

# 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
- ▶ Affects Prices, Quantities, **Type of housing that is build**
- ▶ Is this market-oriented approach effective?
  - How big are the efficiency costs?
  - What are the unintended consequences?
  - Which households benefits the most?
  - What is the effect on developers?



# COLOMBIAN HOUSING POLICY

## ► Policy tools:

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

## ► 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 and 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
<ul style="list-style-type: none"><li>▶ Housing Markets</li><li>▶ Supply,Demand</li><li>▶ Identification of SP</li></ul>	<ul style="list-style-type: none"><li>▶ Policy Notch</li><li>▶ Supply side</li><li>▶ Identification</li></ul>	<ul style="list-style-type: none"><li>▶ Evidence</li><li>▶ Method</li><li>▶ Welfare</li></ul>
<ul style="list-style-type: none"><li>- Housing market applications Best et al. (2019), DeFusco and Paciorek (2017)</li><li>- Methodology <i>Notches &gt;&gt; Kinks</i>: Kleven (2016), Bertanha et al. (2021), Blomquist et al. (2021)</li><li>-</li></ul>	<ul style="list-style-type: none"><li>- Seminal paper S. Rosen (1974),Epple (1987)</li><li>- Recent Contributions Bajari and Benkard (2005), Heckman et al. (2010), Epple et al. (2020), Chernozhukov et al. (2021)</li><li>- Reviews Kuminoff et al. (2013), Greenstone (2017)</li></ul>	<ul style="list-style-type: none"><li>- Developers subsidies Baum-Snow and Marion (2009), Soltas (2020), Sinai and Waldfogel (2005)</li><li>- Households Subsidies Carozzi et al. (2020)</li><li>- Incidence and welfare Poterba (1992), Galiani et al. (2015)</li></ul>

# **I. Descriptive Analysis: Data, Policy and Observed Equilibrium**

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# POLICY TOOLS

## 1. Demand Subsidies

- Downpayment
- Interest rate

Income  $\leq$  4 monthly minimum wages (mMW) classify

## 2. Supply Subsidies

- Value Added Tax (VAT) refund

## 3. Targeting tool for the subsidy:

- Only new *low cost* units are eligible

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

Note: **135 mMW**  $\approx$  40,000 \$USD





# DATA

## 1. Administrative Records from Minister of Housing

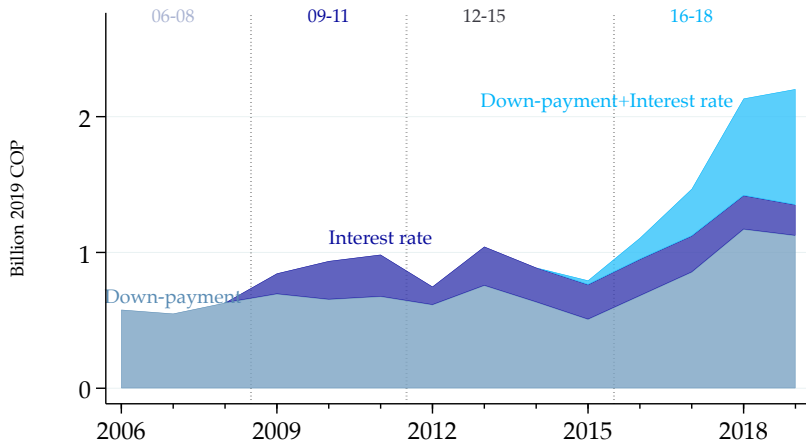
- Subsidy size
- Mortgage information

→ Government expenditure on each subsidy

## 2. New Construction Census (Camacol)

- 126 Municipalities
- Years: 2006-2018
- Unit Characteristics: **size**, location, # rooms, # bathrooms, etc.
- Prices sales prices.
- Quantities

