Why Has House Price Dispersion Gone Up?

Stijn Van Nieuwerburgh (NYU Stern and NBER)
Pierre-Olivier Weill (UCLA)
two facts about regional house prices

House price, panel of U.S. metropolitan areas, 1975-2004

- On the left: increase in cross-sectional average
- On the right: increase in cross-sectional dispersion

two ingredients for an explanation

- Increase in wage dispersion

- Fixed local housing supply regulation: evidence from many papers
results

- **Mechanism**: when wage dispersion increases
  - households move from low- to high-wage areas
    - bid prices up in high-wage areas
    - bid prices down in low-wage areas
  - dispersion goes up, and level also goes up!
results

- **Mechanism**: when wage dispersion increases
  - households move from low- to high-wage areas
    - bid prices up in high-wage areas
    - bid prices down in low-wage areas
  - dispersion goes up, and level also goes up!

- **Calibration**: matches the two facts
results

- **Mechanism**: when wage dispersion increases
  - households move from low- to high-wage areas
    - bid prices up in high-wage areas
    - bid prices down in low-wage areas
  - ⇒ dispersion goes up, and level also goes up!

- **Calibration**: matches the two facts

- **Alternative theory**: increase in regulation
  - qualitatively: goes in the right direction
  - quantitatively: tiny effects
→ Model

→ Calibration

- **Scenario 1:**
  
  increase wage dispersion,
  
  hold regulation fixed at its 1975 level

- **Scenario 2:**
  
  increase regulation,
  
  hold wage dispersion fixed at its 1975 level

→ Welfare effects when both margins are active
setup: islands

Time $t \in \{1, 2, \ldots\}$, $[0, 1]$-continuum of islands

- Competitive firms with linear technology: $n \mapsto A_t n$
  
  Linear technology and competition: $A_t$ is the wage per job
  
  $\{A_t\}_{t=1}^\infty$ first-order Markov process
  
  persistent
  
  i.i.d across islands

- Cross-sectional distribution $g_0(A_0, H_0)$ of initial conditions
  
  initial wage $A_0$
  
  initial housing stock $H_0$
setup: households

→ [0, 1]-continuum

- Infinitely lived, discount factor $\beta \in (0, 1)$, separable utility linear over non-housing consumption goods increasing, strictly concave $v(h)$ over housing services bounded above, unbounded below

- Supplies one unit of labor inelastically each period

- Perfectly mobile: each period, chooses on which island to work how much housing to consume in that island
setup: construction

- Aggregate endowment $M$ of construction material

- A representative competitive construction firm
  
  Buys construction material
  Chooses where to construct
  Linear construction technology (one to one)
  Construction is irreversible, depreciates at rate $\delta$

- Housing supply regulations
  
  $\Pi_t(A_t)$ permits in each island
equilibrium

- Rents, house prices, price of construction material
- Housing consumption and location plan
- Construction plan
- Distribution of households across islands
- Distribution of housing stocks across islands

- Optimality

- Feasibility
  - Location plan generates distribution of households
  - Construction plans generates distribution of housing stock
  - Housing market clears in each island
  - Construction material market clears
household’s problem

- Optimal location

Let $n_t(A^t, H_0)$ be the number of households in island $(A^t, H_0)$

If $n_t(A^t, H_0) > 0$, then

$$A_t + \max_h \{v(h) - \rho_t(A^t, H_0)h\} = U_t$$

$$\leq U_t$$ otherwise
implications of optimal location: monotonicity

- If $n_t(A^t, H_0) > 0$, then

$$A_t + \max_h \{v(h) - \rho_t(A^t, H_0)h\} = U_t$$
implications of optimal location: monotonicity

- If $n_t(A^t, H_0) > 0$, then

\[ A_t + \max_h \{ v(h) - \rho_t(A^t, H_0)h \} = U_t \]

\[ \Rightarrow \rho_t(A^t, H_0) = \rho^*(A_t, U_t) \]

increasing in $A_t$, decreasing in $U_t$
implications of optimal location: monotonicity

