Equilibrium Effects of Housing Subsidies: Evidence from a Policy Notch in Colombia

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Are Market-Oriented Housing Policies Effective?

Governments around the world provide subsidies or tax incentives to promote home-ownership and new housing construction.

e.g., *help to buy*, *first time home buyer programs*, MID, LIHTC,

Questions:

1. Housing market effect?
   - Prices, quantities, **type of housing**
2. Does incentivize home-ownership work?
   - Who benefits from them?
   - What happens if these policies are removed?
   - Are there efficiency costs or unintended consequences?

This Paper

- Challenges:
  1. We need a model that allows for product differentiation.
  2. Identification approach to disentangle demand and supply responses rely on strong assumptions.
  3. Hard to get detailed housing data.
- Colombian Housing Policy:
  1. Subsidies to low-income households to buy ***low-cost housing.***
  2. Tax incentives to developers who build ***low-cost housing.***
  3. ***low-cost housing***: $P < \underline{P} = 135$ monthly minimum wages (mMW)

$\approx 40,000\ \$USD$

... Additionally:

- Subsidy expansion 2006-2018
- Unique and novel data
  - Census data for all new construction projects.
  - Administrative records for the subsidies.

This Paper

I. Evidence of how these policy scheme affects the type of housing built.

II. Identification and Estimation of a model that rationalises the observed equilbirum.

III. Policy evaluation and welfare analysis.



Literature and Contribution

Integrates the ***bunching*** and ***hedonic*** literatures to propose a method to think about welfare consequences of ***housing policies***

Bunching	**Hedonic**	**Housing Policy**
▶ Housing market	▶ Policy notch	▶ Evidence
▶ Link to model	▶ Supply side	▶ Welfare
▶ Supply and demand	▶ Identification	▶ Counterfactuals

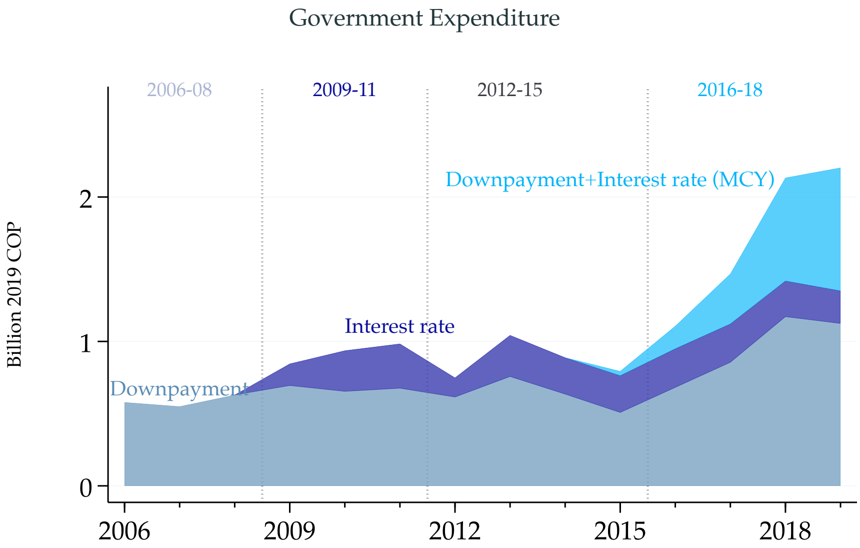
- Housing market applications
  Best et al. (2019), DeFusco and Paciorek (2017)
- Methodology
  Notches >> Kinks:
  Kleven (2016), Bertanha et al. (2021), Blomquist et al. (2021)

- Seminal paper
  Rosen (1974),Epple (1987)
- Recent Contributions
  Bajari and Benkard (2005), Heckman et al. (2010), Epple et al. (2020), Chernozhukov et al. (2021)
- Reviews
  Kuminoff et al. (2013), Greenstone (2017)

- Developers subsidies
  Baum-Snow and Marion (2009), Soltas (2021), Sinai and Waldfogel (2005)
- Households Subsidies
  Carozzi et al. (2020)
- Incidence and welfare
  Poterba (1992), Galiani et al. (2015)

I. Reduced Form Evidence

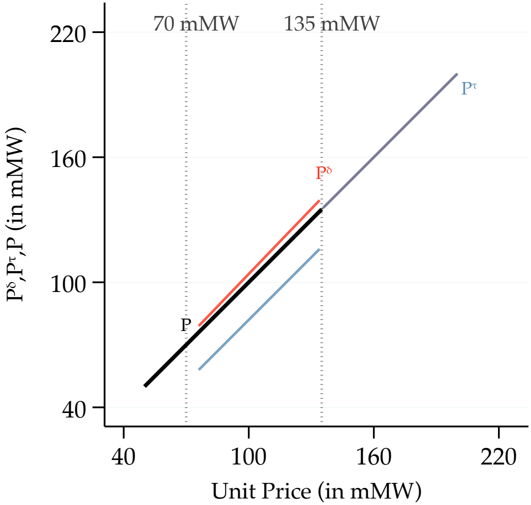
Policy Expansion: The Subsidy Size Doubled and More Households Became Eligible



The Notch: Discontinuous Incentives Trigger Bunching at the Cutoff

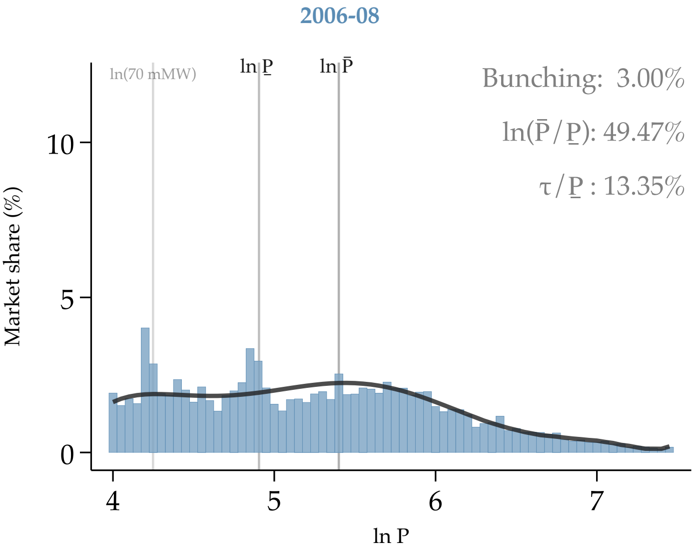
The three prices:

- **Transaction Price**
  P
- **Developers Price**
  $\mathbf{P}^{\delta} = P \cdot (1 + \delta)$:
  δ =Tax refund
- **Households price**
  $\mathbf{P}^{\tau} = P - \tau$
  τ =Subsidy
- Low-cost housing
- $P < \underline{P} = 135mMW$



Agents benefit from buying/selling *low cost housing* ($P \leq 135mMW$)

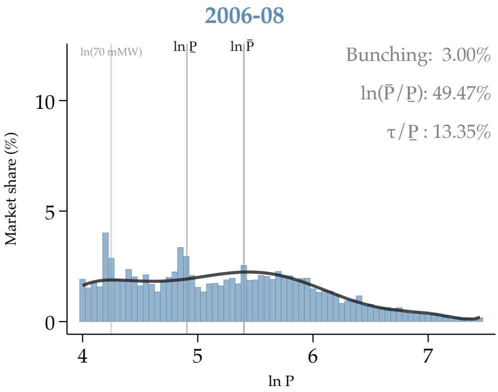
Bunching at the Low-Cost Housing Price Limit

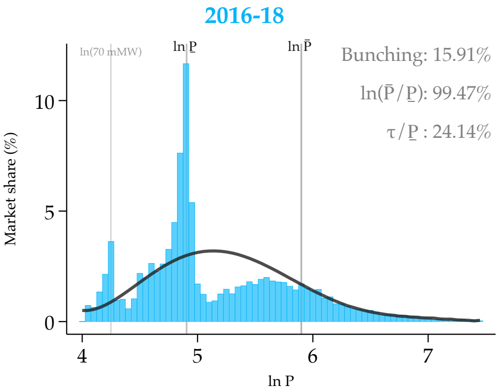


Solid line: Counterfactual Distribution

Kleven (2016); Chen et al. (2021); Diamond and Persson (2016)

Bunching at the Low-Cost Housing Price Limit





There is another notch at 70 *mMW* defining a cutoff targeting vulnerable populations.

II. Equilibrium Model of Housing Supply and Demand

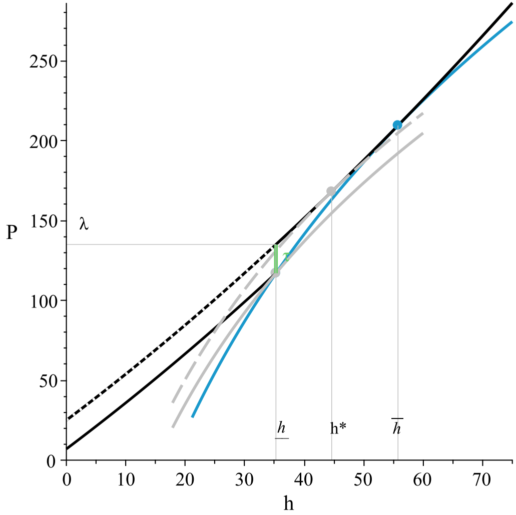
Housing Market Equilibrium Model

Hedonic/Sorting Equilibrium Model + Notched incentives

1. **Housing**
   - Differentiated product described by its size $h \in \mathcal{H}$
   - Price depends on size $P(h)$
2. **Households** $i \in I$, Heterogeneous in Income $Y_i \sim F_Y$
   - Choose h_i and consumption C_i to maximize Utility $U(C_i, h_i; \boldsymbol{\theta})$
3. **Developers** $j \in J$, Heterogeneous in Productivity $A_j \sim G_A$
   - Choose h_j to maximize profits
   - Number of Units: $Q = Q\left(h_j\right) |$lot,regulations
   - Building costs $B(A_j, h_j, Q\left(h_j\right); \boldsymbol{\beta})$
4. **Competitive Market Equilibrium**
   - Price function $P\left(h\right) \rightarrow$ clears the market $\forall h \in \mathcal{H}$

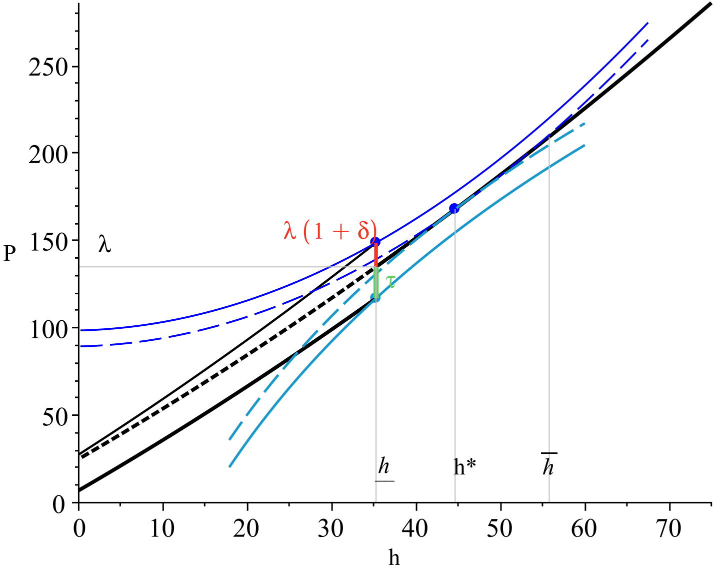
Rosen (1974); Kuminoff et al. (2013)

Households' Optimal Choices



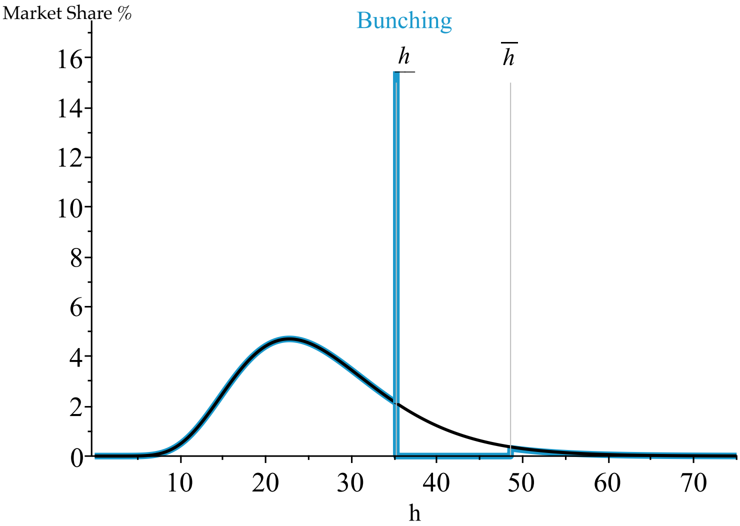
- **Implicit Price Function**
  $P(h)$
- **Subsidy**
  τ
- **Bid functions**
  $\varphi_D\left(h, Y, \bar{U}; \theta\right)$
    - $\bar{U} = U\left(h, Y_i - \varphi_D; \theta\right)$
    - $\bar{U}_\tau = U\left(h, Y_i - \varphi_D + \tau; \theta\right)$

Equilibrium: Developers and Households Match



Equilibrium price $P(h)$: Envelop of offer and bid curves.

