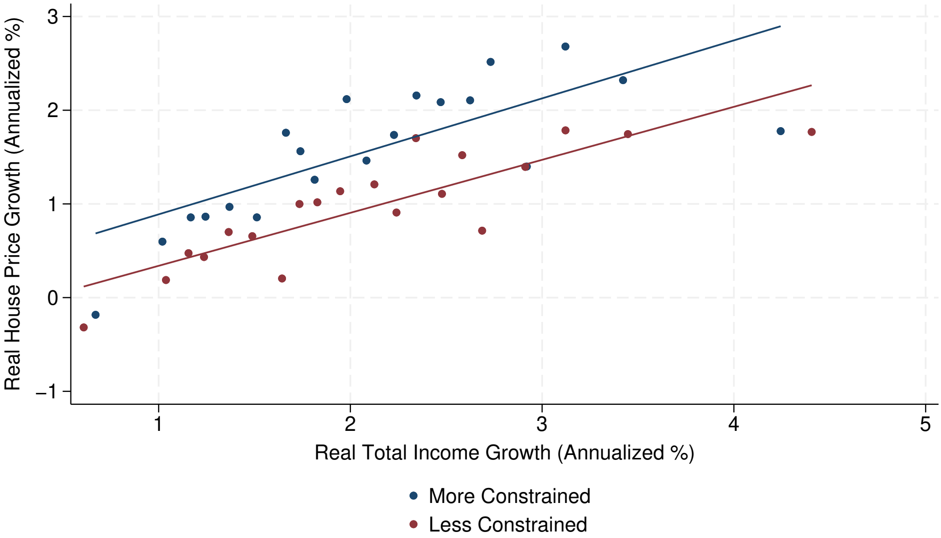

House Price Growth (2000-2020)

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

Per Capita | Population | Home Values | Drop Low Growth | Quartiles

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  - No: a given change in total income growth, per capita income growth, and population growth predicts the **same** change in house price growth in more- and less-constrained cities

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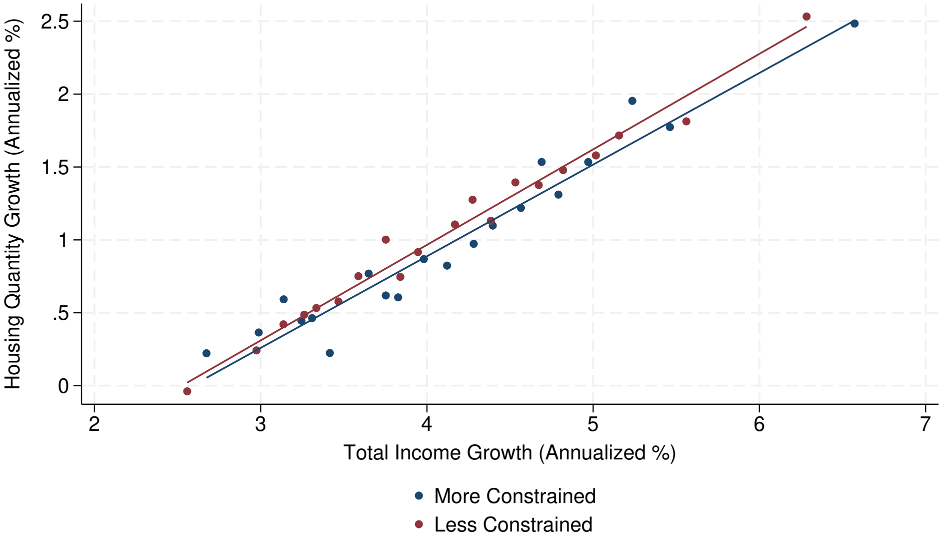
  - No: a given change in total income growth, per capita income growth, and population growth predicts the same change in house price growth in more- and less-constrained cities
- Do changes in total income growth predict more quantity growth in less constrained cities?