- If $n_t(A^t, H_0) > 0$, then

$$A_t + \max_h \left\{ v(h) - \rho_t(A^t, H_0) h \right\} = U_t$$

$$\Rightarrow \rho_t(A^t, H_0) = \rho^*(A_t, U_t)$$

increasing in $A_t$, decreasing in $U_t$

$$\Rightarrow h_t(A^t, H_0) = h^*(A_t, U_t)$$

decreasing in $A_t$, increasing in $U_t$
implication of optimal location: convexity

- If $n_t(A^t, H_0) > 0$, then

$$A_t + \max_h \{v(h) - \rho^*(A_t, U_t)h\} = U_t$$

Take derivative, use envelope condition:

$$1 - \frac{\partial \rho^*}{\partial A} \times h^*(A, U) = 0 \Rightarrow \frac{\partial \rho^*}{\partial A} = \frac{1}{h^*(A, U)}$$
convexity and the level effect of wage dispersion

- increase the dispersion of wage, \( A \), hold \( U \) constant

\[ \Rightarrow \text{the cross-sectional average rent } E \left[ \rho^* (A, U) \right] \text{ increases} \]

\[ \Rightarrow \text{the house price level increases in every island} \]

for example, if \( A_t \) i.i.d over time

\[
\text{house price} = \rho^* (A, U) + \frac{E \left[ \rho^*(A', U) \right]}{1 - \beta (1 - \delta)}
\]
implications of optimal location: house prices

- House price
  
  \[ \text{House price} = \text{expected present value of rents} \]
  
  net of depreciation
  
  conditional on island history
  
  \[ = p^*(A_t, U_t, U_{t+1}, \ldots), \]
  
  increasing \( A_t \)

  decreasing \( U_{t+j} \)

  does not depend on local housing supply
Construction firm’s problem

- Centralized market for construction material
- Linear construction technology, permit constraint \( \Pi_t(A_t) \)
- Optimality: use up all permits in any islands where
  \[
p^*(A_t, U_t, U_{t+1}, \ldots) \geq \text{price of material}
  \]
- House price increasing in \( A_t \) \( \Rightarrow \) cutoff rule. Let \( A^*_t \) such that
  \[
p^*(A^*_t, U_t, U_{t+1}, \ldots) = \text{price of material}
  \]
  \[
  \text{construction} = \Pi_t(A_t) \quad \text{if} \quad A_t > A^*_t
  \]
  \[
  \text{construction} = 0 \quad \text{otherwise}
  \]
market clearing

- Construction material market,

\[ \int_{A^*_t}^{\infty} \Pi_t(A_t) g_t(A_t) dA_t = M \]
market clearing

- Construction material market,

\[ \int_{A^*_t}^{\infty} \Pi_t(A_t) g_t(A_t) dA_t = M \]

- Housing market in each island,

\[ H_t(A^t, H_0) = (1 - \delta) H_{t-1}(A^{t-1}, H_0) + \Pi_t(A_t) \mathbb{1}_{\{A_t > A^*_t\}} \]

\[ n_t(U_t, A^t, H_0) h^*(A_t, U_t) = H_t(A^t, H_0) \]
market clearing

- Construction material market,

\[
\int_{A_t^*}^{\infty} \Pi_t(A_t) g_t(A_t) \, dA_t = M
\]

- Housing market in each island,

\[
H_t(A^t, H_0) = (1 - \delta) H_{t-1}(A^{t-1}, H_0) + \Pi_t(A_t) \mathbb{I}\{A_t > A_t^*\}
\]

\[
n_t(U_t, A^t, H_0) h^*(A_t, U_t) = H_t(A^t, H_0)
\]

- Labor market,

\[
\int n_t(U_t, A^t, H_0) g_t(A^t, H_0) \, dA^t \, dH_0 = 1
\]
some results

- An efficient procedure for computations
- Existence
- Uniqueness
- Convergence to a steady-state
- Efficiency
calibration exercise

- Pick parameters
  So that the steady-state matches features of 1975 US data

- Change parameters to mimic
  increase in wage dispersion (scenario 1)
  or increase in regulation (scenario 2)
  or both at the same time

- Calculate the transition towards the new steady-state:
  Do we match US data in 2004?
calibration: preference

- Time discount factor $\beta = .95$ (Cooley & Prescott, 1995)

