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

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Is a Market-Oriented Housing Policy Effective?

- Governments implement various **market-oriented** policies to promote housing construction and promote homeownership
- Subsidies or tax incentives
- Housing market effect?
  - Prices, quantities, **type of housing**
- Is this market-oriented approach effective?
  - How big are the efficiency costs?
  - Are there any unintended consequences?
  - To what extend households and developers benefit?
  - What happens if these policies are removed?
- I use quasi-experimental variation to estimate a model of supply and demand of housing.

Colombian Housing Policy

- Policy tools:
  - Subsidies to low-income households.
  - Tax incentives to developers who build low-cost housing.
  - A price cap defining eligibility

    135 monthly minimum wages (mMW) $\approx 40,000$ USD
- Empirical advantages of Colombian setting:
  - Price cap on units qualifying for the subsidy.
    - Discontinuous Budget Constraint.
    - Incentives to developers and households to bunch.
  - Unique and novel data:
    - Census data for all new construction projects.
    - Administrative records for the subsidies.
  - Subsidy expansion between 2006-18

This Paper

I. Descriptive evidence
   - Characterization of observed equilibrium.
   - Evidence of housing market responding to the subsidy scheme.

II. Hedonic equilibrium of housing supply and demand
   - Product differentiation and heterogeneous developers and households.
   - Identification using bunching an policy changes.

III. Proposed policy counterfactual and welfare
   - Tax reform in Colombia in 2021– Remove tax incentives to developers.
   - Policy change – phasing out price caps

   → Effects on households and developers

RESULTS

I. Behavioural responses induced by the subsidy scheme.
   - Bunching at price cutoff
   - Larger response as the subsidies increase → market share at cutoff went from 1% to 7%
   - Households downsize → they buy units up to 30% percent smaller to benefit from the subsidy

II. Estimate a model that rationalizes the market observed equilibrium
   - Elasticity of substitution between on housing and consumption is 0.9

III. Effects of the proposed policies
   - Colombian 2021 Tax proposal could create a housing shortage.
   - Removing the price cap increases welfare.

Literature and Contribution

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

Bunching	**Hedonic**	**Housing Policy**
▶ Housing Markets	▶ Policy Notch	▶ Evidence
▶ Supply,Demand	▶ Supply side	▶ Method
▶ Identification of SP	▶ Identification	▶ Welfare

- 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
  S. 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 (2020), Sinai and Waldfogel (2005)
- Households Subsidies
  Carozzi et al. (2020)
- Incidence and welfare
  Poterba (1992), Galiani et al. (2015)

I. Descriptive Analysis: Data, Policy and Observed Equilibrium

POLICY TOOLS

1. Supply Subsidies
   - Value Added Tax (VAT) refund
2. Demand Subsidies
   - Downpayment
   - Interest rate

   Income $\leq$ 4 monthly minimum wages (mMW) classify
3. Targeting tool for the subsidy:
   - Only new *low cost* units are eligible

$$\text{Low cost} = \begin{cases} 1 & \text{if } P_t \leq \mathbf{135}\, mMW_t \\ 0 & \text{if } P_t > \mathbf{135}\, mMW_t \end{cases}$$

Note: $\mathbf{135}\ mMW \approx 40,000\ \$USD$

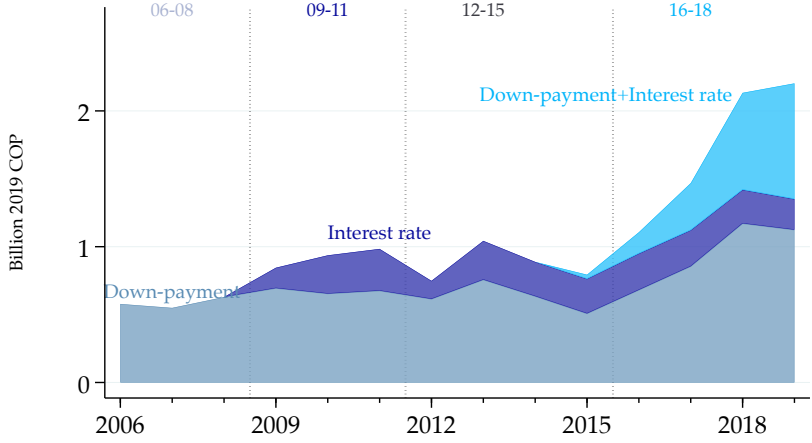
DATA

1. Administrative Records from Minister of Housing
   - Subsidy size
   - Mortgage information

   → Government expenditure on each subsidy
2. New Construction Census (Camacol)
   - 126 Municipalities
   - Years: 2006-2018
   - Sale prices
   - Quantities
   - Unit Characteristics: **size**,location, # rooms, # bathrooms, etc.
   - Everything measure in montly minimum wages (mMW) or 2019 COP

     Inflation and mMW change

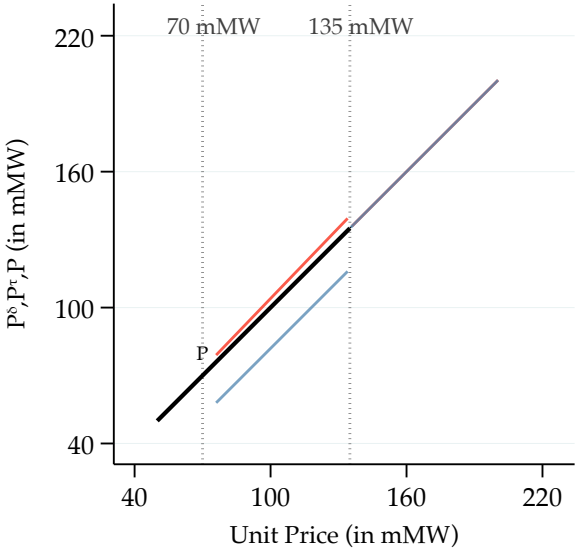
Government Expenditure and Policy Expansion



- Total housing subsidies beneficiaries 100′000 in 2019
- 2 billion COP $\sim$ 0.25% Colombian GDP
- Colombian Conditional Cash Transfers 3, 6 billon COP for 2.3 million households

The Notch

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



Transaction Price

P

Developers Price

$\mathbf{P}^{\delta} = P \cdot (1 + \delta)$:

δ =Tax refund

Households price

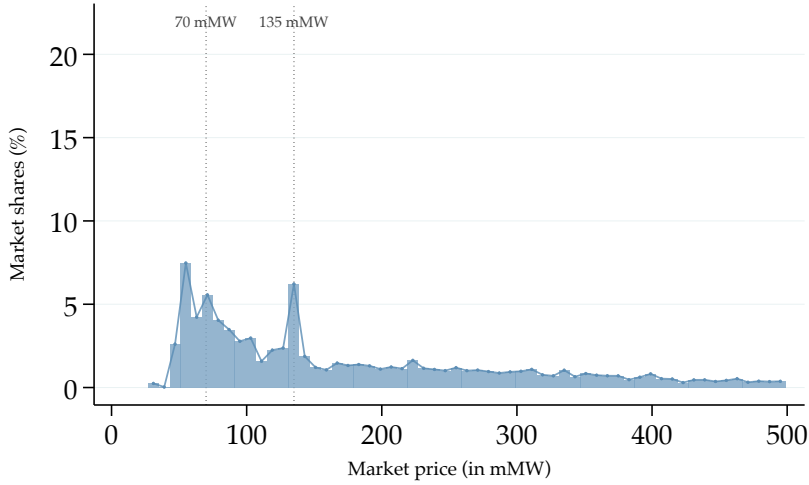
$\mathbf{P}^{\tau} = P - \tau$

τ =Subsidy

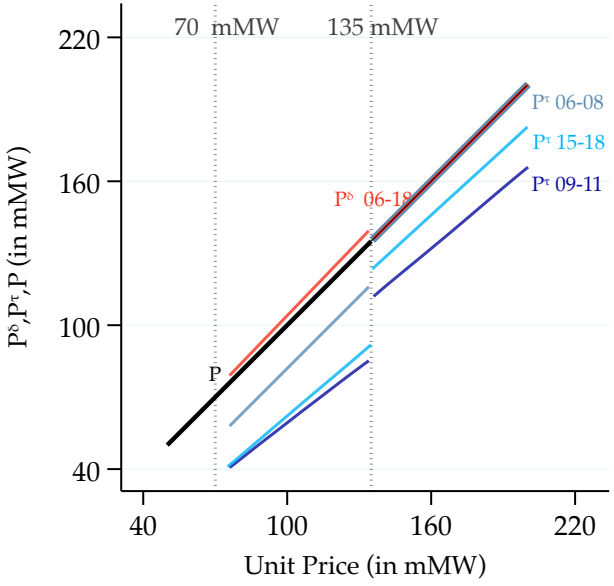
Bunching at the Low-Cost Housing Price Limit

Only downpayment subsidy

2006-08



The Demand Notch Increases Over Time



Supply Notch δ

2006-18 4%

Demand Notch τ_t

2006-08: 19.7 *mMW*

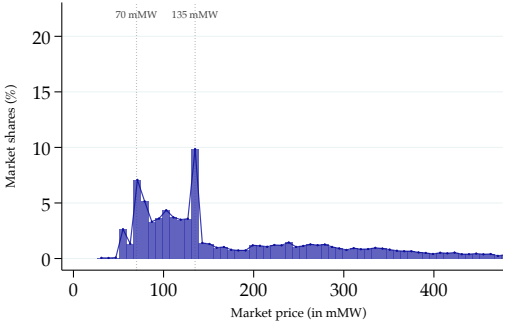
2009-11: 26.4 *mMW*

2016-18: 33.1 *mMW*

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

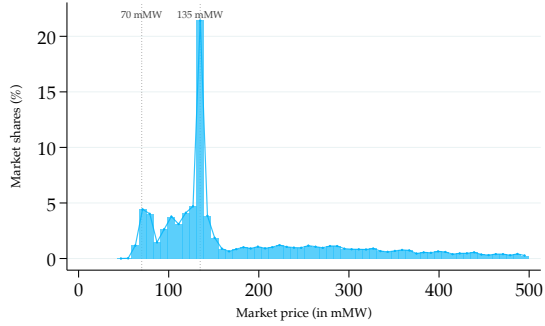
Larger Bunching as Notch Increases

Downpayment and interest rate subsidies
2009-11



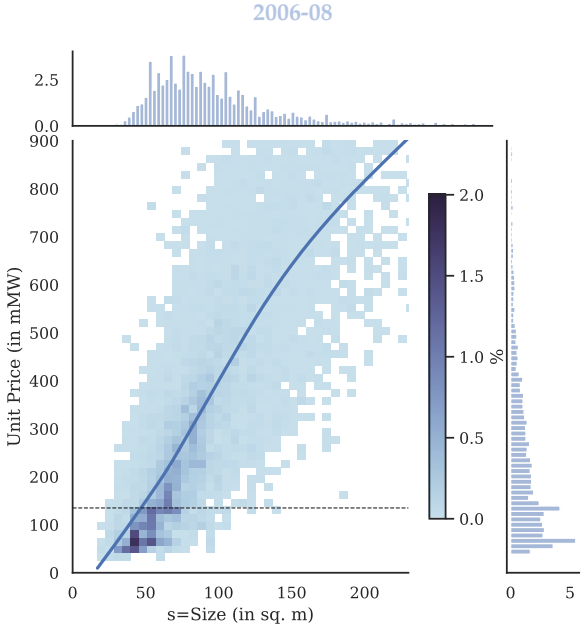
Notch: 19.7 *mMW*

Subsidy expansion
2016-18



Notch: 33.1 *mMW*

Observed Equilibrium: Prices, Quantities, and Size



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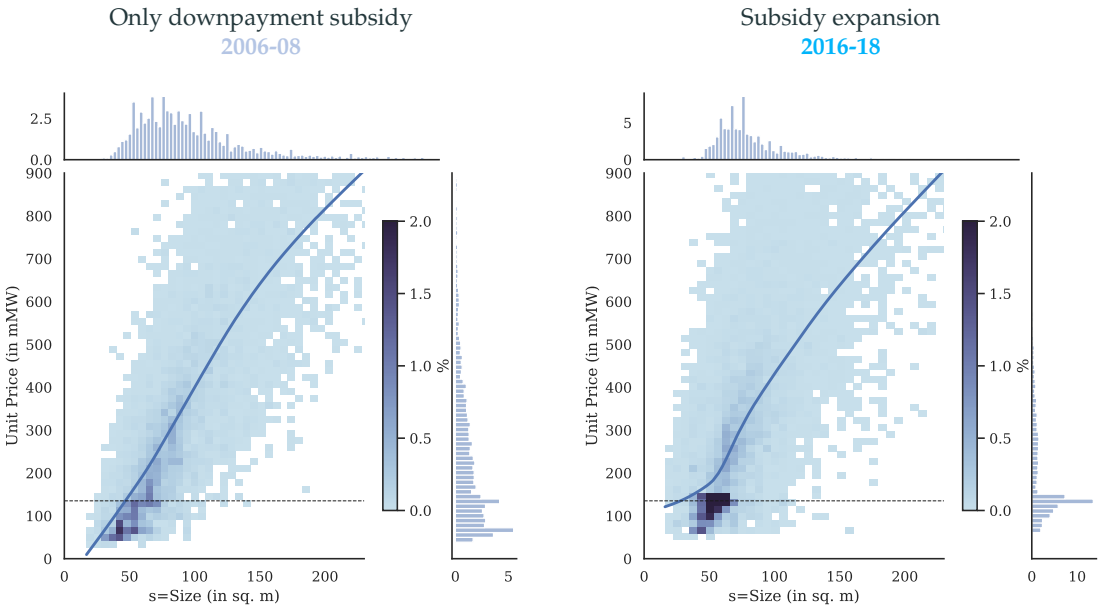
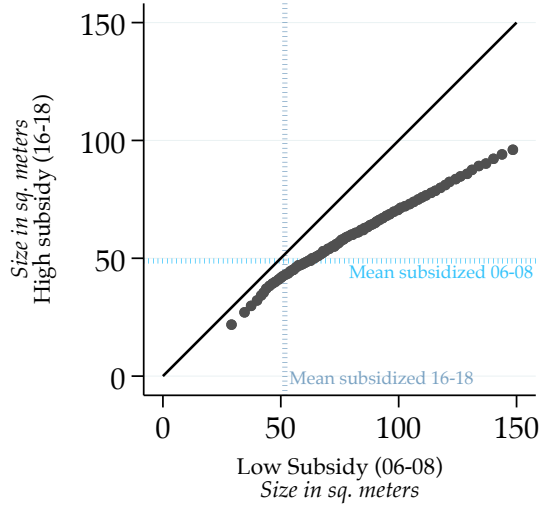