Aggregate Equilibrium Density



How to aggregate? → Change of variable formula and optimality conditions (h^*)
see details

Estimation and Identification

Step I: Equilibrium Characterization

- Hedonic price function:

  $$P_{ltc} = P\left(h_{ltc}\right) + \Gamma' X_{ltc} + \varepsilon_{ltc}$$ see

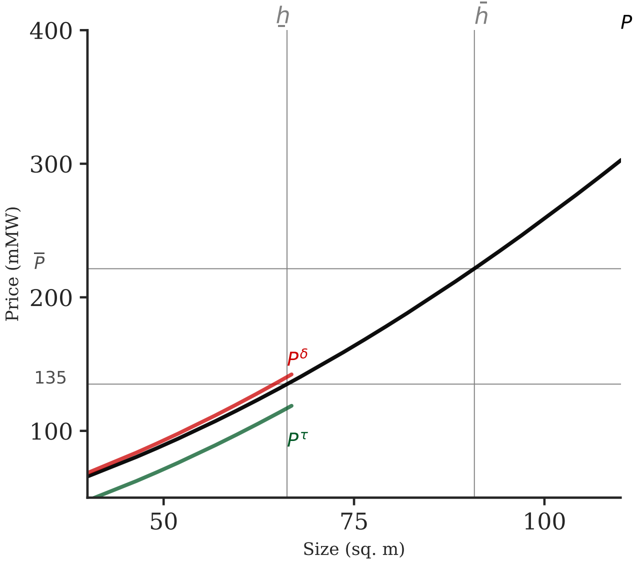
  Cattaneo et al. (2019a, 2019b)

- Notches:
  - Price after subsidy: P^{τ_t}
  - Price after tax: P^{δ} see
- Bunching:
  - $\overline{P} = \min_{P} \left\{ f^{Obs} = f^{CF} | P > \underline{P} \right\}$

    Kleven (2016); Chen et al. (2021)
- Size thresholds:
  - $\underline{h} = P^{-1}\left(135 mMW\right)$
  - $\overline{h} = P^{-1}\left(\overline{P}\right)$
- Unit Supply Function:

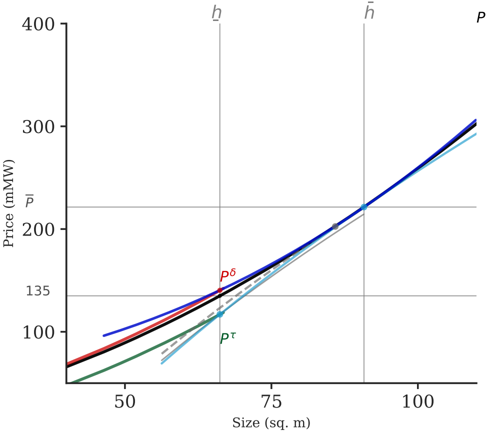
  $$Q_{ltc} = Q(h_{ltc}) + \Omega' X_{ltc} + \epsilon_{ltc}$$ see

  Cattaneo et al. (2019a, 2019b)



Step II: Marginal Buncher Condition and Stuctural Parameters Identification

- *Marginal Buncher Condition*
  - $U\left(\overline{Y}-\overline{P},\overline{h};\boldsymbol{\theta}\right)-U\left(\overline{Y}-\underline{P}^{\tau},\underline{h};\boldsymbol{\theta}\right)=0$
  - $\pi\left(\overline{A},Q(\overline{h}),P\left(\overline{h}\right);\boldsymbol{\beta}\right)-\pi\left(\overline{A},Q(\underline{h}),;P^{\delta}\left(\underline{h}\right);\boldsymbol{\beta}\right)=0$
- *Functional forms:*
  - $B=A_j\cdot Q\cdot h^{\boldsymbol{\beta}}$
  - $U=\left[\frac{1}{2}\cdot C^{\boldsymbol{\theta}}+\frac{1}{2}\cdot h^{\boldsymbol{\theta}}\right]^{\frac{1}{\boldsymbol{\theta}}}$
    $\sigma=1/(1-\theta)$
- *Optimally conditions:*
  - $\overline{Y}=\overline{P}-\left(\frac{\frac{1}{2}h^{\boldsymbol{\theta}-1}}{\overline{p}(\frac{1}{2}-1)}\right)^{\frac{1}{\boldsymbol{\theta}-1}}$
  - $\overline{A}=\frac{\left(\overline{P}\cdot\overline{q}+\overline{p}\cdot\overline{Q}\right)\overline{h}^{(1-\boldsymbol{\beta})}}{\overline{q}\cdot\overline{h}+\overline{Q}\cdot\boldsymbol{\beta}}$