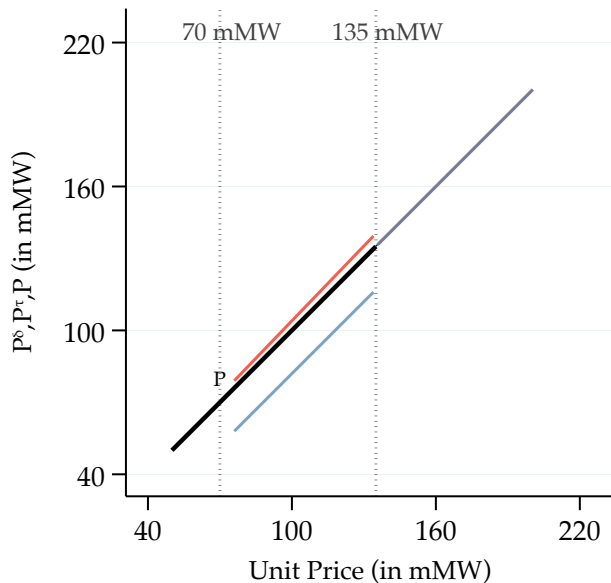
# GOVERNMENT EXPENDITURE AND POLICY EXPANSION



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

# THE NOTCH

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



**Transaction Price**

$P$

**Developers Price**

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

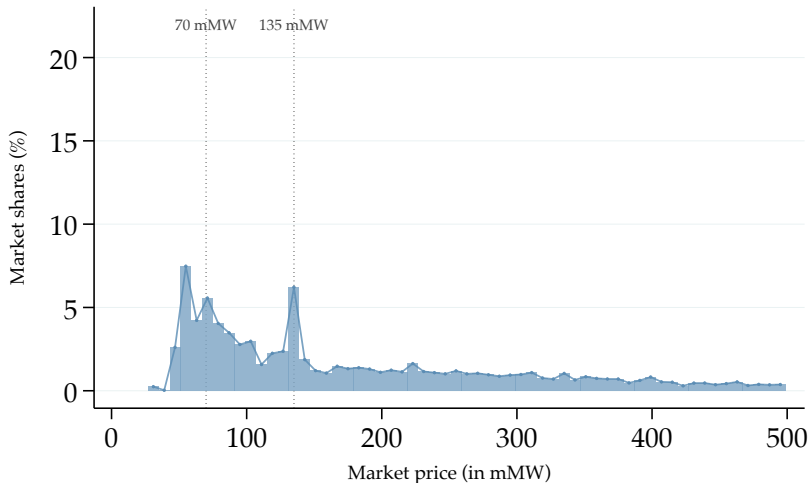
$\delta$  = Tax refund

**Households price**

$$P^\tau = P - \tau$$

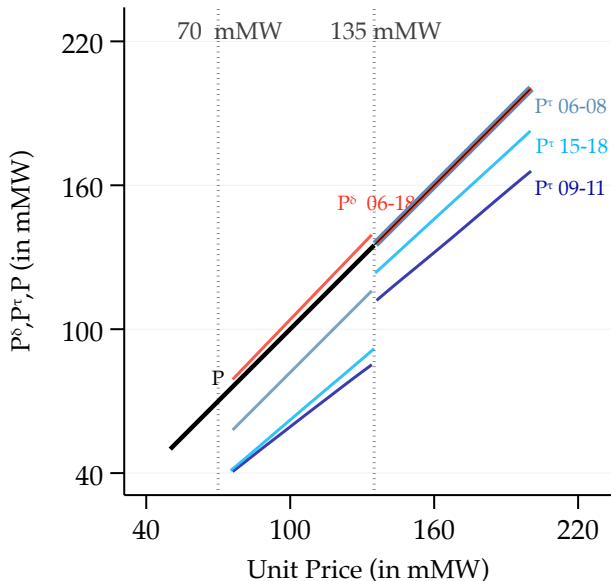
$\tau$  = Subsidy

# BUNCHING AT THE LOW-COST HOUSING PRICE LIMIT



Data: Census of new construction in Colombia 2006-18

# THE DEMAND NOTCH INCREASES OVER TIME



Supply Notch  $\delta$

2006-18 4%

Demand Notch  $\tau_t$

2006-08: 19.7 mMW

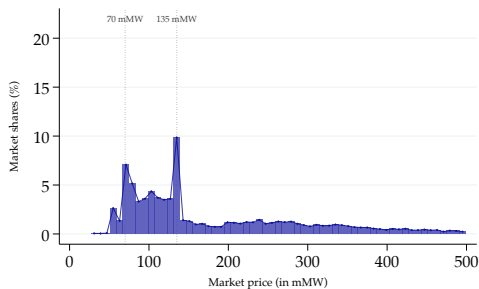
2009-11: 26.4 mMW

2016-18: 33.1 mMW

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

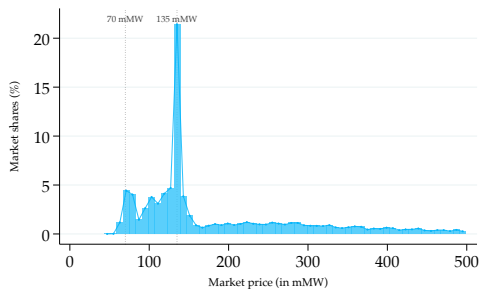
# LARGER BUNCHING AS NOTCH INCREASES

2009-11



*Notch: 19.7 mMW*

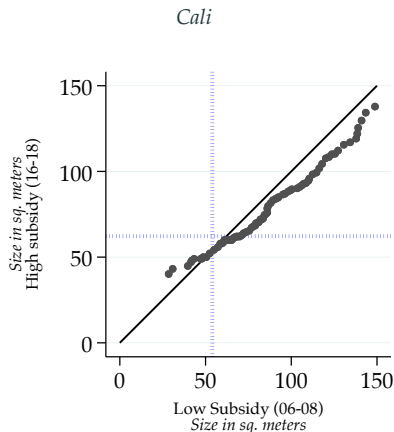
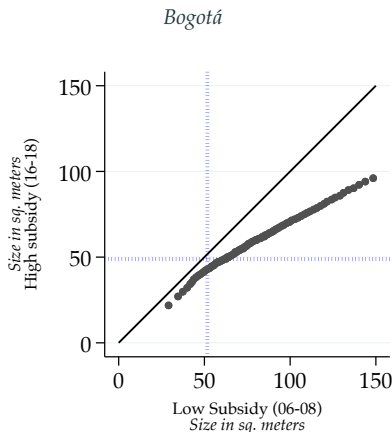
2016-18



*Notch: 33.1 mMW*

# 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

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

- ▶ Standard Unit Size  $h_{ltc}$

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

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

- ▶ Why size?

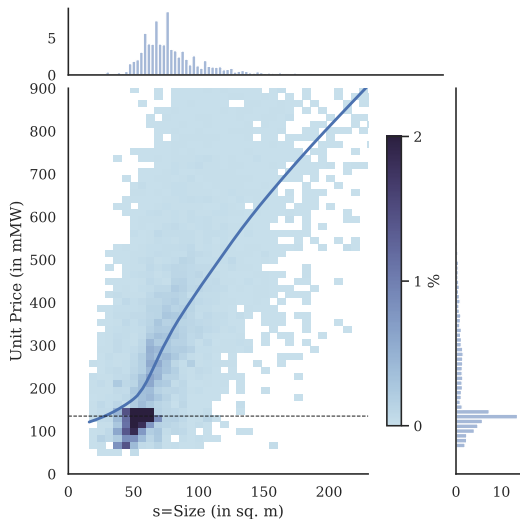
- Continuous, easy to measure, monotonic relationship with price.
- In contrast to most datasets, I observe it.