Changes in Housing Stock Characteristics

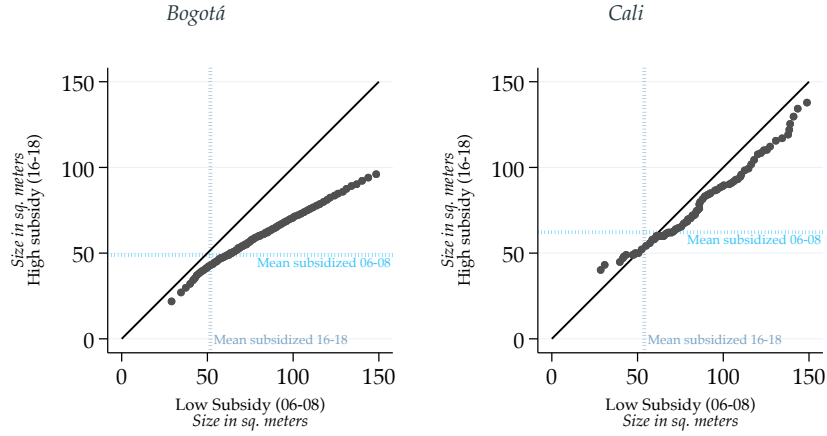
- Changes in unit size (quantile to quantile to q plot)

Bogotá



Changes in Housing Stock Characteristics

- Changes in unit size



- Not only changes in prices
- Size is not the only characteristic

Hedonic Prices and Standardized Housing Unit

- Hedonic price/Implicit price for housing size

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

l, development, t year, c city

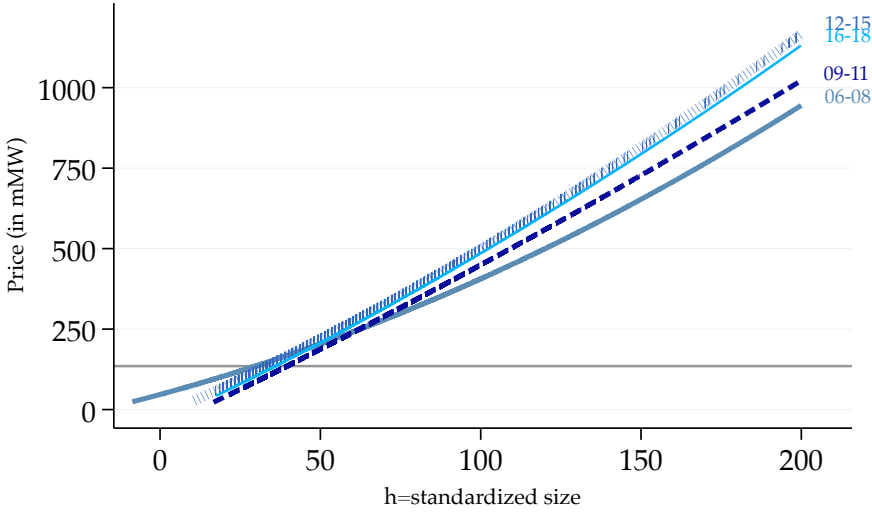
- Standard Unit Size h_{ltc}

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

  - Characteristics of the standard house: $\bar{X}, \bar{\omega}$
  - Simplifying assumption: $\rho\left(s_{ltc}\right) = \rho_1 \cdot s_{ltc} + \rho_2 \cdot {s^2}_{ltc}$
  - Identifying assumption: $\mathrm{E}\left(s_{ltc} | X_{ltc}, \omega_{ltc}\right) = 0$

- Why size?
  - Continuous, easy to measure, monotonic relationship with price and income.
  - In contrast to most datasets, I observe it.

Implicit Prices for Housing Size Over Time



Plotted lines: $P_{ltc} = \hat{\rho}_1 \cdot h_{ltc} + \hat{\rho}_2 \cdot h^2{}_{ltc} + \Gamma' \bar{X} + \bar{\omega}$

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)

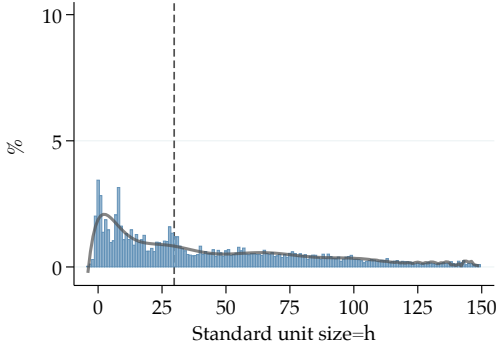
$$h_b = \sum_{p=0}^{T} \hat{\iota}_p h_b^p + \sum_{k=L}^{H} \kappa_k \cdot \mathbb{1}\left[h_k = h_b\right] + v_b$$

$$\hat{f}_{h_0} = \hat{l}\left(h_b\right) = \sum_{p=0}^{T} \hat{\iota}_p h_b^p$$

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

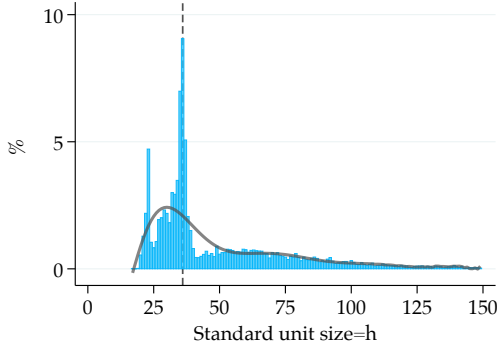
Bunching in Housing Characteristics (Size of std. Unit)

2006-08



Notch: 19.7 *mMW*

2016-18



Notch: 33.1 *mMW*

The Policy Effect on Observed Outcomes

Table 1: Behavioral Responses Estimates'

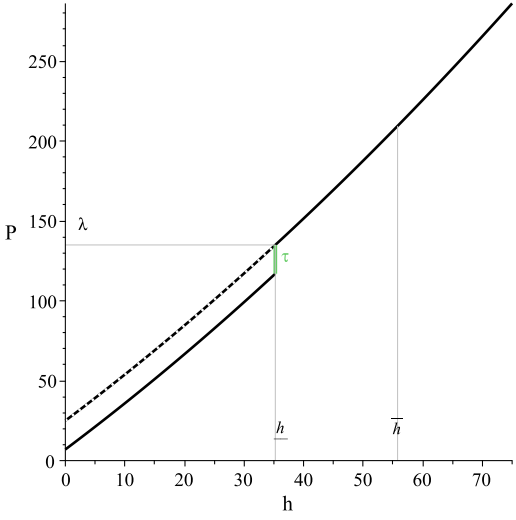
	06-08	09-11	12-15	16-18
$\int_{h_{min}}^{\underline{h}^-} T(h)\mathrm{d}h$	1.03	0.86	3.83	7.28
$\hat{T}(\underline{h})$	0.50	2.02	4.02	6.97
$\int_{h_{min}}^{\underline{h}} T(h)\mathrm{d}h$	1.53	2.88	7.85	14.2
$\int_{\underline{h}}^{\overline{h}} T(h)\mathrm{d}h$	-0.096	-6.25	-4.13	-3.42
$h_{\underline{h}^0}(\underline{h})$	0.72	1.28	1.06	1.44
h_{min}	26	37	29	32
$\underline{h}$	29.8	39.4	33.0	36.0
$\overline{h}$	40	53	45	49