- Utility over housing services $v(h) = \kappa \frac{h^{1-\gamma}}{1-\gamma}$

  $\kappa$: match housing expenditure to labor income ratio of 0.12 (Census)

  price elasticity of housing demand $-1/\gamma = -0.5$ (Hanushek & Quigley, 1980)
calibration: wage per job

- Cross-section: \( \log(A_t) = a_t \sim \mathcal{N}(\mu_a, \sigma^2_{at}) \)
- Time series: \( a_t = (1 - \rho_a)\mu_a + \rho_a a_{t-1} + \sigma_{\varepsilon t} \varepsilon_t \)
- LLN: \( \sigma^2_{at} = \rho^2_a \sigma^2_{at-1} + \sigma^2_{\varepsilon t} \).
- Cross-sectional mean \( \mu_a = \log(15) + \log(1.25) \)
  average real wage per job is 15,000 (BEA, REIS)
  average 1.25 jobs per household (Census)
- Persistence: pooled OLS regression, \( \rho_a = .99 (.0008) \)
- Initial distribution: stationary, pick \( \sigma^2_{\varepsilon,0} \) to match CV of \( A \) in 1975
calibration: construction

- Depreciation: $\delta = 0.016$ (BEA fixed asset tables)

- New construction: $M = 0.03$, because
  \[
  \frac{M}{\delta} = \text{per-capita housing supply} \\
  = \text{average size of a house in the US} \\
  = 1.875 \text{ thousands of square feet (Census)}
  \]

- $\Pi(A) = \bar{\Pi}$: match one feature of 1975 data:
  concentration of jobs in high wage regions
In 1975: $\Pi(A) = \overline{\Pi}$ governs
distribution of housing stock across wage quintiles
distribution of households across wage quintile

⇒ gets the right number of jobs in highest wage quintile
scenario 1: increase in wage dispersion

- Log wage $a \sim \mathcal{N}(\mu_a, \sigma_{a,t}^2)$
- Increase $\sigma_{a,t}$ from 0.127 to 0.220 over 30 periods.
  Through increase in innovation variance $\sigma_{\varepsilon}^2$
  Wage variance $\sigma_{a}^2$ constant after 2004
- This matches increase in CV of $A$ between 1975 and 2004.
scenario 1: population distribution

- Increase in wage dispersion concentrates households
- Fraction in Q5: +1.1% (in 2004) and +11% in new steady state
- Data: +8.5%
scenario 1: house price dispersion

- Large increase in house prices: 47.9% (50% until 2004)
- Large increase in house price st. deviation: 98% (104%)
- CV increases by 0.35 in 30 years, just as in data
scenario 2: increase in regulation, constant dispersion

- Tighter regulation: \( \Pi(A) = \Pi(A/A)\phi \)
- Gradual decrease in \( \phi : 0 \rightarrow -0.5 \) captures:
  - tighter regulation over time
  - tighter regulation in more productive regions
- Transition takes 30 years (1975-2004), \( \phi = -0.5 \) after 2004.
scenario 2: population distribution

- Increase in regulation spreads people out
- Fraction in Q5 decreases by 12.3% (9.7% until 2004)
scenario 2: house price dispersion

- Tiny increase in house prices: .2% (1.9%)
- Tiny increase in house price st.deviation: .1% (1.2%)
- Dispersion level is too low and flat
How large are the welfare effects of housing supply regulation?

Answer: when increasing wage dispersion is taken into account, they are substantial.
Flow utilitarian welfare

\[ w_t = \int n_t(A^t, H_0) \left( A_t + v(h_t(A^t, H_0)) \right) g_t(A^t, H_0) \, dA^t \, dH_0. \]

\[ w_{2004} \] is 1.9% lower than if regulation had stayed at 1975 level

\[ w_{st-st} \] is 5% lower than if regulation had stayed at 1975 level
conclusion: what about

- excessive mobility
conclusion: what about

- excessive mobility
  even though labor is free to move
  migration rates in model are low (high persistence of wage)
  even too low compared to Census data
conclusion: what about

- excessive mobility
- reverse causality from home prices to wages
conclusion: what about

- excessive mobility
- reverse causality from home prices to wages

2 types of workers: local industry and local service workers
local productivity goes up
⇒ house prices go up
⇒ wages of service workers go up to keep them from moving
conclusion: what about