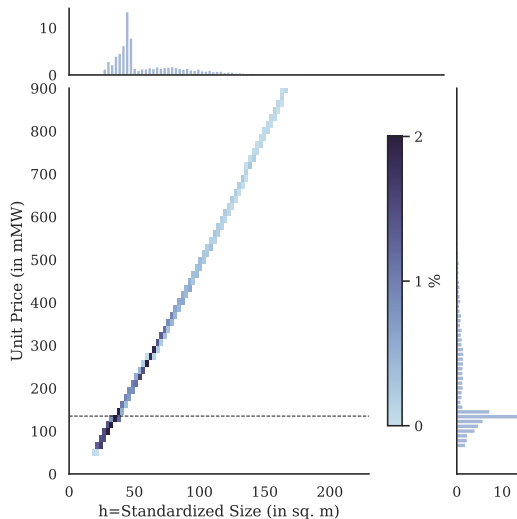
# OBSERVED EQUILIBRIUM: PRICES, QUANTITIES, AND SIZE

## 2016-18

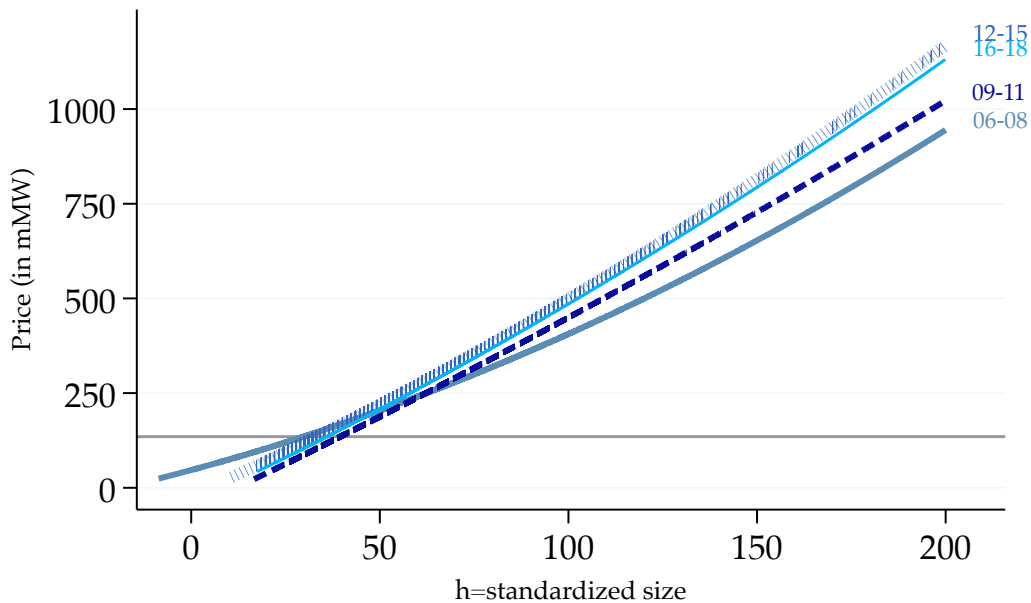
Observed size



Standardized Unit



# IMPLICIT PRICES FOR HOUSING SIZE OVER TIME



## BEHAVIOURAL RESPONSES INDUCED BY THE POLICY

- Recovered by comparing observed and counterfactual distribution

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

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

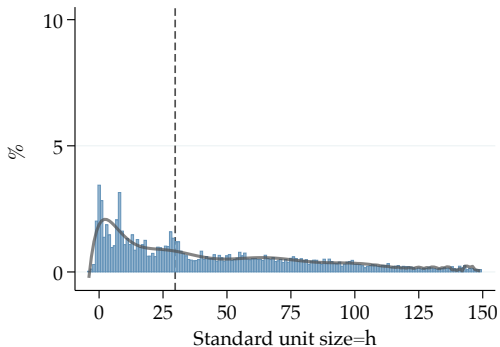
$$h_b = \sum_{p=0}^T \hat{\iota}_p h_b^p + \sum_{k=L}^H \kappa_k \cdot \mathbb{1} [h_k = h_b] + v_b$$

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

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

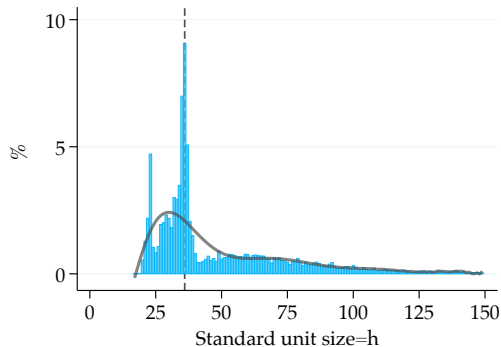
# BUNCHING IN HOUSING CHARACTERISTICS (SIZE OF STD. UNIT)

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
$\int_{h_{min}}^{\underline{h}} T(h)dh$	1.03	0.86	3.83	7.28
$\hat{T}(\underline{h})$	0.50	2.02	4.02	6.97
$\int_{h_{min}}^{\underline{h}} T(h)dh$	1.53	2.88	7.85	14.2
$\int_{\underline{h}}^{\bar{h}} T(h)dh$	-0.096	-6.25	-4.13	-3.42
$h_{h^0}(\underline{h})$	0.72	1.28	1.06	1.44
$h_{min}$	26	37	29	32
$\underline{h}$	29.8	39.4	33.0	36.0
$\bar{h}$	40	53	45	49

## II. Equilibrium Model of Housing Supply and Demand

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# 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  $U(C_i, h_i; \theta)$

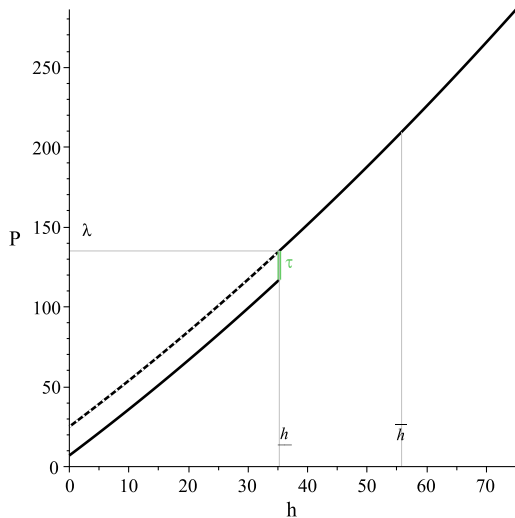
## 3. Developers $j \in J$ , Heterogeneous in Productivity $A_j \sim G_A$

- Pick  $h_j$  to maximize profits
- Building costs  $B(h_j, Q(h_j); \beta)$

## 4. Competitive Market Equilibrium

- Price function  $P^*(h) \rightarrow$  clears the market  $\forall h$

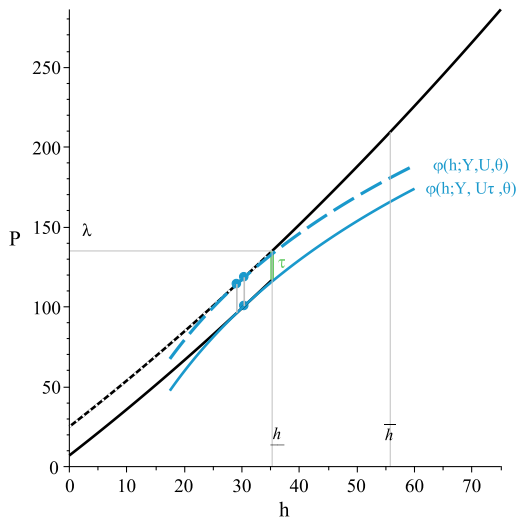
# HOUSEHOLDS' OPTIMAL CHOICES



- Implicit Price Function:  $P(h)$
- Subsidy  $\tau$



# HOUSEHOLDS' OPTIMAL CHOICES



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

- **Subsidy**  $\tau$

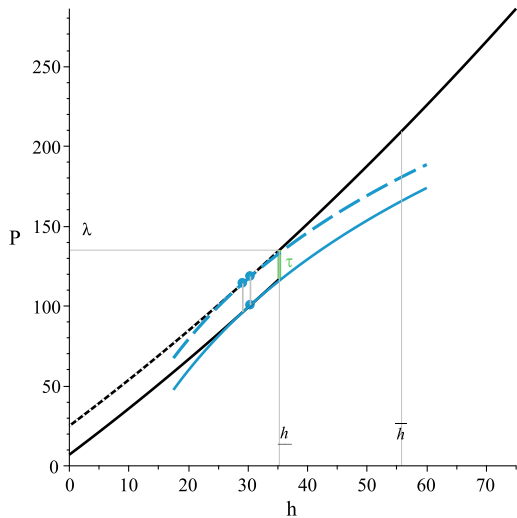
- **Bid functions**  $\varphi_D(h, Y, \bar{U}; \theta)$