Quantities: Saiz (2010)



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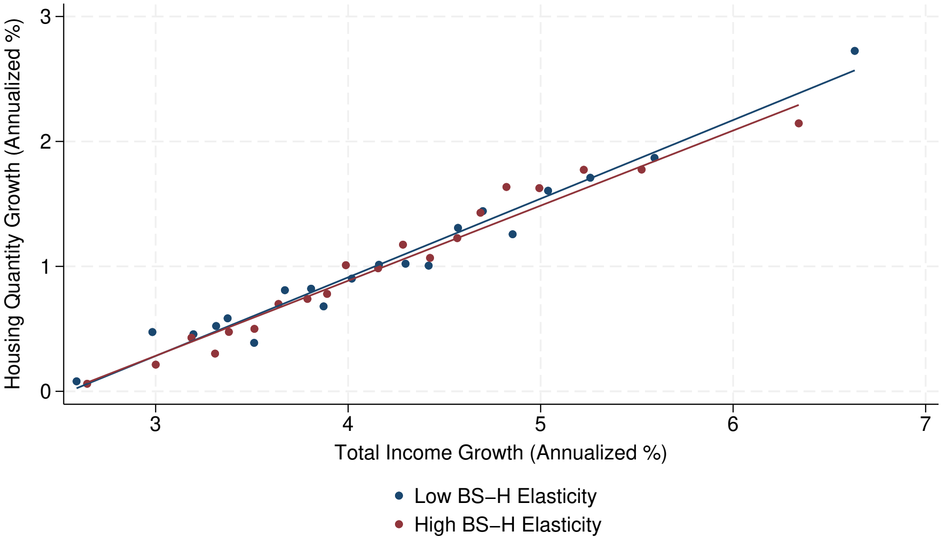

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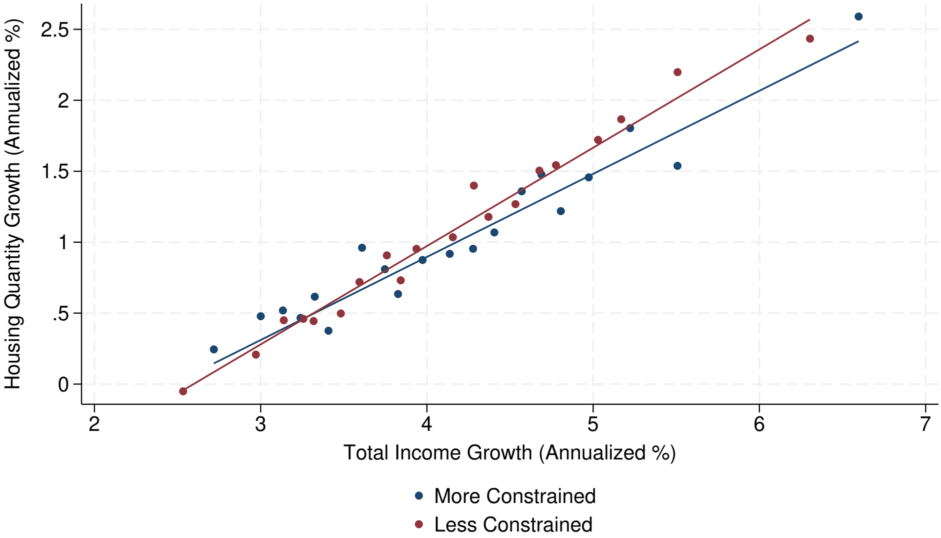