II. Equilibrium Model of Housing Supply and Demand

A Stylized Housing Market Model

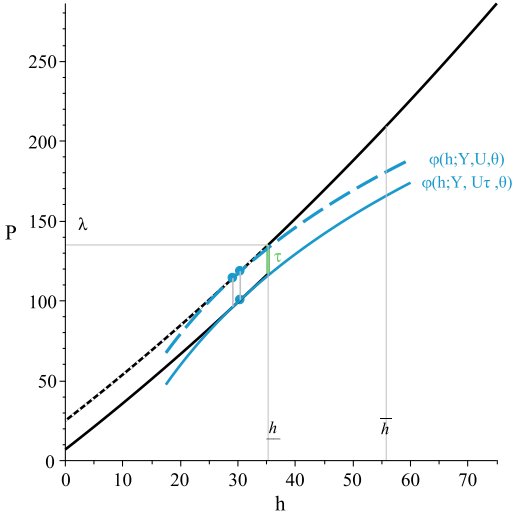
1. **Housing**
   - Differentiated product described by its size $h \in \mathcal{H}$
   - Price depends on size $P(h)$
2. **Households** $i \in I$, Heterogeneous in Income $Y_i \sim F_Y$
   - Choose h_i and consumption C_i to maximize Utility $U(C_i, h_i; \theta)$
3. **Developers** $j \in J$, Heterogeneous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

Households' Optimal Choices



- **Implicit Price Function**: $P(h)$
- **Subsidy** τ

Households' Optimal Choices

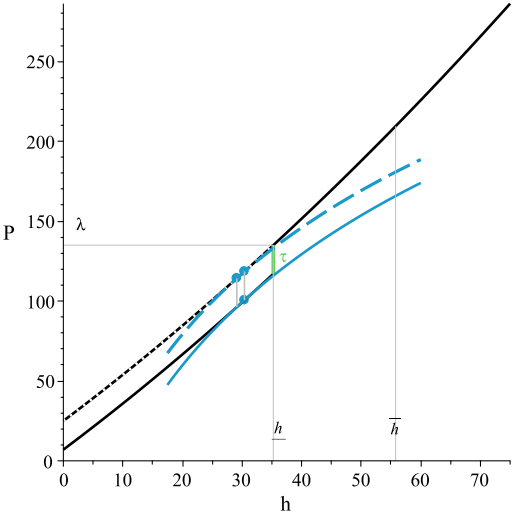


- **Implicit Price Function**: $P(h)$
- **Subsidy** τ
- **Bid functions** $\varphi_D\left(h, Y, \bar{U}; \theta\right)$

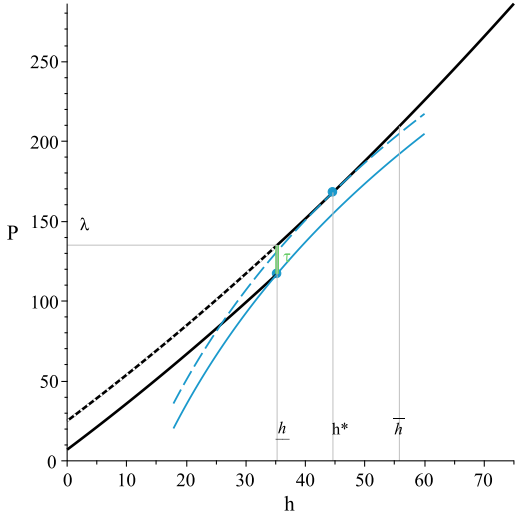
$$\bar{U} = U\left(h, Y_i - \varphi_D; \theta\right)$$
$$\bar{U}_\tau = U\left(h, Y_i - \varphi_D + \tau; \theta\right)$$

Households' Optimal Choices

A.Subsidized

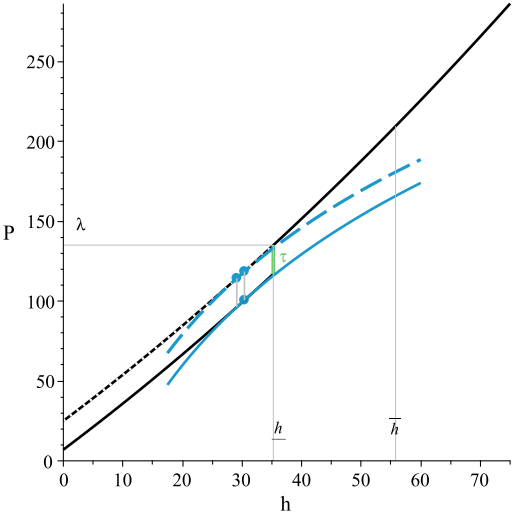


B.Marginally Subsidized and Bunchers



Households' Optimal Choices

A.Subsidized



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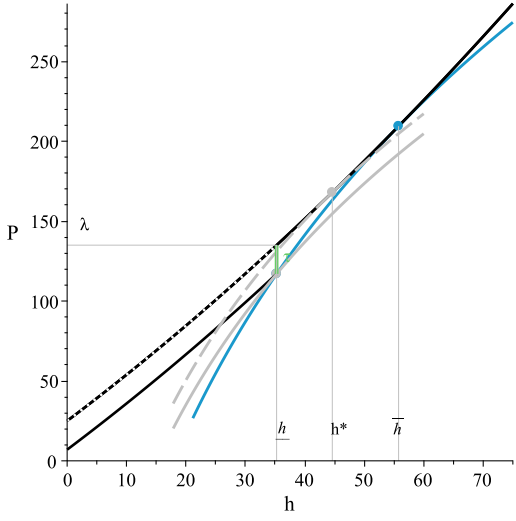


Households' Demand Function

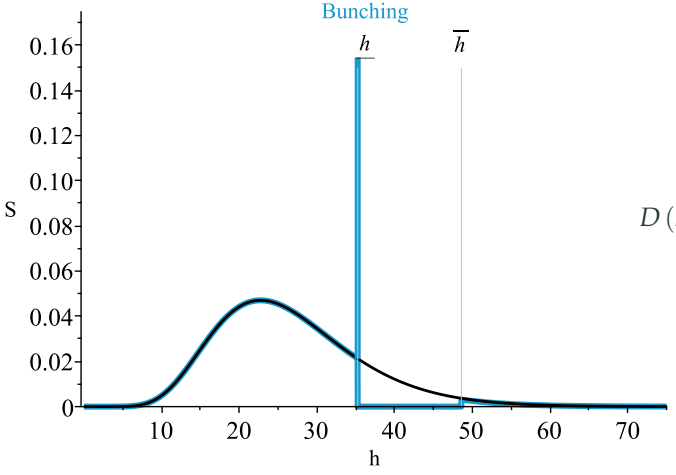
Tangency conditions: $h^{*}\left(Y_i, \tau; \theta, \boldsymbol{\rho}, \lambda\right)$

- Housing demand:

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

- How to aggregate:
  - Income and unit size: $Y_i = \tilde{Y}\left(h, \tau; \theta, \boldsymbol{\rho}, \lambda\right) = {h^{*}}^{-1}\left(h_i, \tau; \theta, \boldsymbol{\rho}, \lambda\right)$
  - change of variable formula using the distribution of income