$$\bar{U} = U(h, Y_i - \varphi_D; \theta)$$

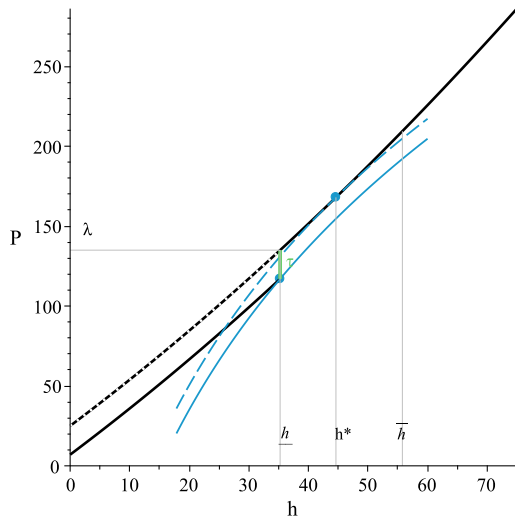
$$\bar{U}_\tau = U(h, Y_i - \varphi_D + \tau; \theta)$$

# HOUSEHOLDS' OPTIMAL CHOICES

A. Subsidized

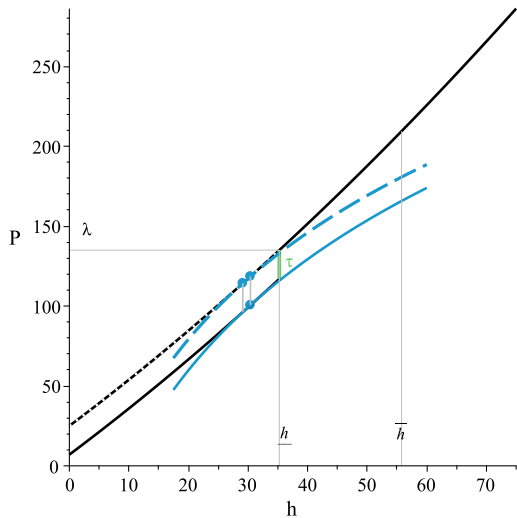


B. Marginally Subsidized and Bunchers

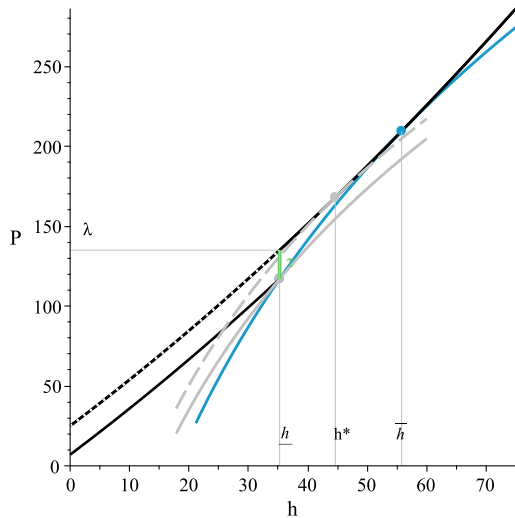


# HOUSEHOLDS' OPTIMAL CHOICES

A. Subsidized



B. Marginally Subsidized and Bunchers



# HOUSEHOLDS' DEMAND FUNCTION

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

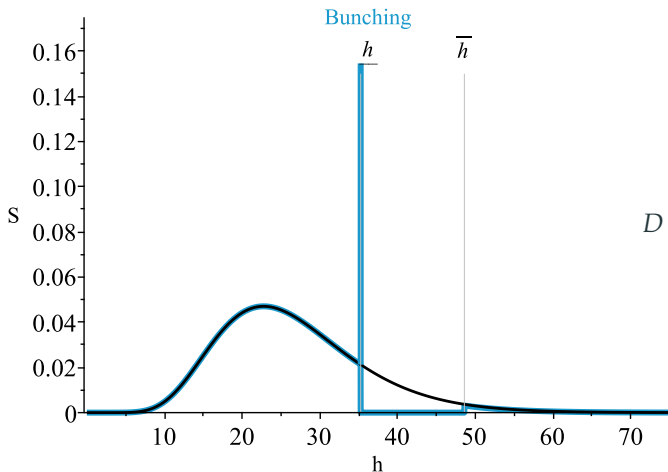
► Housing demand:

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

► How to aggregate:

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

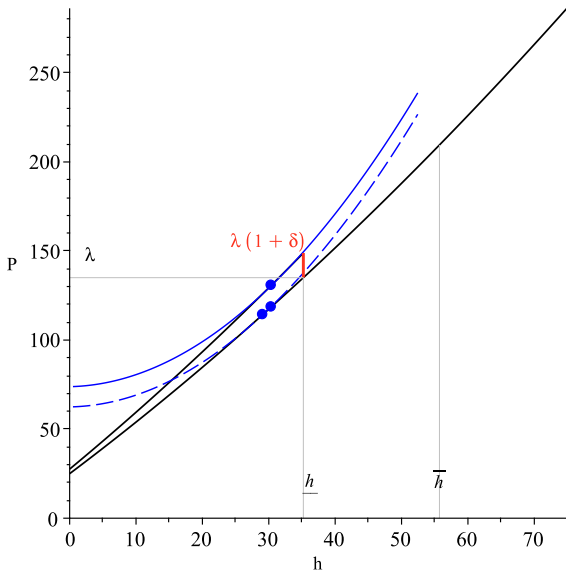
# AGGREGATE DEMAND DENSITY



$$D(h) = \begin{cases} f_{h^*}(h) \, dh & \text{if } h < \underline{h} \\ f_{h^*}(h) \, dh + \int_{\underline{h}}^{\bar{h}} f_{h^*}(h) \, dh & \text{if } \underline{h} = h \\ 0 & \text{if } h \in (\underline{h}, \bar{h}) \\ f_h^*(h) \, dh & \text{if } \bar{h} \leq h \end{cases}$$