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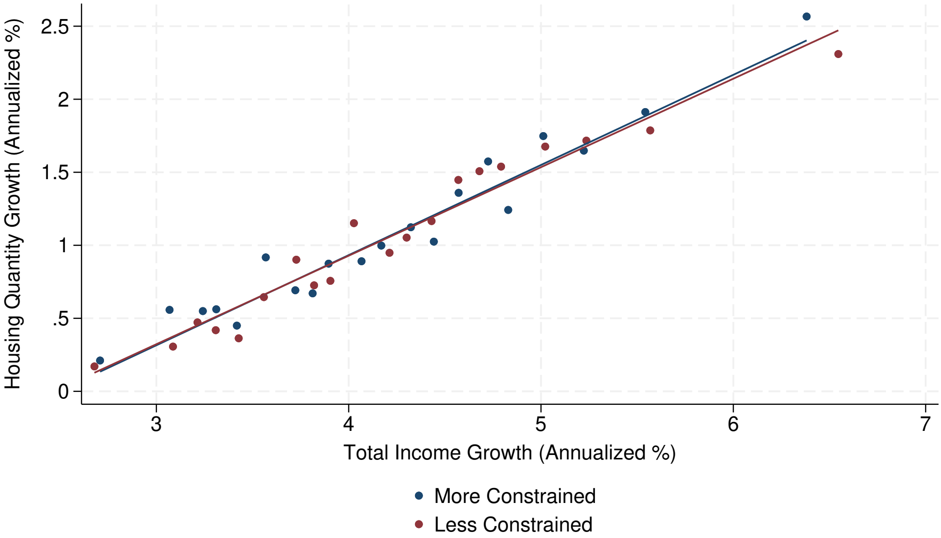

House Quantity Growth (2000-2020)

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

Per Capita | Population | Population (LHS) | Drop Low Growth | Quartiles | IV

Change in Rooms per Person (2000-2020)

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

Questions

- Do changes in total income growth predict less price growth in less constrained cities?
  - No: a given change in total income growth, per capita income growth, and population growth predicts the same change in house price growth in more- and less-constrained cities
- Do changes in total income growth predict more quantity growth in less constrained cities?
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- But is the "intercept" term evidence that supply elasticities matter as expected?

Understanding the Intercept

- A number of price specifications, especially those using Saiz, show that for the same **level** of income growth unconstrained cities had **less** house price growth **on average** compared to constrained cities.
- At the same time, there is no difference in house quantity growth on average.
- How should we think about this?

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- These shocks have to be implausibly large: equivalent to the average growth in housing quantities overall!
- A better explanation (we think) is that the price gap is picking up differential growth in the demand for housing **quality**. Quality model

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Median Home Value Growth (1980-2000)

	(1) Saiz	(2) BS-H	(3) WRLURI	(4) Building
Real Median House Value Growth (Annualized %)				
Less Constrained × Income Growth	0.225***	0.236***	0.149*	0.092
	(0.084)	(0.083)	(0.089)	(0.092)
Income Growth	0.137**	0.157**	0.161**	0.182***
	(0.061)	(0.063)	(0.064)	(0.060)
Less Constrained	-0.980***	-0.898***	-0.756***	-0.768***
	(0.265)	(0.260)	(0.274)	(0.284)
R2	0.22	0.21	0.21	0.22
Number of Observations	269	310	269	308

HPI 1980-2000 Median HP 1980-2020 HPI 1980-2020

House Quantity Growth (1980-2000)

	(1) Saiz	(2) BS-H	(3) WRLURI	(4) Building
Housing Quantities Growth (Annualized %)				
Less Constrained × Income Growth	-0.076*	-0.010	0.014	0.048
	(0.045)	(0.048)	(0.051)	(0.049)
Income Growth	0.709***	0.668***	0.665***	0.653***
	(0.036)	(0.039)	(0.037)	(0.032)
Less Constrained	0.364***	0.279**	0.084	0.088
	(0.127)	(0.135)	(0.142)	(0.142)
R2	0.80	0.78	0.80	0.76
Number of Observations	268	309	268	307

Quantity 1980-2020

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Plausibly Exogenous Shifts in Demand

- We argue that 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 should address this concern.

Plausibly Exogenous Shifts in Demand

- We argue that 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 should address 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
Real House Price Growth (Annualized %)				
More Constrained × Price Growth	1.161^{***}	1.078^{***}	0.984^{***}	1.018^{***}
	(0.216)	(0.168)	(0.183)	(0.170)
Less Constrained × Price Growth	1.216^{***}	0.965^{***}	1.383^{***}	1.088^{***}
	(0.175)	(0.133)	(0.201)	(0.159)
Less Constrained	1.058^{***}	0.447	0.443	0.547^{*}
	(0.405)	(0.280)	(0.356)	(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

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Supply Elasticities: Standard Instruments