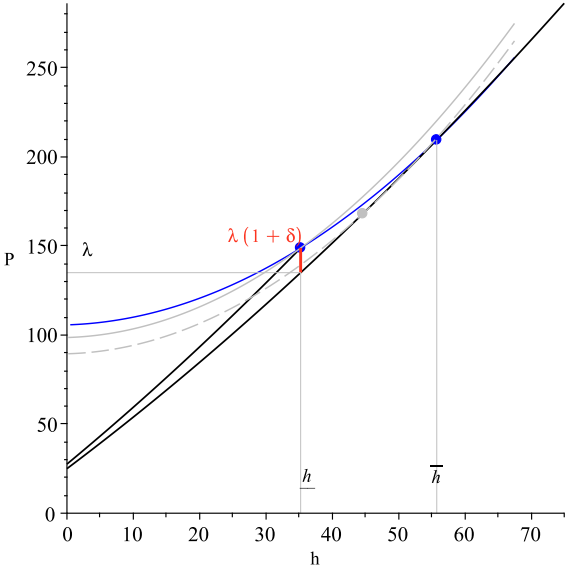
Aggregate Demand Density



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

Developers' Choices

Marginally Subsidized and Bunchers



- **Implicit Price Function**: $P(h)$
- **Tax incentives**: $P(h) \cdot (1+\delta)$
- **Offer Functions**

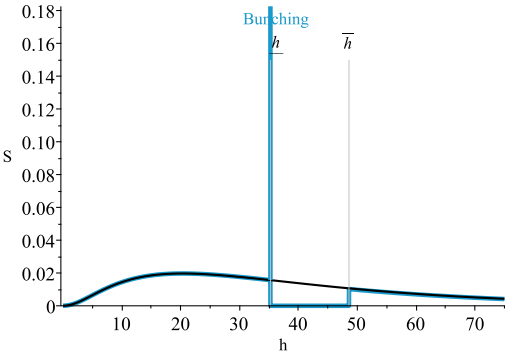
  $\varphi_S\left(h, A_j, \bar{\pi}, \boldsymbol{\beta}\right)$

  $\bar{\pi} = \left(h, A_j, P\left(h\right), \boldsymbol{\beta},\right)$

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

Developers Aggregate Supply Density

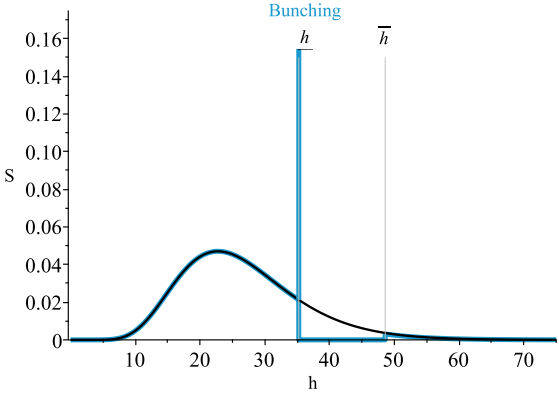
Density function $g_h(h)$

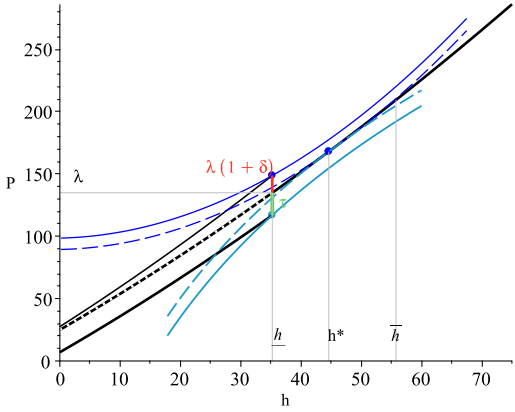


$$S(h) = \begin{cases} g_{h^*}(h) \cdot Q(h) & \text{if } h < \underline{h} \\ \left(g_{\underline{h}^*}(\underline{h}) + \int_{\underline{h}}^{\overline{h}} g_{h^*}(h)\ \mathrm{d}h \right) \cdot Q(\underline{h}) & \text{if } \underline{h} = h \\ 0 & \text{if } \underline{h} < h < \overline{h} \\ g_{h^*}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

Assumption: $Q_j = \alpha_0 + \alpha_1 \cdot h_j(exogenous)$

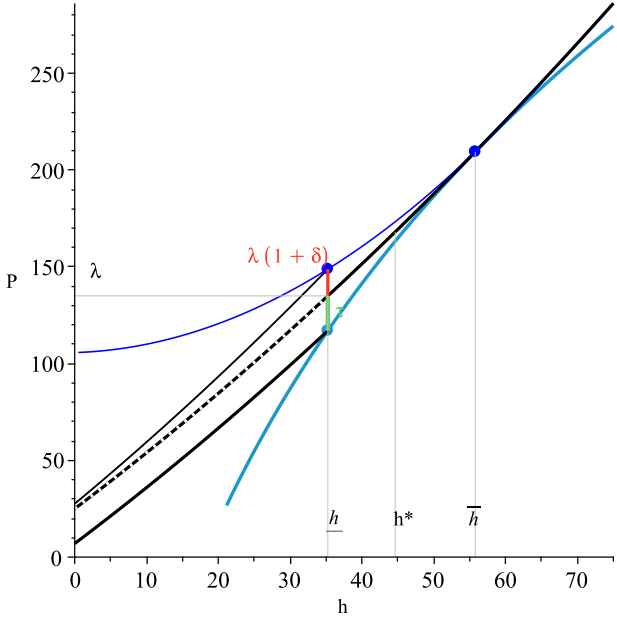
Equilibrium





Identification

Marginal Buncher Condition



Marginal Buncher Condition

Marginal Buncher Condition	
Household	$V_D = U\left(\overline{Y} - P\left(\overline{h}\right), \overline{h}; \boldsymbol{\theta}\right) - U\left(\overline{Y} - P^{\tau}\left(\underline{h}\right), \underline{h}; \boldsymbol{\theta}\right) = 0$
Developer	$V_S = \pi\left(Q(\overline{h}), \overline{A}, P\left(\overline{h}\right); \boldsymbol{\beta}\right) - \pi\left(Q(\underline{h}), \overline{A}; P^{\delta}\left(\underline{h}\right); \boldsymbol{\beta}\right) = 0$
Optimality Conditions	
Income	$\overline{Y} = \tilde{Y}\left(\overline{h}; \boldsymbol{\theta}, P(h), \lambda\right)$
Productivity	$\overline{A} = \tilde{A}\left(\overline{h}; \boldsymbol{\beta}, P(h), \lambda\right)$
Functional Forms	
Implicit Price	$P = \rho_0 + \rho_1 \cdot h + \rho_2 \cdot h^2$
Utility	$U = \left[\frac{1}{2} \cdot C^{\boldsymbol{\theta}} + \frac{1}{2} \cdot h^{\boldsymbol{\theta}}\right]^{\frac{1}{\boldsymbol{\theta}}}$
Unit Supply	$Q = \alpha_0 + \alpha_1 h$
Cost	$B = A_j \cdot Q \cdot h^{\boldsymbol{\beta}}$