- excessive mobility
- reverse causality from home prices to wages
- more general non-separable preferences
conclusion: what about

- excessive mobility
- reverse causality from home prices to wages
- more general non-separable preferences

  convexity effect goes through

richer SDF: asset pricing with durable goods

  e.g. Brunnermeier and Julliard (06), Piazessi, Schneider, and Tuzel (06), Lustig and Van Nieuwerburgh (06), and many others
Real house prices went up by 1.46% per year on average.
data: standard deviation of house price increases

Cross-sectional standard deviation of real house prices increases by factor of 5-6.
another look at the basic fact

Define wage quintiles in each year and plot \( \frac{\text{median wage in Q5}}{\text{median wage overall}} \)

and \( \frac{\text{median house price in Q5}}{\text{median house price overall}} \)

![Graph of House Prices and Wages in the Top Wage Quintile Relative to Average (npw)]

![Graph of House Prices and Wages in the Top Wage Quintile Relative to Average (pw)]
Focus on young (25-39), college-educated singles: most likely to move for productive reasons (most similar to agents in our model)

Census data: in-migration and out-migration between 1995 and 2000
mobility in the model - 40 wage bins in 1995

Most productive areas see large inflows
solving for an equilibrium

- Find the sequence \( \{ A_t^* \}_t=1^\infty \) of construction cutoffs using
  construction material market clearing

- Solve for the distribution of housing stock at each time using

\[
H_t(A_t, H_0) = (1 - \delta) H_{t-1}(A_{t-1}, H_0) + \Pi_t(A_t)I\{A_t > A_t^*\}
\]
solving for an equilibrium

- Find \( \{A^*_t\}_{t=1}^{\infty} \) and solve for \( H_t(A^t, H_0) \)
- Solve for the distribution \( n_t(A^t, H_0) \) of households in three steps

1. indifference condition: \( h_t^*(A_t, U_t) \)

2. local housing market clearing:
   \[
   n_t(A^t, H_0) = \frac{H_t(A^t, H_0)}{h_t^*(A_t, U_t)}
   \]

3. labor-market clearing:
   \[
   \int H_t(A^t, H_0)/h_t^*(A_t, U_t) g_t(A^t, H_0) \, dA^t \, dH_0 = 1
   \]
   \[
   \rightarrow \text{one equation in the one unknown } U_t
   \]
   \[
   \Rightarrow n_t \text{ increasing in } A_t \text{ and } H_t
   \]
some results

- First welfare theorem holds
  
  the allocation of housing and labor is Pareto optimal
  (subject to regulatory constraints)
some results

• First welfare theorem holds
  the allocation of housing and labor is Pareto optimal
  (subject to regulatory constraints)

• Under regularity and stationarity, convergence to a steady-state
  steady-state utility $U^*$ of moving and cutoff $A^*$
  steady-state price function $p^*(A_t)$
  steady-state distribution of $(A_t, H_t)$ under boundedness
  conditions
  (otherwise convergence of some moments)
some results

- First welfare theorem holds
  the allocation of housing and labor is Pareto optimal
  (subject to regulatory constraints)

- Under regularity and stationarity, convergence to a steady-state
  steady-state utility $U^*$ of moving and cutoff $A^*$
  steady-state price function $p^*(A_t)$
  steady-state distribution of $(A_t, H_t)$ under boundedness
  conditions
  (otherwise convergence of some moments)

- Approximation: increase in wage dispersion
  $\Rightarrow$ higher average rent and higher CS variation in rent
calibrating initial wage distribution
Raven Saks (2005) compiles index of housing supply regulation based on 6 sources of data. Mean 0, standard deviation 1.

- **Top 10 most regulated**: New York (2.2), San Francisco (2.1), Sacramento (1.9), Charleston (1.8), Riverside-San Bernardino (1.7), San Jose (1.65), San Diego (1.6), Santa Barbara (1.5), Seattle (1.5), Gary (1.2)

- **Top 5 least regulated**: Bloomington (-2.4), Buffalo (-2), Nashville (-1.6), Owensboro (-1.5), Joplin (-1.5)
what is an island?