# DEVELOPERS' CHOICES

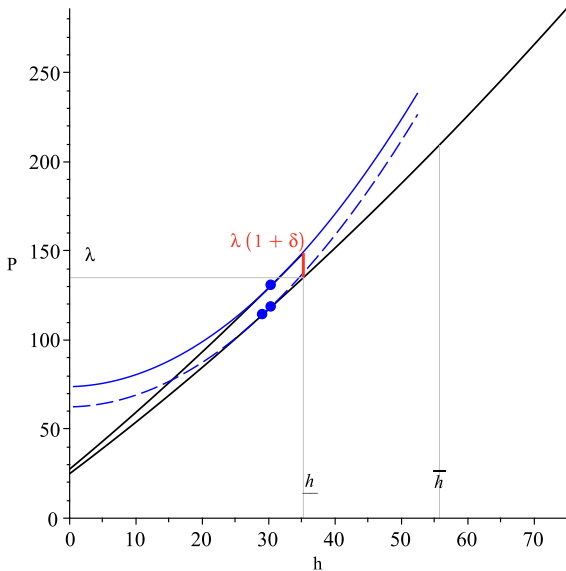
## A.Subsidized



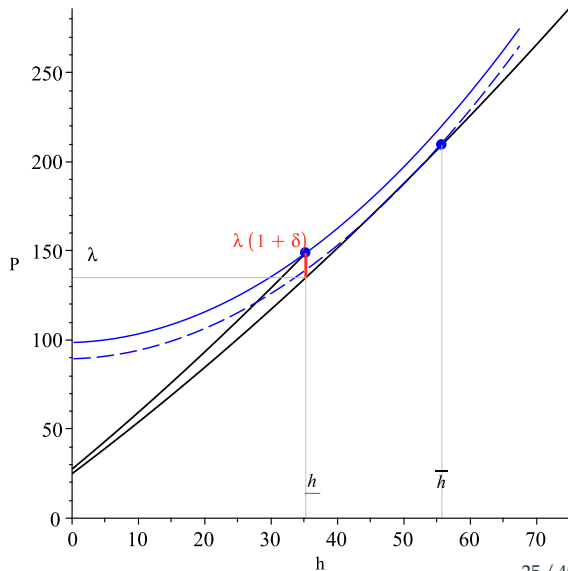
- **Implicit Price Function:**  $P(h)$
- **Tax incentives:**  $P(h) \cdot (1 + \delta)$
- **Offer Functions**  $\varphi_S(h, A_j, \bar{\pi}, \beta)$ 
  - $\bar{\pi} = (h, A_j, P(h), \beta, )$
  - $\bar{\pi}_\delta = (h, A_j, P(h) * (1 + \delta)), \beta, )$