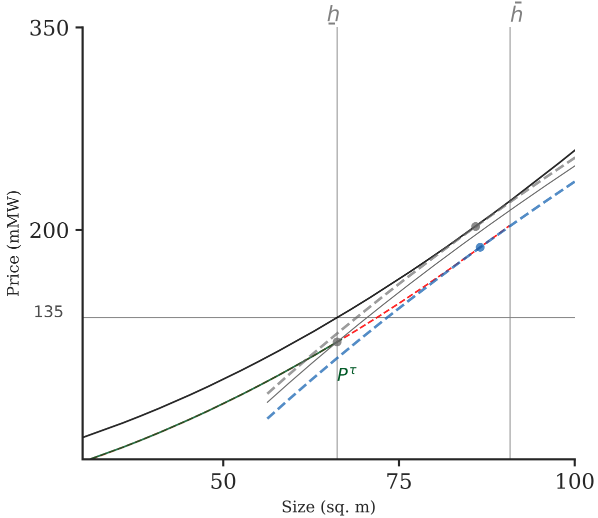


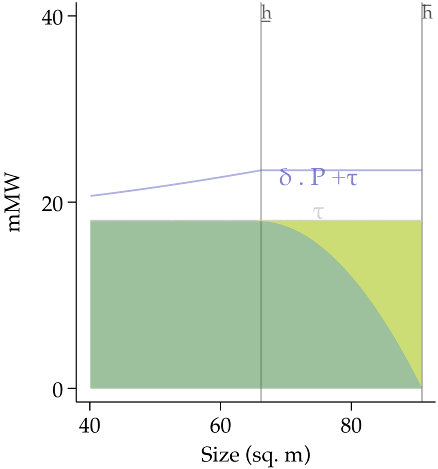
	06-08	09-11	12-15	16-18
β	2.34	2.03	1.65	1.29
σ	2.23	1.68	2.22	3.88

III. Welfare

Effect on Marginally Subsidized Households 2006-08

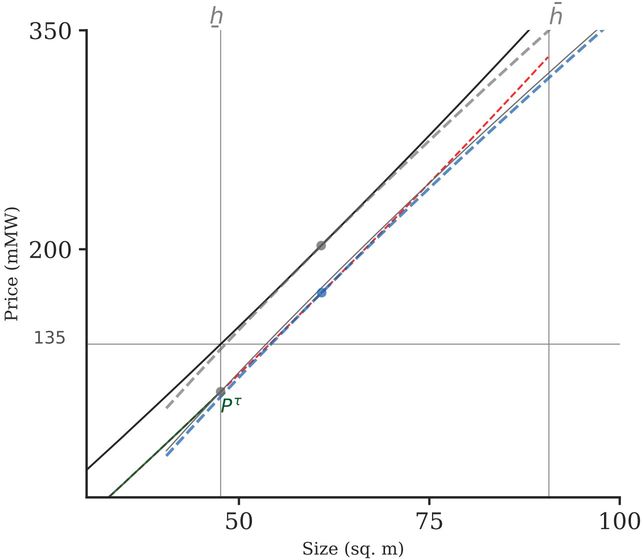
Same households get subsidy but they can buy any house.

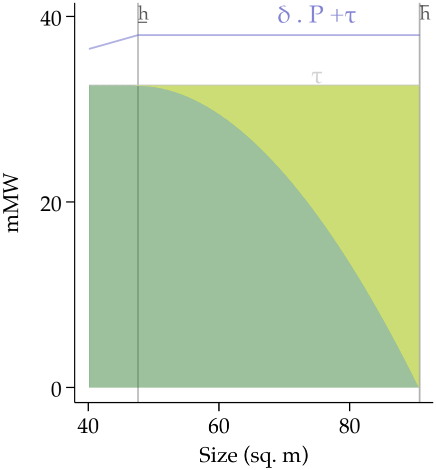




Effect on Marginally Subsidized Households

2016-18

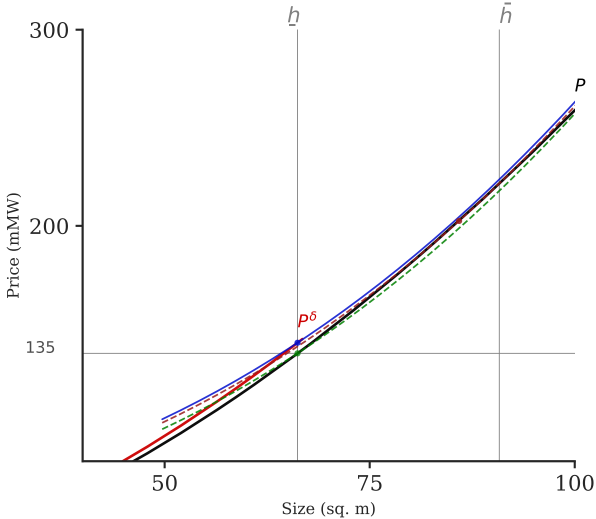


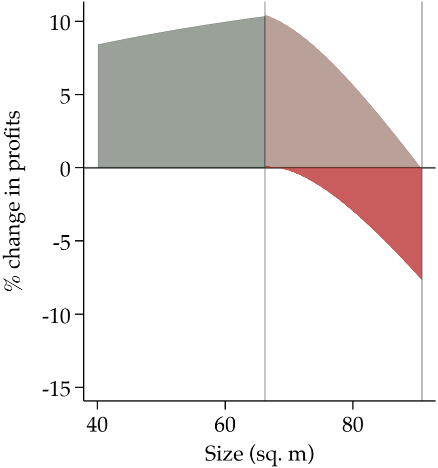


Developer Response to Tax Incentives

2006-08

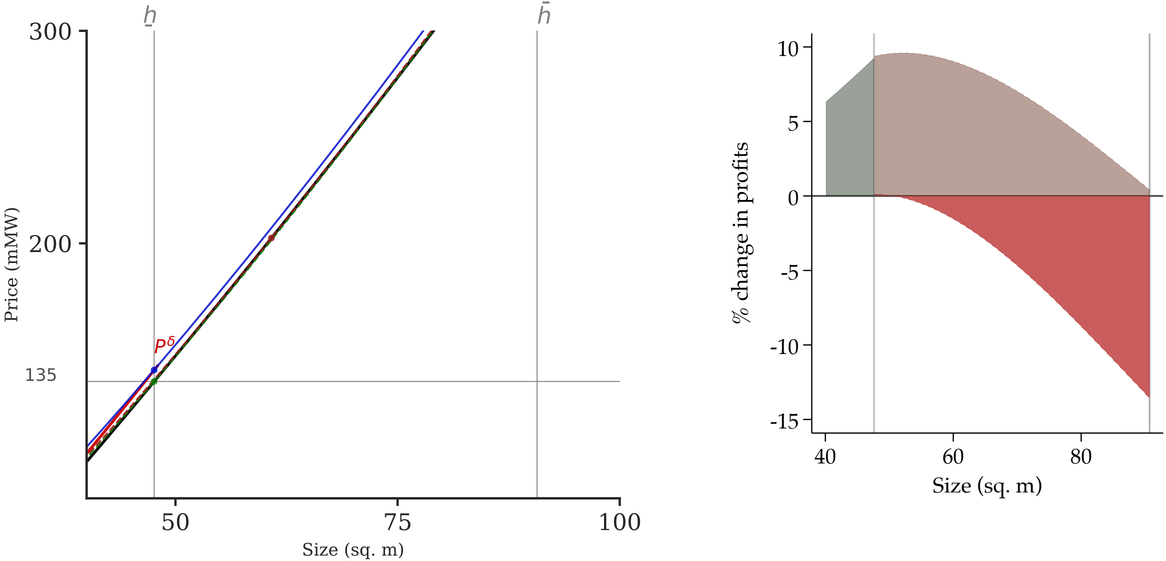
What happens if tax incentives are removed.