It’s a Core-based Statistical Area = central county or counties containing the core, plus adjacent outlying counties having a high degree of social and economic integration with the central county as measured through commuting.
(OMB definition Dec 2005, based on Census 2000)


Edison, NJ Metropolitan Division: Middlesex County, NJ, Monmouth County, NJ, Ocean County, NJ, Somerset County, NJ
Nassau-Suffolk, NY Metropolitan Division: Nassau County, NY, Suffolk County, NY
Newark-Union, NJ-PA Metropolitan Division: Essex County, NJ, Hunterdon County, NJ, Morris County, NJ, Sussex County, NJ, Union County, NJ, Pike County, PA

- For the 11 CBSAs with metropolitan divisions, we use those.
summary: increasing wage dispersion

- Fix the housing supply regulation ($\log(\bar{\Pi}) = .139$ and $\phi = -.5$)

- Compare final steady state and situation after 30 years in the economy with an increase in dispersion to benchmark economy with no increase

<table>
<thead>
<tr>
<th>Experiment:</th>
<th>$\sigma_\varepsilon \uparrow$, $\bar{\sigma}_\varepsilon$</th>
<th>$\text{Benchmark: } \sigma_\varepsilon \uparrow$, $\bar{\sigma}_\alpha$</th>
<th>$\rho_\alpha \uparrow$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moment</td>
<td>st-st 30 years</td>
<td>st-st 30 years</td>
<td>st-st 30 years</td>
</tr>
<tr>
<td>Output</td>
<td>36.41 12.25</td>
<td>13.82 12.26</td>
<td>19.58 4.73</td>
</tr>
<tr>
<td>Pop. in Q5</td>
<td>20.13 0.94</td>
<td>8.62 0.97</td>
<td>16.01 -23.24</td>
</tr>
<tr>
<td>Mean HP</td>
<td>120.40 56.12</td>
<td>45.32 49.74</td>
<td>52.72 10.42</td>
</tr>
<tr>
<td>Std HP</td>
<td>207.10 107.02</td>
<td>96.33 104.10</td>
<td>124.19 56.25</td>
</tr>
<tr>
<td>Mean HP/CC</td>
<td>175.45 49.30</td>
<td>65.29 55.30</td>
<td>134.34 22.65</td>
</tr>
<tr>
<td>Welfare</td>
<td>5.85 3.12</td>
<td>4.71 3.13</td>
<td>2.71 0.90</td>
</tr>
</tbody>
</table>
- Fix the increase in wage dispersion
- Scenario C (regulation) minus scenario B (no regulation), both in steady state and after 30 years

<table>
<thead>
<tr>
<th>Experiment:</th>
<th>$\phi = -0.7$</th>
<th>Benchmark: $\phi = -0.5$</th>
<th>$\phi = -0.3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pop. in Q5</td>
<td>-20.53</td>
<td>-14.69</td>
<td>-8.65</td>
</tr>
<tr>
<td>Output</td>
<td>-7.79</td>
<td>-5.57</td>
<td>-3.33</td>
</tr>
<tr>
<td>Pop. in Q5</td>
<td>-20.53</td>
<td>-14.69</td>
<td>-8.65</td>
</tr>
<tr>
<td>Mean HP</td>
<td>-2.83</td>
<td>-2.33</td>
<td>-1.61</td>
</tr>
<tr>
<td>Std HP</td>
<td>-1.83</td>
<td>-1.61</td>
<td>-1.15</td>
</tr>
<tr>
<td>Mean HP/CC</td>
<td>33.30</td>
<td>22.10</td>
<td>12.54</td>
</tr>
</tbody>
</table>

- Log difference times 100
scenario 1: aggregate output

- Output increases 17% between steady-states (13% until period 30)
- Max attainable utility of extra person increases 14% (6.5%) (8.7%)
- Average house price over construction cost increases 28% (11%)
scenario 1: House Price to Construction Cost Ratio

- Mimic GGS exercise
- The ratio, or “regulation share”, constant over time. Slope is 0.99...
- ... but population-weighted average goes up by 35%
scenario 2: aggregate output

- Output falls 2.6% between steady-states (0.9% until period 30)
- Max attainable flow utility $U_t$ decreases 3.7% (1.1%)
- House price over construction cost increases 24% (27%)
scenario 2: house price to construction cost ratio