# DEVELOPERS' CHOICES

A. Subsidized

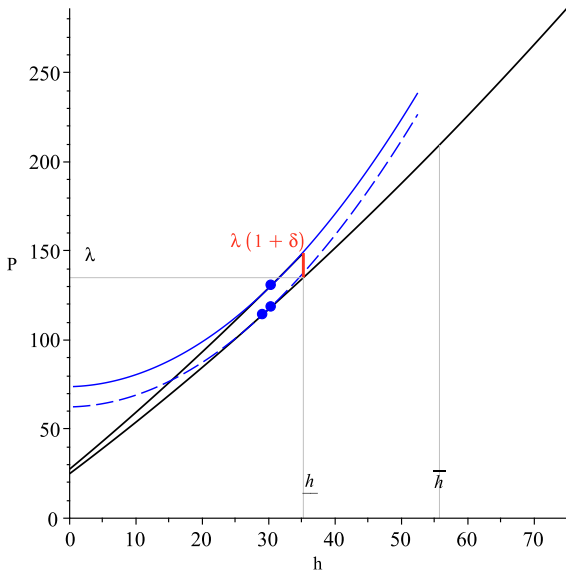


B. Marginally Subsidized and Bunchers

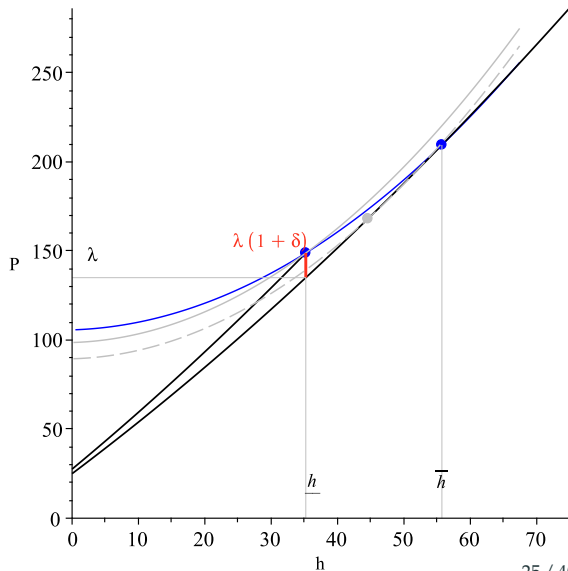


# DEVELOPERS' CHOICES

A. Subsidized



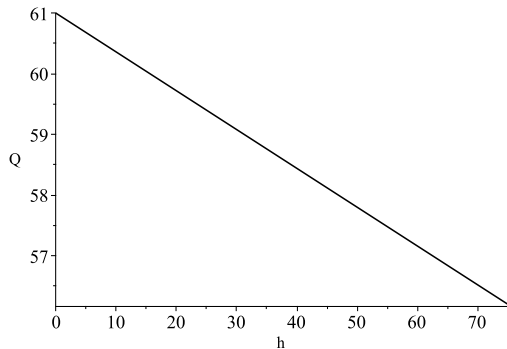
B. Marginally Subsidized and Bunchers





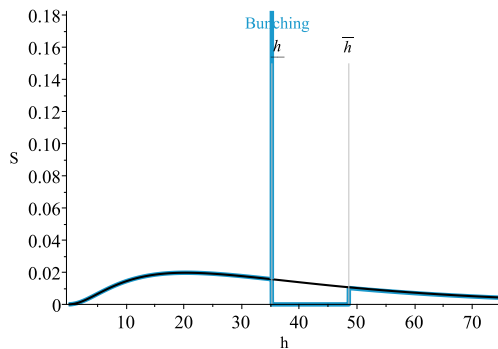
# DEVELOPERS AGGREGATE SUPPLY DENSITY

a. Unit supply function



$$Q_j = \alpha_0 + \alpha_1 \cdot h_j$$

b. Density function  $g_h(h)$

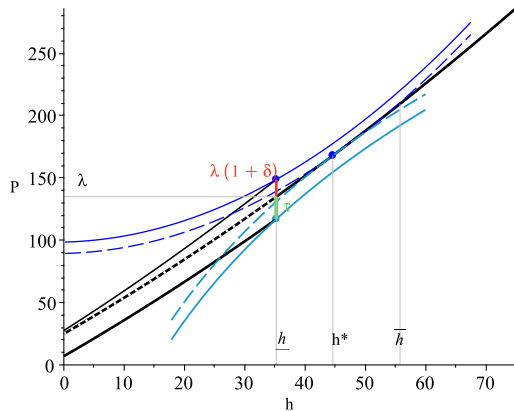
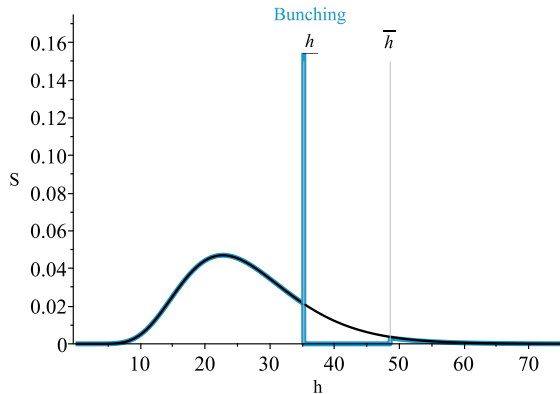


$$s(h) = \begin{cases} g_{h^*}(h) \cdot Q(h) & \text{if } h < \underline{h} \\ \left( g_{\underline{h}^*}(\underline{h}) + \int_{\underline{h}}^{\bar{h}} g_{h^*}(h) \, dh \right) \cdot Q(\underline{h}) & \text{if } \underline{h} = h \\ 0 & \text{if } \underline{h} < h < \bar{h} \\ g_{h^*}(h) \cdot Q(h) & \text{if } \bar{h} \leq h \end{cases}$$

# EQUILIBRIUM

Price function makes the market clear:

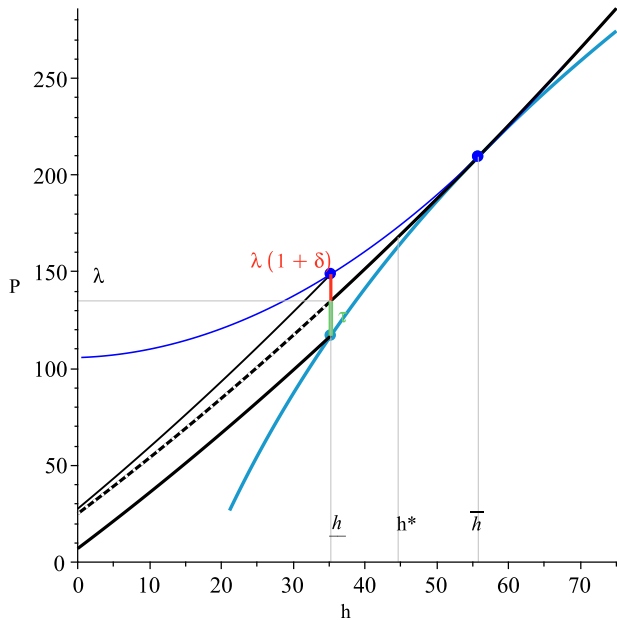
$$E = \left\{ P(h; \rho) \in \mathcal{P} : D(h; \tau, \theta, \rho, \gamma, \lambda) = S(h; A_j, \rho, \phi) \forall h \in \mathcal{H} \right\}$$



# Identification

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# MARGINAL BUNCHER CONDITION



# MARGINAL BUNCHER CONDITION

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## *Marginal Buncher Condition*

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Household	$V_D = U\left(\bar{Y} - P\left(\bar{h}\right), \bar{h}; \theta\right) - U\left(\bar{Y} - P^\tau\left(\underline{h}\right), \underline{h}; \theta\right) = 0$
Developer	$V_S = \pi\left(Q\left(\bar{h}\right), \bar{A}, P\left(\bar{h}\right); \beta\right) - \pi\left(Q\left(\underline{h}\right), \bar{A}; P^\delta\left(\underline{h}\right); \beta\right) = 0$

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## *Optimality Conditions*

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Income	$\bar{Y} = \tilde{Y}\left(\bar{h}; \theta, P(h), \lambda\right)$
Productivity	$\bar{A} = \tilde{A}\left(\bar{h}; \beta, P(h), \lambda\right)$

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## *Functional Forms*

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Implicit Price	$P = \rho_0 + \rho_1 \cdot h + \rho_2 \cdot h^2$
Utility	$U = \left[\frac{1}{2} \cdot C^\theta + \frac{1}{2} \cdot h^\theta\right]^{\frac{1}{\theta}}$
Unit Supply	$Q = \alpha_0 + \alpha_1 h$
Cost	$B = A_j \cdot Q \cdot h^\beta$

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# Estimation

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# STEP I

## 1. Price function:

$$\boldsymbol{\rho}_t = \rho_{0t}, \rho_{1t}, \rho_{2t}$$

## 2. Policy Parameters:

Notches:  $\tau_t, \delta$

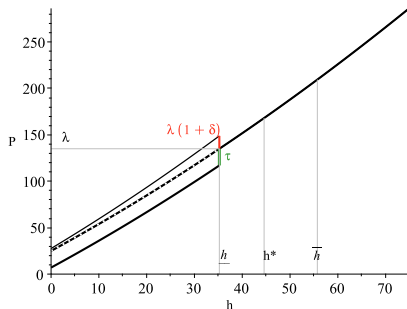
Size threshold:  $\underline{h} = P^{-1}(\lambda; \boldsymbol{\rho})$

## 3. Unit Supply Function:

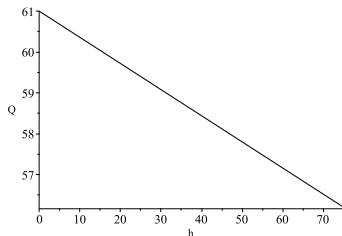
$$\boldsymbol{\alpha} = \alpha_0, \alpha_1$$

## 4. Behavioural Responses:

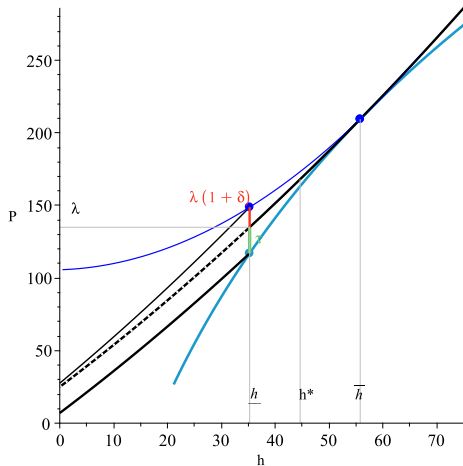
Housing size for marginal buncher without subsidy:  $\bar{h}$