	(1) Saiz	(2) BS-H	(3) WRLURI	(4) Building
Real House Price Growth (Annualized %)				
More Constrained × Price Growth	0.694***	0.636***	0.479***	0.526***
	(0.132)	(0.120)	(0.098)	(0.097)
Less Constrained × Price Growth	0.513***	0.309***	0.811***	0.452***
	(0.126)	(0.107)	(0.190)	(0.107)
Less Constrained	0.741***	0.491**	0.044	0.349*
	(0.242)	(0.197)	(0.219)	(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
Number of Observations	268	308	268	304

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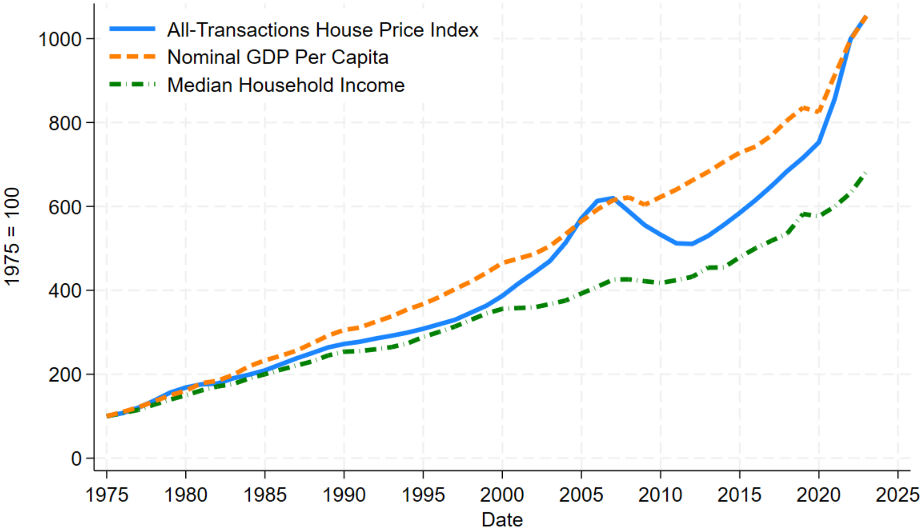
- What if we use exogenous shocks to housing demand?
  - Plausibly exogenous shocks give the same results

Outline

Conclusion

- We find that supply constraints do not explain differences in the growth of house prices and house quantities relative to income
- This is starkly inconsistent with the standard view
- Suggests that efforts to relax supply constraints are unlikely to have material effects on house prices or quantities
- But our results bring up more questions:
  - Is this just about the US? (Preliminary work suggests no, rich countries all seem quite similar)
  - Maybe what we're seeing are differences in labor supply?
  - How does the cost of land enter into the production function for housing and interact with capital at the MSA level?
  - Is a competitive, static framework the right way to think about the production and pricing of housing (Watson and Ziv 2021; Watson and Ziv 2024; Baker 2024; Murray and Limb 2023; Lange and Teulings 2024)?

Housing Affordability Crisis?



Outline

Variance of Supply Shocks

- One way for income growth to be more positively correlated with supply shocks is for supply shocks to be relatively more common in inelastic cities.
- However, in the context of a very general local labor market model, this has empirical implications that are **strongly rejected** in the data

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- Then the covariance of total income growth with supply shocks is: $Cov_j(\widehat{\sigma}_i, \widehat{Y}_i) = Cov_j(\widehat{\sigma}_i, \widehat{Z}_i) + (1-\gamma) Cov_j(\widehat{\sigma}_i, \widehat{L}_i)$

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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)

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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:

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

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- Prices:

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

- Quantities:

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

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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:

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

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- We estimate

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

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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)

Empirical Implications for Quantities

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

$$\widehat{H}_i = \delta_j + \gamma_j \widehat{Y}_i + \nu_i$$

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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,

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

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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:

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

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

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

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

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
Real House Price Growth (Annualized %)				
Less Constrained × Per Capita Income Growth	0.158	-0.162	-0.218	-0.222
	(0.253)	(0.248)	(0.268)	(0.232)
Per Capita Income Growth	0.984***	1.284***	1.139***	1.252***
	(0.178)	(0.187)	(0.163)	(0.170)
Less Constrained	-1.120***	-0.263	-0.492	-0.381
	(0.335)	(0.328)	(0.354)	(0.312)
R2	0.41	0.27	0.34	0.32
Number of Observations	268	308	268	306