Estimation

STEP I

1. Using the observed hedonic equilibrium
   - Price function: $\boldsymbol{\rho_t} = \rho_{0t}, \rho_{1t}, \rho_{2t}$
   - Size threshold: $\underline{h} = P^{-1}(\lambda; \boldsymbol{\rho})$
   - Standard Unit Size: h

   data

2. Policy Parameters:
   - Notches: τ_t,δ

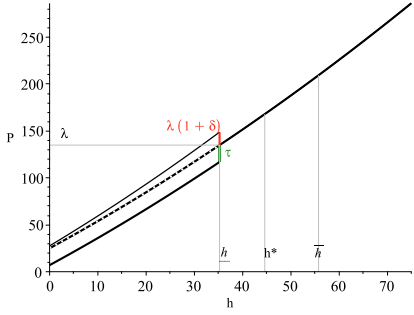
   data

3. Unit Supply Function:
   $Q = \boldsymbol{\alpha} = \alpha_0 + \alpha_1 \cdot h_{ltc}$

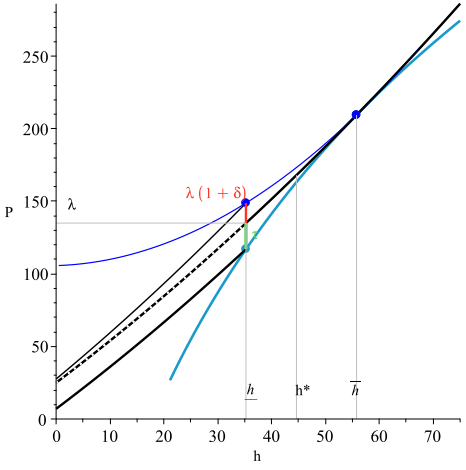
   data

4. Behavioural Responses:
   - Housing size for marginal buncher: $\overline{h}$

   data



Step II



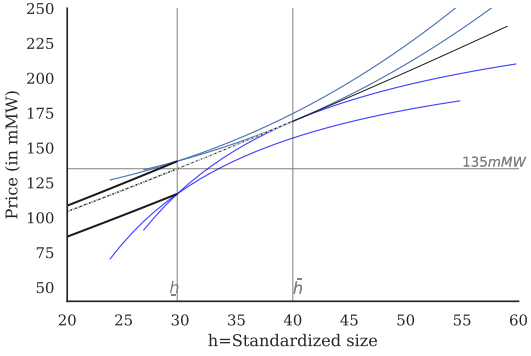
$$V_D\left(\boldsymbol{\theta}|\underline{h},\overline{h},P\left(h\right),\tau,\tilde{Y}\left(\overline{h},\boldsymbol{\theta},P\left(h\right),\lambda\right)\right)=0$$
$$V_S\left(\boldsymbol{\beta}|\underline{h},\overline{h},P\left(h\right),\boldsymbol{\alpha},\delta,\tilde{A}\left(\overline{h};\boldsymbol{\beta},P\left(h\right),\lambda\right)\right)=0$$

Structural Parameters				
	2006-08	2009-11	2012-15	2016-18
β	2.53	1.67	1.77	1.70
σ	0.85	0.97	0.90	0.90
θ	-0.17	-0.028	-0.11	-0.11

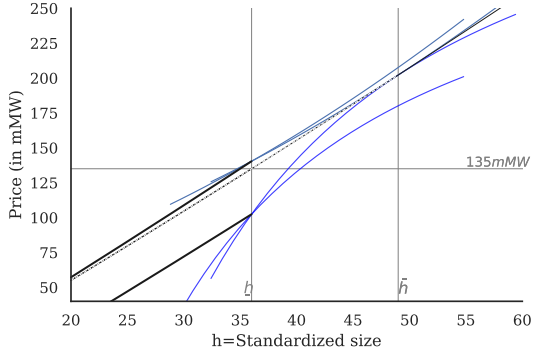
Elasticity of Substitution: $\sigma=\dfrac{1}{1-\theta}$

Graphical Representation of the Equilibrium Using the Parameter Estimates

2006-08



2016-18



III. Policy Evaluation:

Counterfactual Policy I: Proposed tax reform.

- Policy proposal: Remove the tax incentives to developers

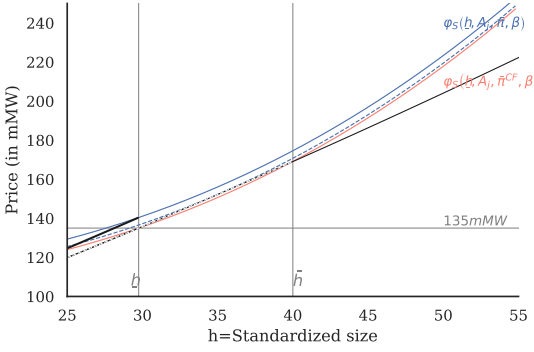
- Developers reaction:

  If these items are repealed, in Valle del Cauca we would go from having an offer of SH and sales of 23,000 homes, average year, to one of sales of 4,600 homes El Tiempo (2021)

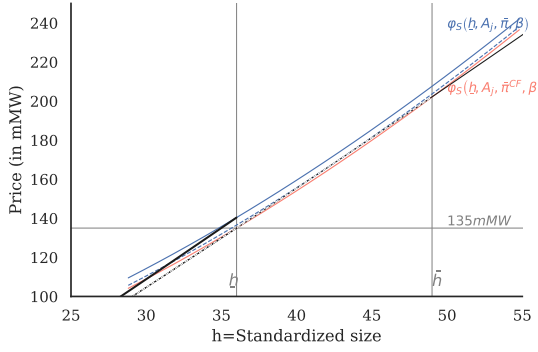
- Question: What happens to the marginally subsidized developers?

Effect on Marginally Subsidized Developers

2006-08



2016-18



Changes in profits (%)

	2006-08	2009-11	2012-15	2016-18
$\frac{\pi - \pi^{PC}}{\pi}$	4.9	15.9	9.3	12.3

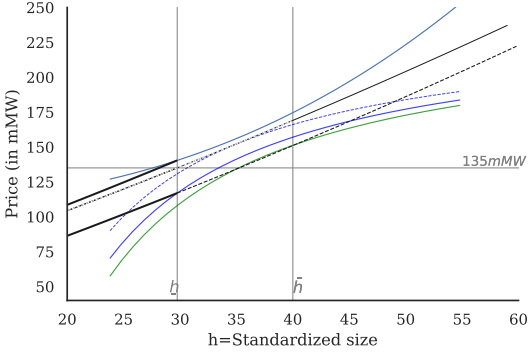
Counterfactual Policy II: Remove Price Cutoff

- Policy change: the same households get the subsidy but they can buy any type of housing.

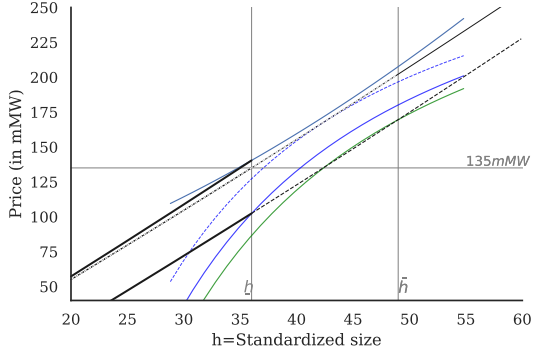
- Question: How much better off households are.

Effect on Marginally Subsidized Households

2006-08



2016-18



Changes in utility (%)

	2006-08	2009-11	2012-15	2016-18
$\frac{U^{PC} - U}{U}$	2.9	1.9	2.7	2.7
$\frac{U - U^{0}}{U}$	4.7	3.4	4.5	4.5

Conclusion (I): The paper

- Characterization of the equilibrium.
- compelling evidence of the market responding to subsidies.
- An hedonic housing market equilibrium with heterogeneous agents can rationalize the response.
- Propose a identification strategy to recover the model parameters.
- Model+estimates $\rightarrow$ Welfare.
- Policy design matters: need to be careful of how agents respond to incentives.

Conclusion (II): Generalization

- The method I propose could be used to evaluate housing policy more generally.