Developer Response to Tax Incentives

2016-18



Conclusion

- Policy design matters $\rightarrow$ need to know how agents respond to incentives in equilibrium to design effective policies.
- This method can be used to evaluate other housing policies.

  1. There is increasing evidence to bunching responses to discontinuous incentives (e.g., help to buy, voucher housing programs in the USA)
  2. Many regulations or targeting rules use arbitrary cutoffs.

- Further, it can be applied to other markets (e.g., labor markets, drugs, etc.)

Appendix

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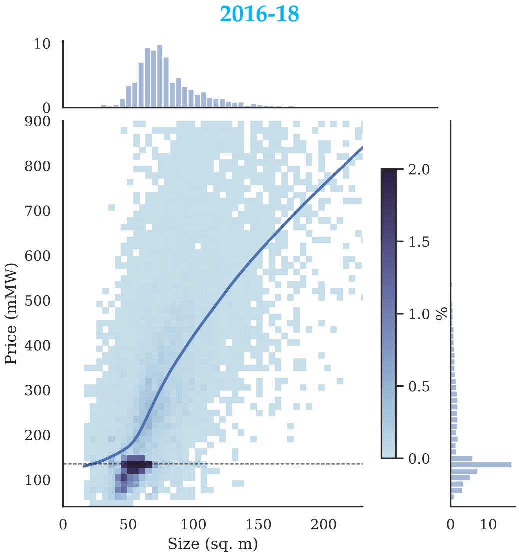
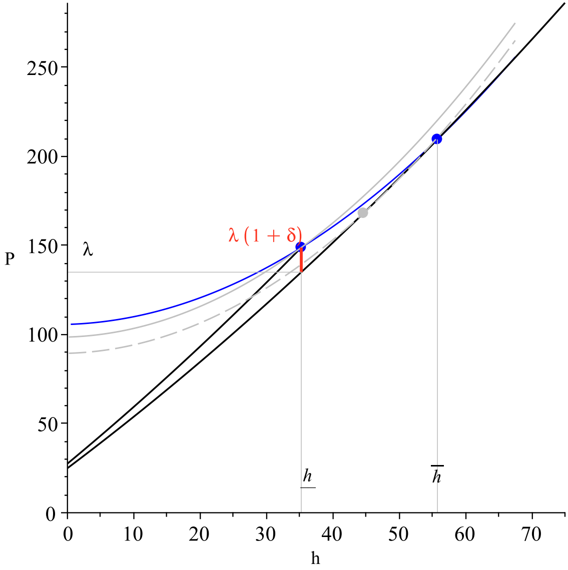
Observed Equilibrium: Prices, Quantities, and Size



- Solid line: price vs size
  → hedonic price function
- Multiple characteristics
  → Reduce to a single characteristic
- Standard unit size (h):
  → Size of a unit with average characteristics that costs the same price

details

Developers' Optimal Choices



- **Implicit Price Function**
  $P(h)$

- **Tax incentives**
  $P(h) \cdot (1 + \delta)$

- **Offer Functions**
  $\varphi_S \left(h, A_j, \bar{\pi}; \beta\right)$

$$\bar{\pi} = \pi \left(h, A_j, P\left(h\right); \boldsymbol{\beta}\right)$$
$$\bar{\pi}_\delta = \pi \left(h, A_j, P\left(h\right) * (1 + \delta)); \boldsymbol{\beta}\right)$$

Hedonic Prices

- Hedonic price/Implicit price for housing size

$$P_{ltc} = P\left(s_{ltc}\right) + \Gamma' X_{ltc} + \omega_{ltc} \tag{1}$$

l, house type in a development, t year, c city

  - Identifying assumption: $\mathrm{E}\left(s_{ltc} | X_{ltc}, \varepsilon_{ltc}\right) = 0$

- Standard Unit Size h_{ltc}

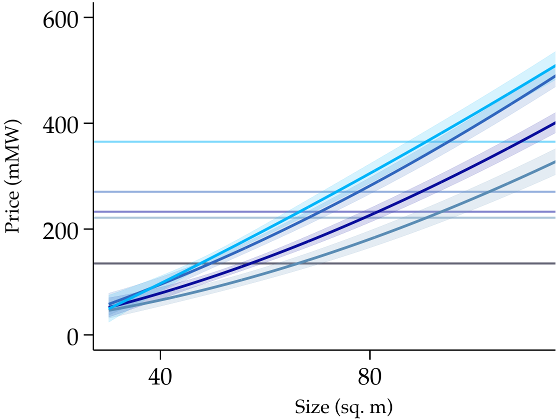
$$P = P\left(h_{ltc}\right) + \Gamma' \bar{X} + \bar{\omega} = P\left(size_{ltc}\right) + \Gamma' X_{ltc} + \omega_{ltc} \tag{2}$$