- Mimic GGS exercise
  - Draw 322 regions from 1975 stationary distribution
  - Follow them until 2004
  - Plot 2004 ratio against 1975 ratio
- The ratio, or “regulation share”, increases over time. Slope is 1.25.
scenario 3: increasing regulation and dispersion

Two forces work in opposite directions for:

- Population in Q5: -3.6% (-4.2%)

- House price: Large increase in house prices: 46% (52%) and in the standard deviation: 96% (105%) ⇒ C.V. increases by 0.35 in 30 years.
Scenario 3: output

- Output increases 11% between steady-states (11% until period 30)
- Max attainable utility increases 6.7% (4.6%)
- Average price over construction cost increases 67% (61%)
Scenario 3: population distribution

- Two forces work in opposite direction.
- Net effect on fraction in Q5: -3.6% (-4.2%)
Scenario 3: house price dispersion

- Large increase in house prices: 46% (52%)
- Large increase in house price st. deviation: 96% (105%)
- Dispersion level increases by 0.35 in 30 years!
Scenario 3: house price to construction cost ratio

- Mimic GGS exercise
- The ratio, or “regulation share”, increases over time. Slope is 1.64.
- Pop-weighted average HP/CC increases by 77% (77%)
welfare table

- PV welfare comparison: \( \sum_{t=1975}^{2004/st-st} \beta^{t-1} w_t \)

<table>
<thead>
<tr>
<th>Experiment:</th>
<th>( \phi = -0.7 )</th>
<th>Benchmark: ( \phi = -0.5 )</th>
<th>( \phi = -0.3 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \sigma_\varepsilon \uparrow, \bar{\sigma}_\varepsilon )</td>
<td>st-st 30 years</td>
<td>st-st 30 years</td>
<td>st-st 30 years</td>
</tr>
<tr>
<td>-1.52</td>
<td>-1.03</td>
<td>-0.56</td>
<td></td>
</tr>
<tr>
<td>-0.22</td>
<td>-0.08</td>
<td>-0.02</td>
<td></td>
</tr>
<tr>
<td>Benchmark: ( \sigma_\varepsilon \uparrow, \bar{\sigma}_a )</td>
<td>st-st 30 years</td>
<td>st-st 30 years</td>
<td>st-st 30 years</td>
</tr>
<tr>
<td>-1.49</td>
<td>-1.06</td>
<td>-0.64</td>
<td></td>
</tr>
<tr>
<td>-0.48</td>
<td>-0.33</td>
<td>-0.19</td>
<td></td>
</tr>
<tr>
<td>( \rho_a \uparrow )</td>
<td>st-st 30 years</td>
<td>st-st 30 years</td>
<td>st-st 30 years</td>
</tr>
<tr>
<td>-1.74</td>
<td>-1.24</td>
<td>-0.75</td>
<td></td>
</tr>
<tr>
<td>-0.41</td>
<td>-0.27</td>
<td>-0.15</td>
<td></td>
</tr>
</tbody>
</table>
conclusions and extensions

- Increase in wage dispersion induces reallocation towards more productive regions can quantitatively account for rise in house price dispersion and level captures that this rise is situated in the non-structure component

- While baseline level of regulation is important, increase in regulation is not sufficient to explain house price changes

- Extensions
  - Congestion externalities: optimal taxation/regulation
  - Heterogeneity within the region
  - House pricing with more realistic SDF
household’s problem

Island \((A^t, H_0)\) : 
\[
    u_t(A^t, H_0) = A_t + \max_h \{ v(h) - \rho_t(A^t, H_0) h \}
\]

Best island : 
\[
    U_t = \max_{(A^t, H_0)} u_t(A^t, H_0)
\]
household’s problem

Island \((A^t, H_0)\):
\[
u_t(A^t, H_0) = A_t + \max_h \{v(h) - \rho_t(A^t, H_0)h\}
\]

Best island:
\[
U_t = \max_{(A^t, H_0)} u_t(A^t, H_0)
\]

⇒ Optimal location:

Let \(n_t(A^t, H_0)\) be the number of households in island \((A^t, H_0)\)

if \(n_t(A^t, H_0) > 0\) then \(u_t(A^t, H_0) = U_t\)

if \(n_t(A^t, H_0) = 0\) then \(u_t(A^t, H_0) \leq U_t\)