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House Price Growth (2000-2020)

	(1) Saiz	(2) BS-H	(3) WRLURI	(4) Building
Real House Price Growth (Annualized %)				
Less Constrained × Population Growth	0.061	0.117	-0.001	0.067
	(0.130)	(0.131)	(0.137)	(0.139)
Population Growth	0.460***	0.498***	0.494***	0.483***
	(0.102)	(0.090)	(0.107)	(0.110)
Less Constrained	-0.992***	-0.401**	-0.788***	-0.677***
	(0.158)	(0.158)	(0.168)	(0.166)
R2	0.38	0.20	0.32	0.24
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Median Home Value Growth (2000-2020)

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

Back

House Price Growth (2000-2020)

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

Back

House Price Growth w/out Low Growth Cities (2000-2020)

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

Back

House Quantity Growth (2000-2020)

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

Back

House Quantity Growth (2000-2020)

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

Back

Population Growth (2000-2020)

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

Back

House Quantity Growth (2000-2020)

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

Back

House Quantity w/out Low Growth Cities (2000-2020)

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

Back

House Price Growth (2000-2020)

	(1) Saiz	(2) BS-H	(3) WRLURI	(4) Building
Real House Price Growth (Annualized %)				
Elasticity Measure	-0.278***	-1.660***	-0.479***	-3.936***
	(0.070)	(0.298)	(0.061)	(0.443)
Income Growth	0.532***	0.611***	0.542***	0.594***
	(0.056)	(0.055)	(0.054)	(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

Back

House Price Growth (2012-2020)

	(1) Saiz	(2) BS-H	(3) WRLURI	(4) Building
Real House Price Growth (Annualized %)				
Elasticity Measure	-0.170**	-1.751***	-0.300***	-1.826**
	(0.066)	(0.474)	(0.115)	(0.748)
Income Growth	1.112***	1.161***	1.122***	1.153***
	(0.083)	(0.071)	(0.084)	(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
Housing Quantity Growth (Annualized %)				
Elasticity Measure	0.023	-0.015	0.057***	0.481***
	(0.014)	(0.124)	(0.021)	(0.181)
Income Growth	0.656***	0.628***	0.658***	0.627***
	(0.024)	(0.025)	(0.024)	(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
Real House Price Growth (Annualized %)				
Less Constrained × Income Growth	-0.092	0.071	-0.076	-0.133
	(0.120)	(0.112)	(0.116)	(0.117)
Income Growth	0.058	0.078	0.056	0.148*
	(0.092)	(0.093)	(0.093)	(0.090)
Less Constrained	-0.229	-0.538	-0.346	-0.108
	(0.400)	(0.359)	(0.381)	(0.383)
R2	0.04	0.04	0.05	0.06
Number of Observations	268	308	268	306

Back

House Price Growth (1980-2020)

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

Back

Median Home Value Growth (1980-2020)

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

Back

House Quantity Growth (1980-2020)

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

Back

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

Back

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?

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

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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 out supply shocks as a functions of empirical estimates and average supply elasticities:

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

$$E[\widehat{\sigma}_{iYL}] = \delta - \psi_L \alpha.$$

where

$$\widehat{P}_i = \alpha + \beta_1 \widehat{Y}_i + \beta_2 \mathbb{I}_i(\text{Less Constrained}) + \beta_3 \widehat{Y}_i \times \mathbb{I}_i(\text{Less Constrained}) + e_i,$$

$$\widehat{H}_i = \delta + \gamma_1 \widehat{Y}_i + \gamma_2 \mathbb{I}_i(\text{Less Constrained}) + \gamma_3 \widehat{Y}_i \times \mathbb{I}_i(\text{Less Constrained}) + v_i.$$

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- More-constrained cities had negative supply shocks equivalent to -1%, less-constrained cities had positive supply shocks equivalent to 0.9%
- 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**