  - Characteristics of the standard house: $\bar{X}$, $\bar{\omega}$

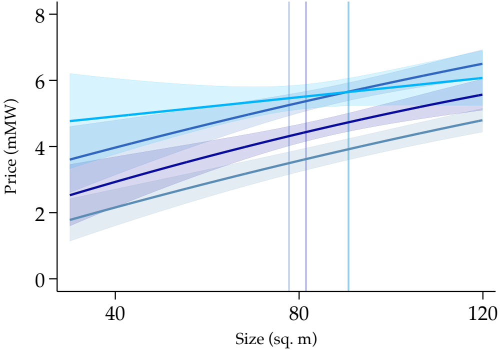
figures

Implicit Prices for Housing Size Over Time

$P(h)$

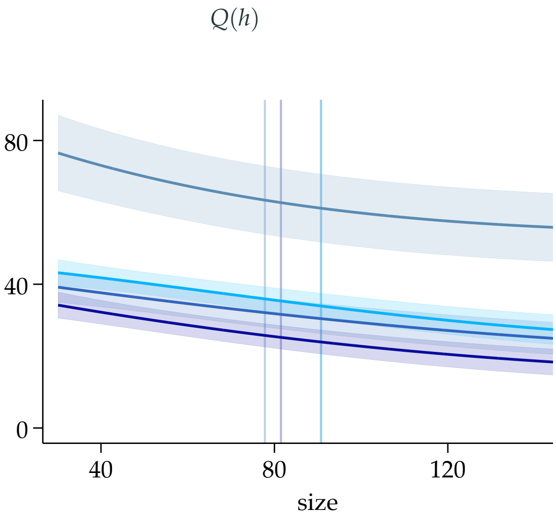


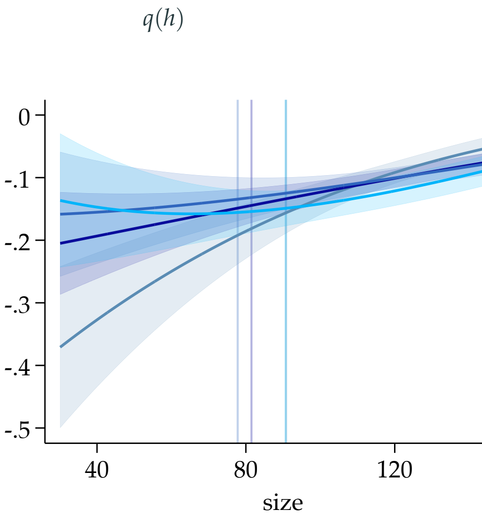
$p(h)$



Data

Developers Choices of Size and Unit Supply





Data

Behavioural Responses Induced by the Policy

- Recovered by comparing observed and counterfactual distribution

Observed f_{h^*} $\rightarrow$ histogram

Counterfactual f_{h_0} $\rightarrow$ predicted density excluding observations around the cutoff (Kleven, 2016)

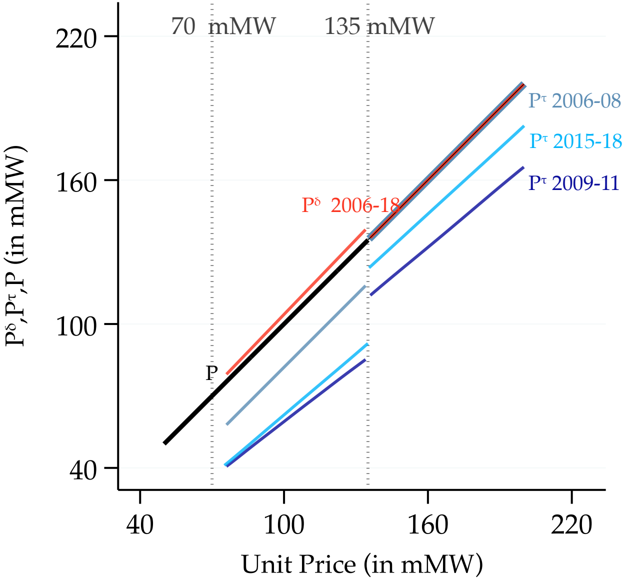
$$h_b = \sum_{p=0}^{T} \hat{\iota}_p h_b^p + \sum_{k=L}^{H} \kappa_k \cdot \mathbb{1}\left[h_k = h_b\right] + v_b$$

$$\hat{f}_{h_0} = \sum_{p=0}^{T} \hat{\iota}_p h_b^p$$

Choice parameters: bin size, bounds for excluded area (L,H) and polynomial degree p

Figures

The Demand Notch Increases Over Time



Supply Notch δ

2006-18 4%

Demand Notch τ_t

2006-08: 18 mMW

2009-11: 26 mMW

2016-18: 33 mMW

Note: 2012-15 Too many changes and free housing at 70 mMW

Notches

- Demand Notch Overtime

	Notch *(in mMW)*			# Subsidies *(in thousand)*		
	τ^M	τ^i	τ	*down payment*	*i rate*	*Mi Casa Ya*
2006-08	18.0	.	18.0	47.1	.	.
2009-11	20.0	5.85	25.9	46.4	16.7	.
2012-15	19.9	9.55	29.5	41.1	22.2	.
2016-18	25.3	7.24	32.6	44.5	23.4	16.8

- Supply Notch: 4 percent

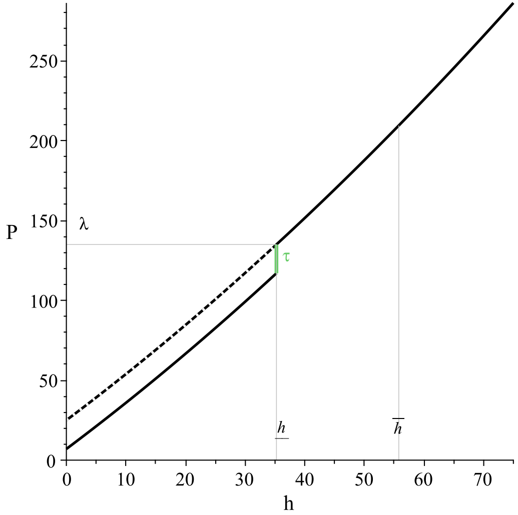
Step I

Model

Housing Market Equilibrium Model

1. **Housing**
   - Differentiated product described by its size $h \in \mathcal{H}$
   - Price depends on size $P(h)$
2. **Households** $i \in I$, Heterogeneous in Income $Y_i \sim F_Y$
   - Choose h_i and consumption C_i to maximize Utility $U(C_i, h_i; \theta)$
3. **Developers** $j \in J$, Heterogeneous in Productivity $A_j \sim G_A$
   - Choose h_j to maximize profits
   - Building costs $B(A_j, h_j, Q\left(h_j\right); \beta)$
4. **Competitive Market Equilibrium**
   - Price function $P(h) \rightarrow$ clears the market $\forall h \in \mathcal{H}$