- 2 facts suggest this could be potentially effective.

1. There is increasing evidence to bunching responses to nonlinear incentives (e.g., help to buy, housing programs in the USA)

2. Many other sources of non linear incentives in housing markets.

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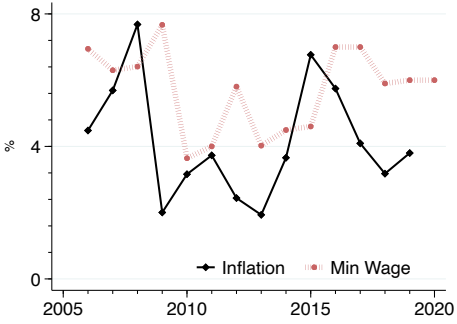
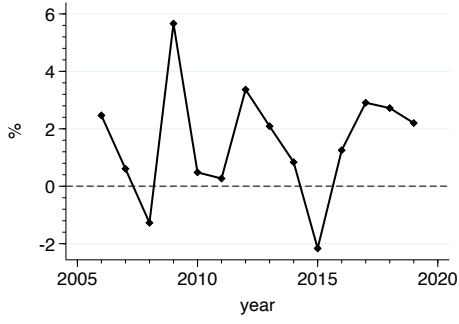
Appendix

Inflation and minimum wages.



a. Min wage and Inflation



b. Min wage and Inflation

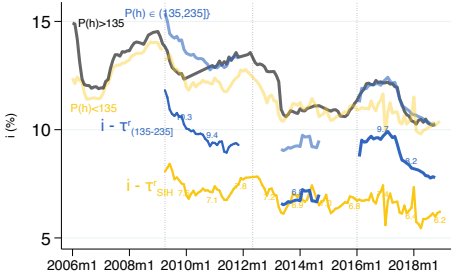
Data

Data: Mortgages and Interest Rates

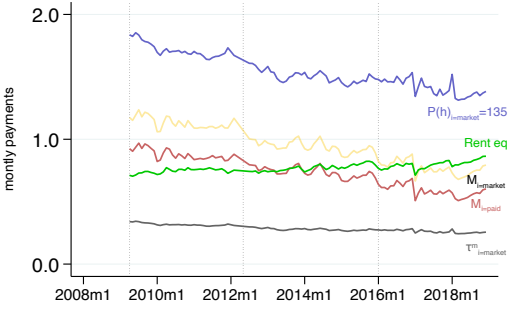
rent equivalent ((?, ?), (Bishop & Timmins, 2019) assume it is 0.05)

- 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. $P(h) < 135$

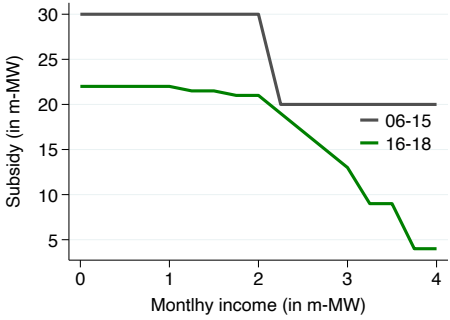


- To convert the magnitudes into monthly payments I use:

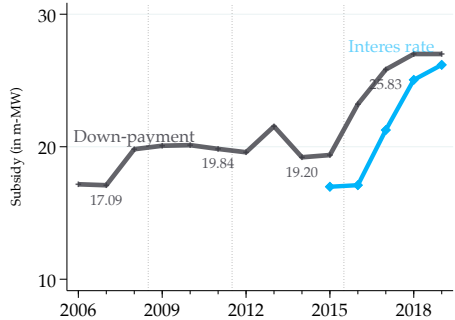
$$X_{montly} = X \cdot \kappa(i,n)\,;\kappa(i,n) = \frac{\frac{i}{12}\cdot\left(1+\frac{i}{12}\right)^{12\cdot n}}{\left(1+\frac{i}{12}\right)^{n\cdot 12}-1}$$

The Notch: Down Payment Subsidy

Subsidy by household income

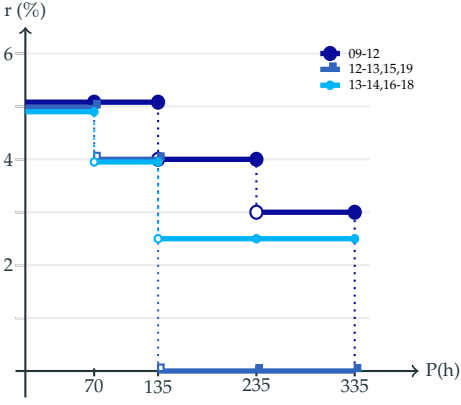


Average subsidy over time

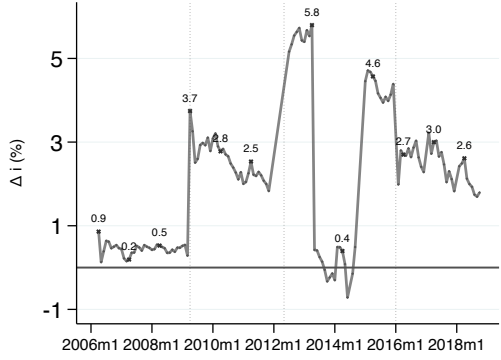


- Varies by income.
- Increase in 2016.
- Expanded trough *mi casa YA*

The Notch: Interest Rate Subsidy



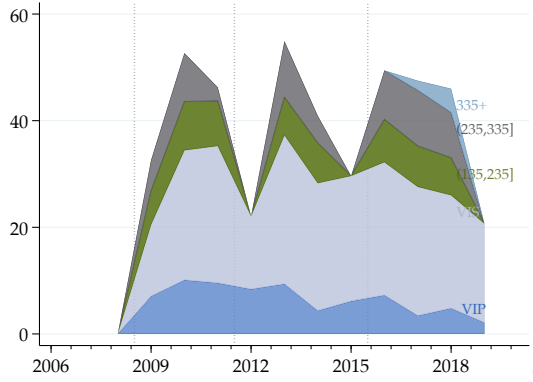
Comparing monthly payments around P(h)=135 m-MW



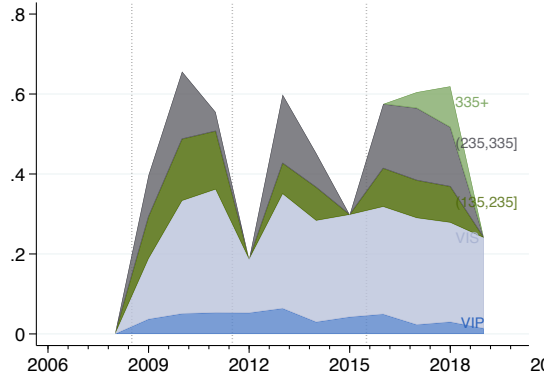
Subsidies and Government Expenditure (VIP-$P(h) < 70$)