Quality Model Back

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**

Back Back - Intercept

- 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

$$\widehat{q}_i + \widehat{u}_i = \varepsilon_y \widehat{y}_i + \varepsilon_N \widehat{N}_i - \varepsilon_P \widehat{P}_i + \theta_i,$$
$$\widehat{q}_i = \varepsilon_y \widehat{y}_i - \varepsilon_{P_q} \widehat{P}_{q,i} + \theta_{q,i},$$
$$\widehat{u}_i = \varepsilon_N \widehat{N}_i - \varepsilon_{P_u} \widehat{P}_{u,i} + \theta_{u,i}.$$

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$$\begin{aligned} \widehat{q}_i + \widehat{u}_i &= \varepsilon_y \widehat{y}_i + \varepsilon_N \widehat{N}_i - \varepsilon_P \widehat{P}_i + \theta_i, \\ \widehat{q}_i &= \varepsilon_y \widehat{y}_i - \varepsilon_{P_q} \widehat{P}_{q,i} + \theta_{q,i}, \\ \widehat{u}_i &= \varepsilon_N \widehat{N}_i - \varepsilon_{P_u} \widehat{P}_{u,i} + \theta_{u,i}. \end{aligned}$$

- Supply side has a parallel structure

$$\begin{aligned} \widehat{q}_i &= \psi_{q,i} \widehat{P}_{q,i} + \sigma_{q,i}, \\ \widehat{u}_i &= \psi_{u,i} \widehat{P}_{u,i} + \sigma_{u,i}. \end{aligned}$$

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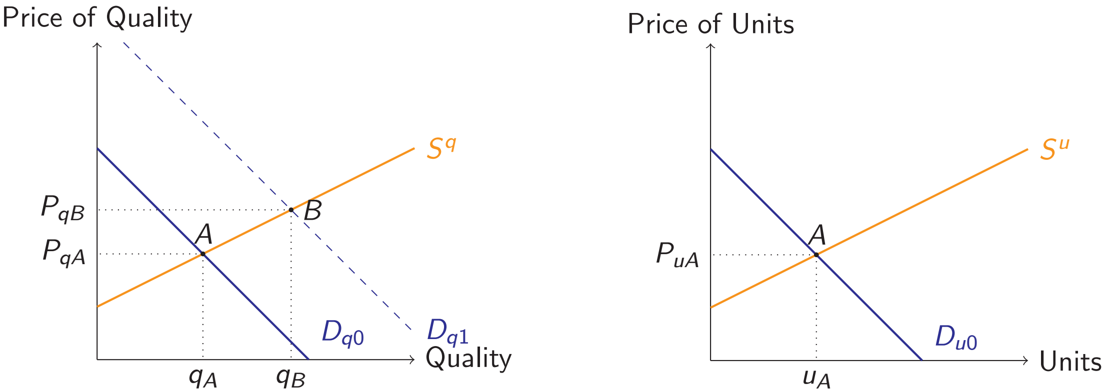
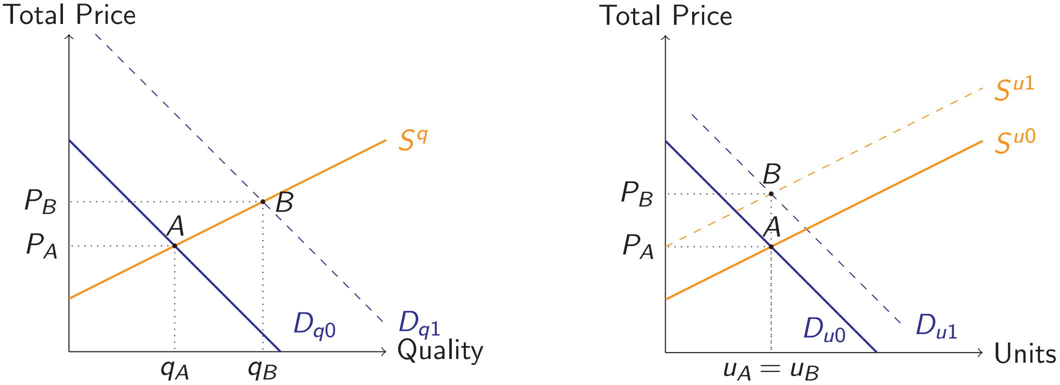
- What happens if there is an increase in income ($\widehat{y}$), holding population growth constant?