Unit Supply Function  $Q(h)$



## STEP II



$$V_D \left( \theta | \underline{h}, \bar{h}, P(h), \tau, \tilde{Y} \left( \bar{h}, \theta, P(h), \lambda \right) \right) = 0$$

$$V_S \left( \beta | \underline{h}, \bar{h}, P(h), \alpha, \delta, \tilde{A} \left( \bar{h}; \beta, P(h), \lambda \right) \right) = 0$$



# ESTIMATES

	06-08	09-11	12-15	16-18
<i>Price Function</i>				
$\rho_0$	17.0	-300.0	-243.5	-240.6
$\rho_1$	2.70	4.75	4.48	4.66
$\rho_2$	0.90	0.32	0.73	0.60
<i>Policy Parameters</i>				
$\tau$	18.0	25.9	29.5	32.6
<i>Bunchers Interval</i>				
$\bar{h}$	40	53	45	49
$\underline{h}$	29.8	39.4	33.0	36.0
<i>Unit Supply Function</i>				
$\alpha_0$	70.5	12.7	81.1	33.3
$\alpha_1$	-0.068	-0.020	-0.020	-0.042
<i>Structural Parameters</i>				
$\beta$	2.53	1.67	1.77	1.70
$\sigma$	0.85	0.97	0.90	0.90
$\theta$	-0.17	-0.028	-0.11	-0.11

### **III. Policy Evaluation:**

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## COUNTERFACTUAL POLICIES

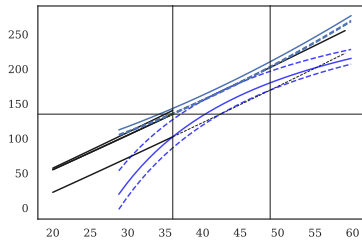
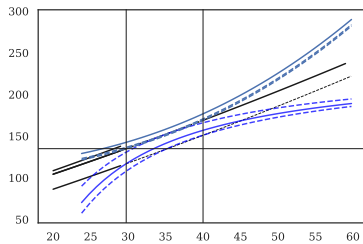
- Does the presence of a consumer housing subsidy and price caps create a problem of rationing in the absence of supply subsidies ?

Ongoing policy debate:

*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)

- What happens if the same households get the subsidy but there is not a price cutoff.

# WELFARE EVALUATION ILLUSTRATION



# ESTIMATES: DEVELOPERS

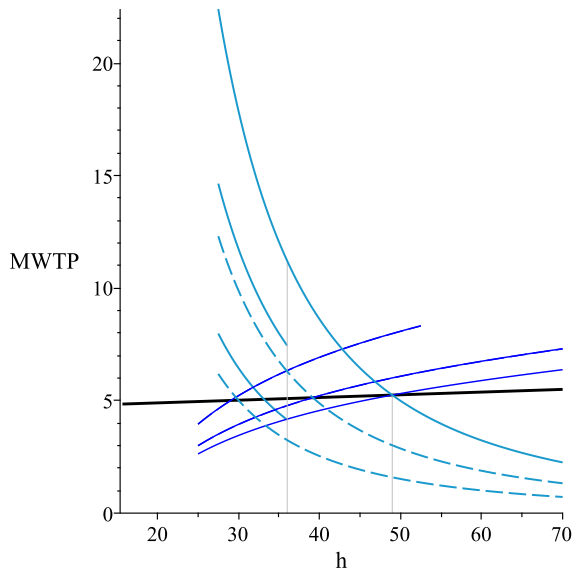
	Developers			
	2006-08	2009-11	2012-15	2016-18
$\underline{A}$	0.0068	0.26	0.19	0.25
$A_*$	0.0054	0.23	0.17	0.22
$\overline{A}$	0.0045	0.21	0.15	0.20
$MgC(\underline{h}, Q(\underline{h}), \underline{A})$	214.4	59.5	398.2	160.7
$MgC(\underline{h}, Q(\underline{h}), A_*)$	219.0	59.0	404.4	161.2
$MgC(h^*, Q(h^*), A_*)$	172.4	53.7	356.0	144.9
$MgC(\overline{h}, Q(\overline{h}), \overline{A})$	223.4	58.6	410.6	161.7
$\pi(Q(\underline{h}), \underline{A}; P(\underline{h}))$	6725.5	205.8	3449.4	881.6
$\pi(Q(\underline{h}), A_*; P^\delta(\underline{h}))$	7588.2	406.1	4668.9	1388.9
$\pi(Q(\underline{h}), A_*; P(\underline{h}))$	7218.6	341.6	4234.4	1217.2
$\pi(Q(h^*), A_*; P^\delta(h^*))$	7740.0	439.8	4889.1	1478.6
$\pi(Q(h^*), A_*; P(h^*))$	7326.4	359.9	4359.1	1266.4
$\pi(Q(\overline{h}), \overline{A}; P(\overline{h}))$	7930.5	512.2	5262.2	1646.0

# ESTIMATES: HOUSEHOLDS

	Households			
	2006-08	2009-11	2012-15	2016-18
$\underline{Y}$	215.7	324.0	275.6	291.5
$Y_*$	248.7	392.5	333.7	355.6
$\bar{Y}$	282.8	461.7	393.2	421.1
$U(\underline{Y} - P(\underline{h}), \underline{h})$	47.9	85.6	66.3	72.9
$U(\underline{Y} - P^\tau(\underline{h}), \underline{h})$	52.5	91.2	72.4	79.5
$U(Y_* - P(h^*), h^*)$	56.8	100.7	78.9	86.6
$U(Y_* - P^\tau(\underline{h}), \underline{h})$	59.6	104.3	82.7	90.7
$U(Y_* - P^\tau(h^*), h^*)$	61.4	106.3	84.9	93.2
$U(\bar{Y} - P(\bar{h}), \bar{h})$	65.9	116.0	91.7	100.5