This figure shows interest rate subsidies to all the different price levels

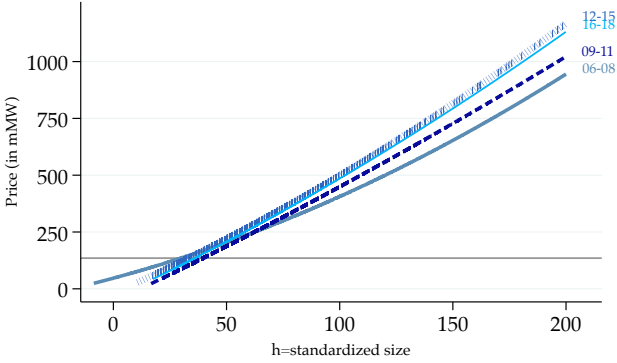
a. Total # of subsidies

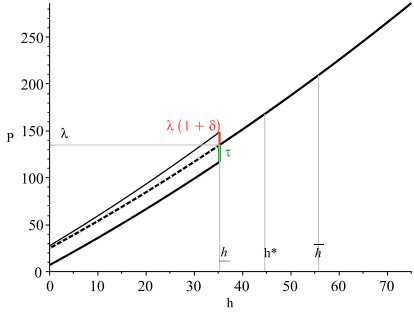


b. Total amount of subsidies



PRICES

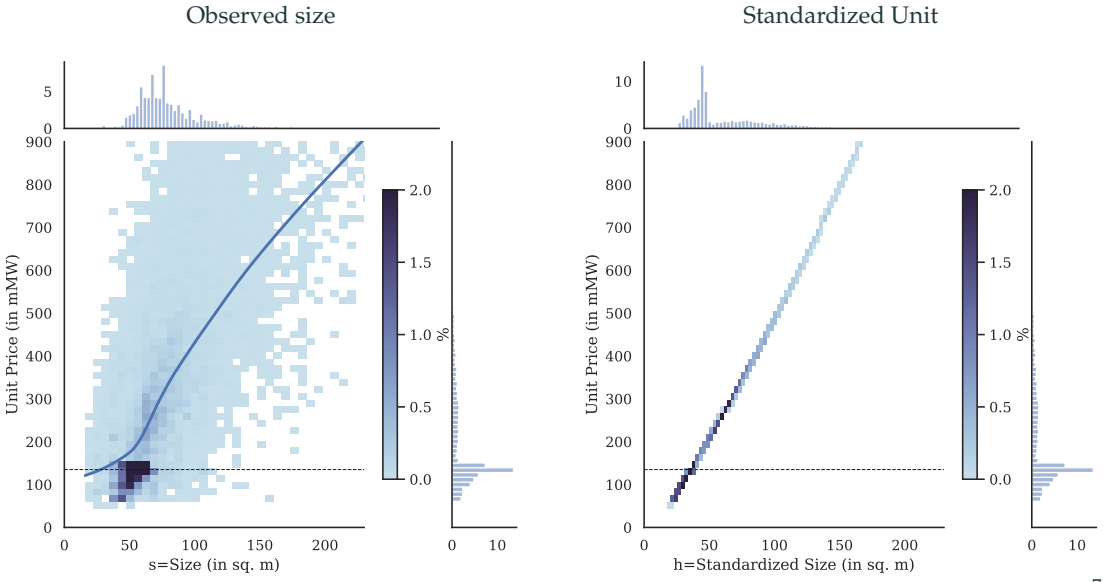

12-15
16-18
09-11
06-08
Price (in mMW)
1000
750
500
250
0
0
50
100
150
200
h=standardized size


P
250
200
150
100
50
0
λ
λ (1 + δ)
τ
h
h*
h̄
0
10
20
30
40
50
60
70
h

back

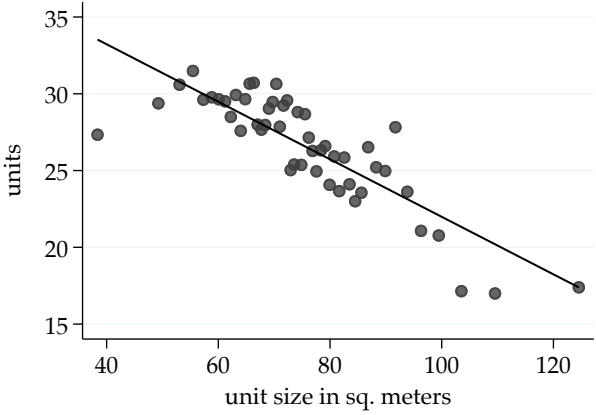
Observed Equilibrium: Prices, Quantities, and Size

Subsidy expansion **2016-18**



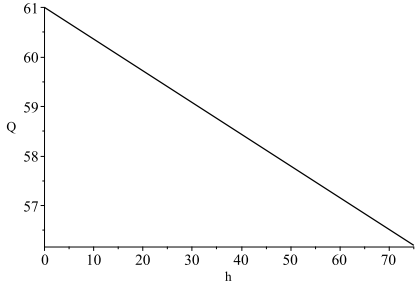
UNIT SUPPLY FUNCTION

Data



Model

Unit Supply Function $Q(h)$



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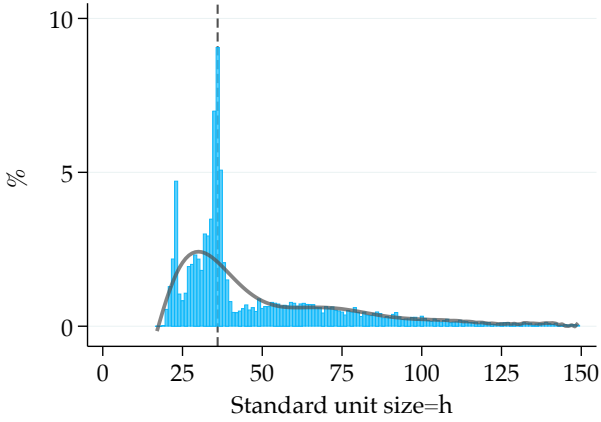
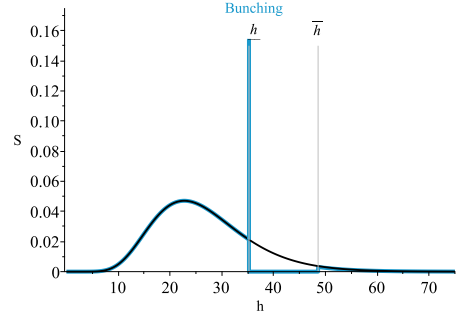
Behavioral responses

2016-18





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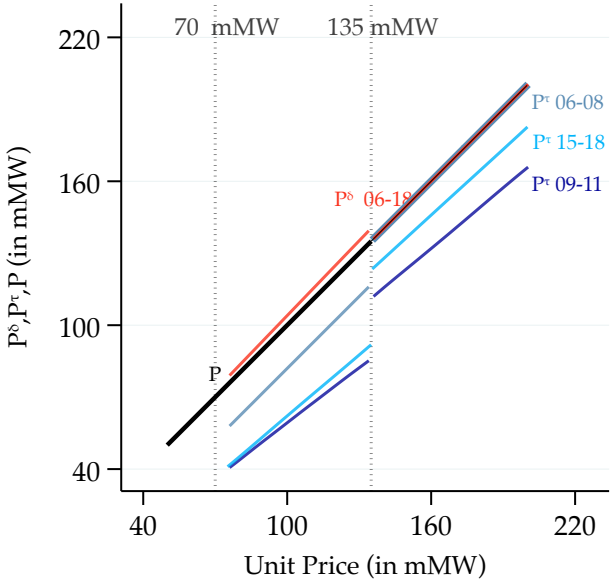
The Demand Notch Increases Over Time



Supply Notch δ

2006-18 4%

Demand Notch τ_t

2006-08: 19.7 *mMW*

2009-11: 26.4 *mMW*

2016-18: 33.1 *mMW*

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

Alternative Representation of the Equilibrium. Demand and Supply for Size