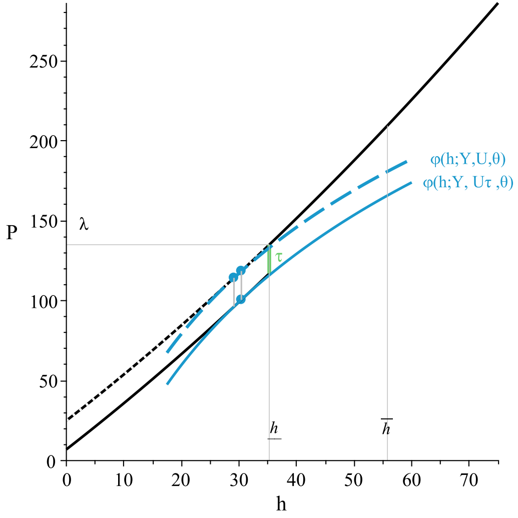
Households' Optimal Choices



- **Implicit Price Function**
  $P(h)$

- **Subsidy**
  τ

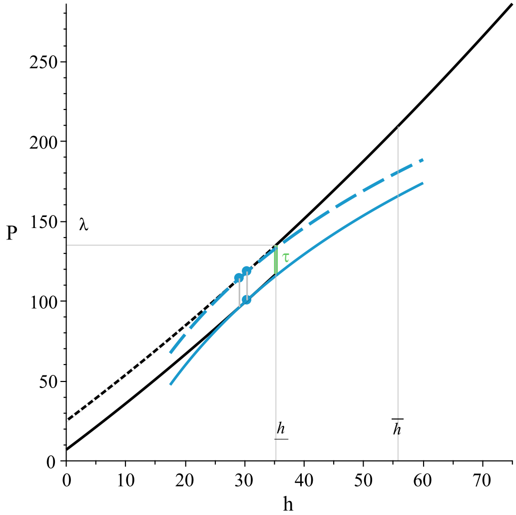
Households' Optimal Choices



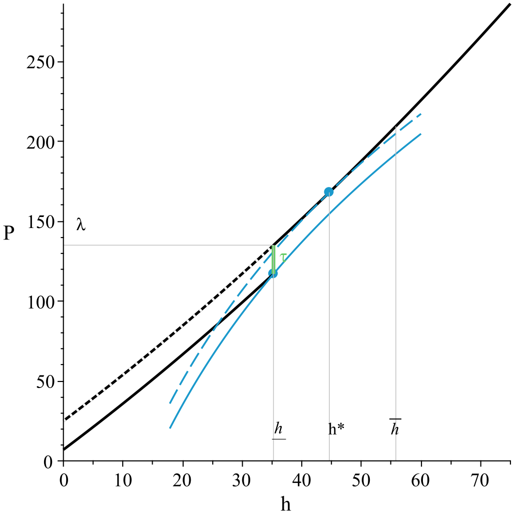
- **Implicit Price Function**
  $P(h)$
- **Subsidy**
  τ
- **Bid functions**
  $\varphi_D\left(h, Y, \bar{U}; \theta\right)$
  - $\bar{U} = U\left(h, Y_i - \varphi_D; \theta\right)$
  - $\bar{U}_\tau = U\left(h, Y_i - \varphi_D + \tau; \theta\right)$

Households' Optimal Choices

A.Subsidized

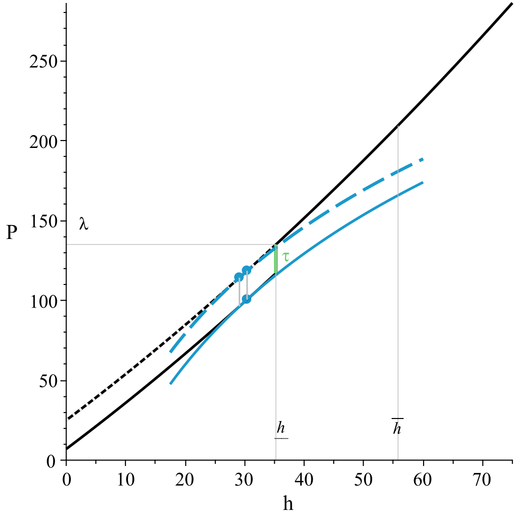


B.Marginally Subsidized and Bunchers

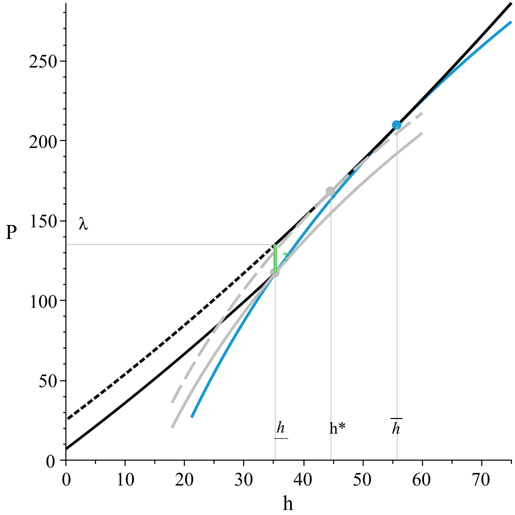


HOUSEHOLDS' OPTIMAL CHOICES

A.Subsidized



B.Marginally Subsidized and Bunchers



Housing demand function

Households' Demand Function

$$h^{\mathrm{D}}\left(Y_i\right) = \begin{cases} h^*\left(Y_i, \tau; \theta, \boldsymbol{\rho}, \lambda\right) & \text{if } Y_i \leq \underline{Y} \\ \underline{h} & \text{if } \underline{Y} < Y_i < \overline{Y} \\ h^*\left(Y_i, \tau; \theta, \boldsymbol{\rho}, \lambda\right) & \text{if } \overline{Y} \leq Y_i \end{cases}$$

- Tangency conditions: $h^*\left(Y_i, \tau; \theta, \boldsymbol{\rho}, \lambda\right)$
- Income and unit size: $Y_i = \tilde{Y}\left(h, \tau; \theta, \boldsymbol{\rho}, \lambda\right) = h^{*\,-1}\left(h_i, \tau; \theta, \boldsymbol{\rho}, \lambda\right)$