# ALTERNATIVE REPRESENTATION OF THE EQUILIBRIUM.

## DEMAND AND SUPPLY FOR SIZE



## 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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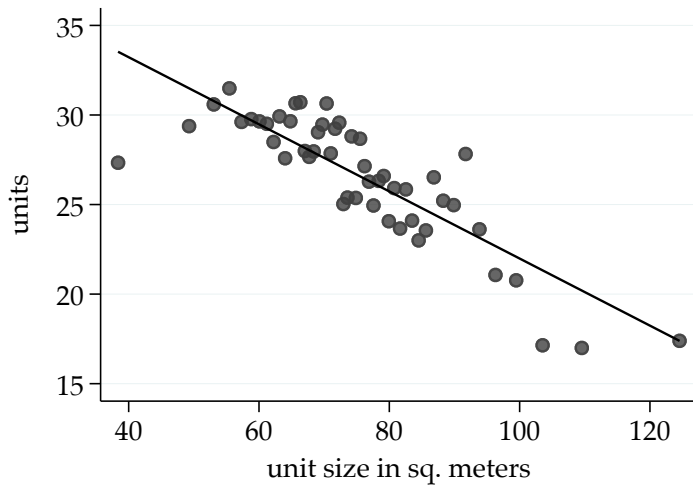
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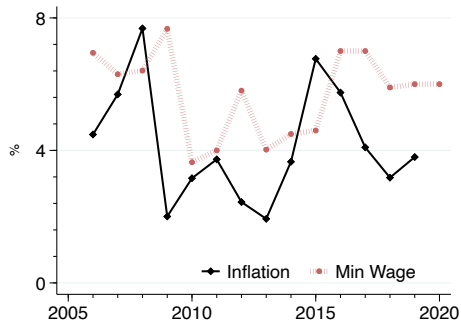
# Appendix

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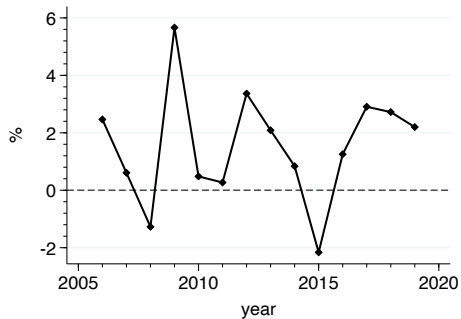
## QUANTITIES BY SIZE



# Inflation and minimum wages.



*a. Min wage and Inflation*



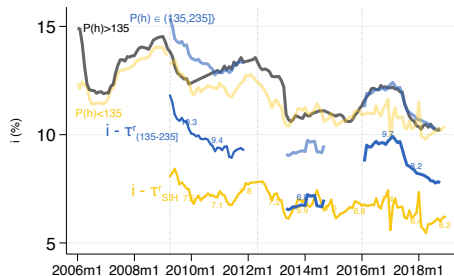
*b. Min wage and Inflation*

# DATA: MORTGAGES AND INTEREST RATES

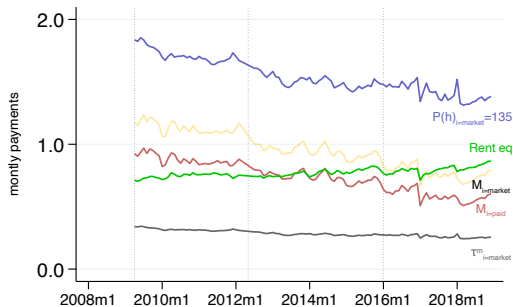
rent equivalent ((?, ?), (Bishop & Timmins, 2019) assume it is 0.05)

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

Market interest rate  $i$  and subsidy  $\tau^r$



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

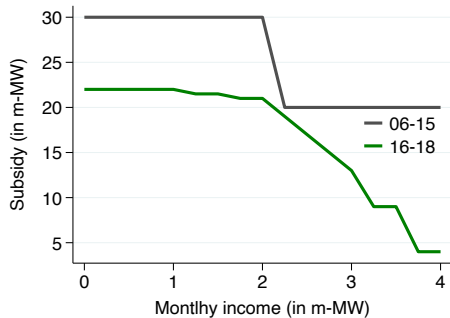


- To convert the magnitudes into monthly payments I use:

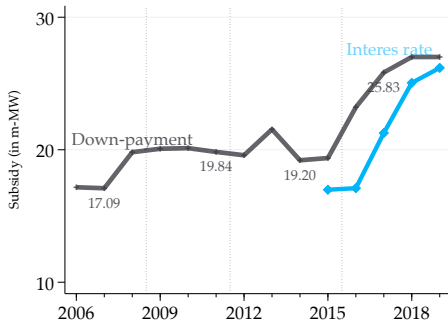
$$X_{\text{monthly}} = X \cdot \kappa(i, n); \kappa(i, n) = \frac{\frac{i}{12} \cdot \left(1 + \frac{i}{12}\right)^{12 \cdot n}}{\left(1 + \frac{i}{12}\right)^{n \cdot 12} - 1}$$

# THE NOTCH: DOWN PAYMENT SUBSIDY

Subsidy by household income

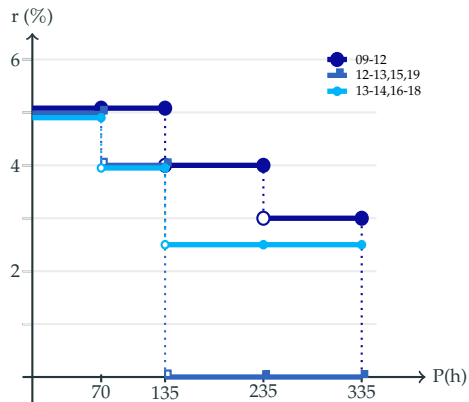


Average subsidy over time

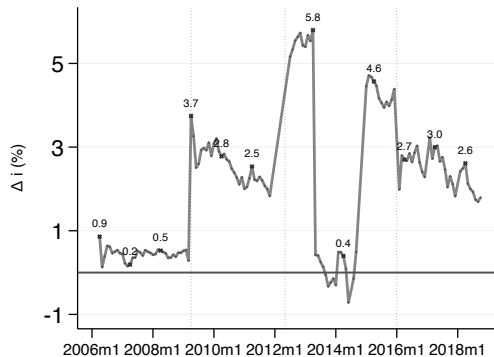


- Varies by income.
- Increase in 2016.
- Expanded through *mi casa* YA

# THE NOTCH: INTEREST RATE SUBSIDY



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

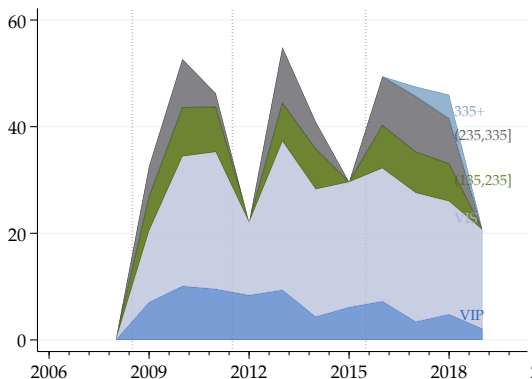




# SUBSIDIES AND GOVERNMENT EXPENDITURE (VIP- $P(h) < 70$ )

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

*a. Total # of subsidies*



*b. Total amount of subsidies*