Perfect Measurement of Quality



Prices increase, but not when held at constant quality

No Measurement of Quality



Supply and demand shift up in the units market!

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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  1. They do not use any transactions where the property changed hands twice within 180 days to avoid picking up "flipping".
  2. They do not use any transactions where the **annualized** appreciation rate is greater than 40% in absolute value.
  3. They drop outliers.

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- 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?

Back

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- We rely on Mondragon and Wieland (2025), who argue (with others) that the shift to remote work increased housing demand
  - Workers who shifted to WFH increased their demand for housing
  - Cities amenable to remote work saw large inflows of remote workers

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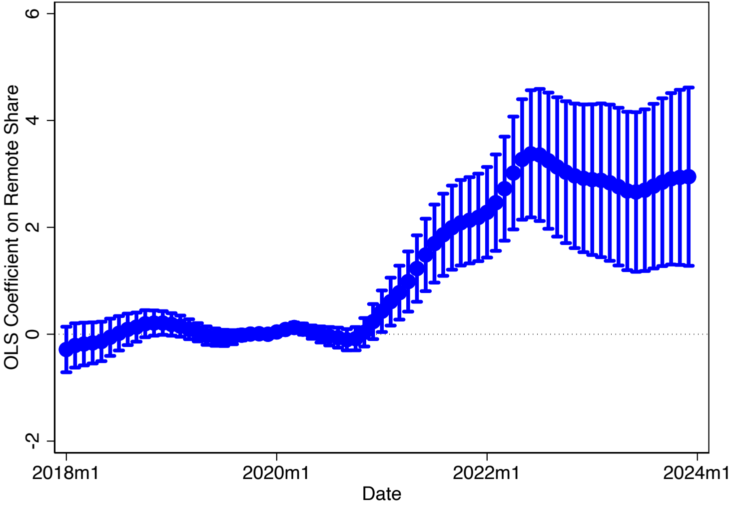
  - Workers who shifted to WFH increased their demand for housing
  - Cities amenable to remote work saw large inflows of remote workers
- Plausibly exogenous
- Does the WFH shock have different effects on house prices and housing quantities (permits) in more- and less-elastic cities

Back

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)
Total Income Growth (Annualized %)								
WFH Shock × Less Constrained		0.082		0.146		0.325***		0.024
		(0.115)		(0.098)		(0.115)		(0.104)
WFH Shock	0.437***	0.455***	0.407***	0.366***	0.437***	0.357***	0.381***	0.408***
	(0.056)	(0.083)	(0.050)	(0.078)	(0.056)	(0.078)	(0.048)	(0.074)
Less Constrained		-0.017		-0.290		-0.812*		0.132
		(0.460)		(0.388)		(0.443)		(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)
House Price Growth (Annualized %)								
WFH Shock × Less Constrained		0.122		0.110		0.633***		0.203
		(0.228)		(0.213)		(0.232)		(0.229)
WFH Shock	0.344***	0.252	0.401***	0.401**	0.344***	0.086	0.449***	0.375**
	(0.116)	(0.161)	(0.108)	(0.162)	(0.116)	(0.162)	(0.107)	(0.157)
Less Constrained		-0.770		0.081		-2.382***		-0.751
		(0.917)		(0.825)		(0.893)		(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)
Cumulative Permit Growth (Annualized %)								
WFH Shock × Less Constrained		0.747		0.886		0.168		1.331
		(0.793)		(0.710)		(0.708)		(0.834)
WFH Shock	1.006***	0.951*	0.842**	0.623	1.006***	1.096*	0.841**	0.873*
	(0.373)	(0.501)	(0.368)	(0.468)	(0.373)	(0.566)	(0.387)	(0.522)
Less Constrained		-1.547		-1.447		0.602		-1.715
		(3.069)		(2.889)		(2.964)		(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