Graphs

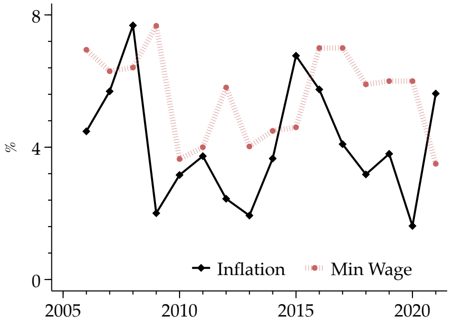
Equilibrium: Developers Aggregate Supply Density

$$D(h) = \begin{cases} f_{h^*}(h)\,\mathrm{d}h & \text{if } h < \underline{h} \\ f_{h^*}(h)\,\mathrm{d}h \\ \qquad + \int\limits_{\underline{h}}^{\overline{h}} f_{h^*}(h)\,\mathrm{d}h & \text{if } \underline{h} = h \\ 0 & \text{if } h \in \left(\underline{h}, \overline{h}\right) \\ f_h^*(h)\,\mathrm{d}h & \text{if } \overline{h} \leq h \end{cases}$$

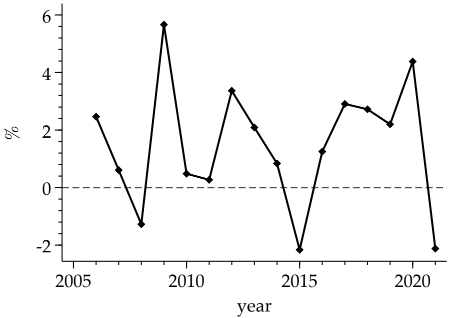
$$S(h) = \begin{cases} g_{h^*}(h) \cdot Q(h) & \text{if } h < \underline{h} \\ \left(g_{\underline{h}^*}(\underline{h}) + \int\limits_{\underline{h}}^{\overline{h}} g_{h^*}(h)\ \mathrm{d}h \right) \cdot Q(\underline{h}) & \text{if } \underline{h} = h \\ 0 & \text{if } \underline{h} < h < \overline{h} \\ g_{h^*} \cdot Q(h) & \text{if } \overline{h} \leq h \end{cases}$$

Equilibrium Figures

Inflation and minimum wages.



a. Min wage and Inflation



b. Min wage and Inflation

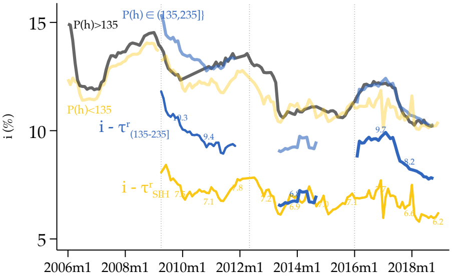
Data

DATA: MORTGAGES AND INTEREST RATES

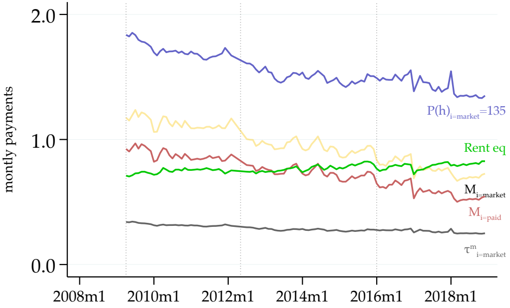
rent equivalent ((Poterba, 1984), (Bishop & Timmins, 2019) assume it is 0.05)

- Size of the mortgages and interest rate.
- Identifier for SIH.

Market interest rate i and subsidy τ^r



Monthly payments and monthly equivalent for relevant values. $P(h) < 135$

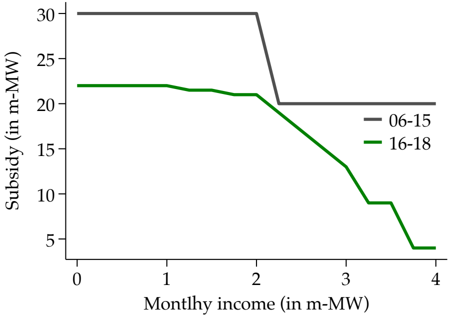


- To convert the magnitudes into monthly payments I use:

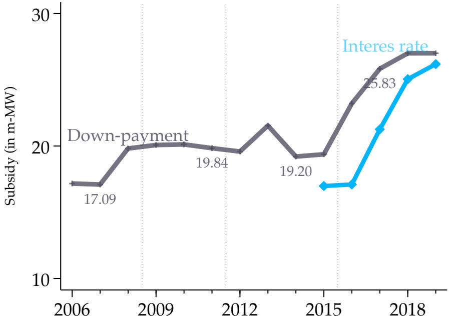
$$X_{montly} = X \cdot \kappa(i,n) \, ; \kappa(i,n) = \frac{\frac{i}{12} \cdot \left(1 + \frac{i}{12}\right)^{12 \cdot n}}{\left(1 + \frac{i}{12}\right)^{n \cdot 12} - 1}$$

The Notch: Down Payment Subsidy

Subsidy by household income

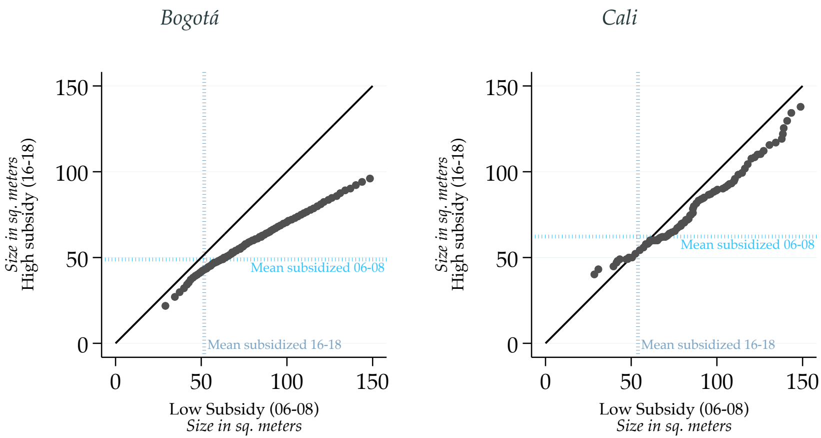


Average subsidy over time



- Varies by income.
- Increase in 2016.
- Expanded trough *mi casa YA*

Changes in Housing Stock Characteristics



model