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

Juan Pablo Uribe

February 1, 2022

Cornerstone

ARE MARKET-ORIENTED HOUSING POLICIES EFFECTIVE?

- Governments implement various **market-oriented** policies to promote housing construction and home-ownership.
  - Subsidies or tax incentives

QUESTIONS:

1. Housing market effect?
   - Prices, quantities, **type of housing**
2. Does incentivizing home-ownership work?
   - Are there any unintended consequences?
   - What happens if these policies are removed?
   - How big are the efficiency costs?

- I use a quasi-experiment to estimate a housing market model.
- Counterfactual policy evaluation and welfare analysis.

Colombian Housing Policy

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

     135 monthly minimum wages (mMW) $\approx 40,000\ \$USD$

- Empirical advantages:
  1. Price cap
     - Discontinuous incentives for developers and households to bunch at the cutoff.
  2. Unique and novel data
     - Census data for all new construction projects.
     - Administrative records for the subsidies.
  3. Subsidy expansion (2006-18)

This Paper

I. Descriptive evidence

- Policy description and 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:

Step 1: Equilibrium characterization $\rightarrow$ *Detailed data and literature best practices*

Step 2: Preferences and cost function parameters $\xrightarrow{new}$ *bunching and policy tools*

III. Proposed policy counterfactual and welfare

- Colombian 2021 tax reform – remove tax incentives to developers
- Policy change – phasing out price caps

$\rightarrow$ 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 housing and consumption is 0.9

III. Effects of the proposed policy reforms

- Colombian 2021 tax reform 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 policies***

Bunching

- Housing market
- Link to model
- Supply and demand

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

Hedonic

- Policy notch
- Supply side
- Identification

- 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)

Housing Policy

- Evidence
- Welfare
- Counterfactuals

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

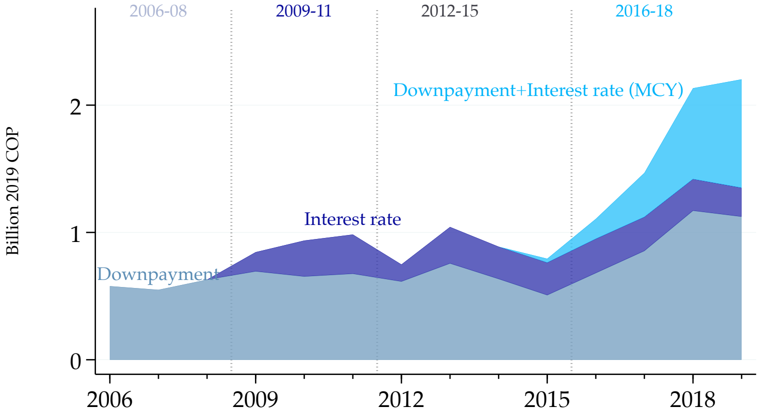
Data

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 and quantities
   - Unit characteristics: **size**, location, # rooms, # bathrooms, etc.
   - Development characteristics: lot size, # towers, # floors, developer id, etc.

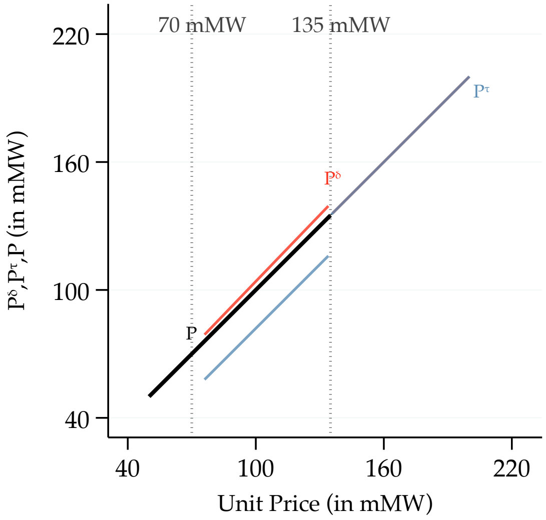
Everything measured in monthly minimum wages (mMW) or 2019 COP Inflation and mMW change

Government Expenditure and Policy Expansion



- Four different periods of expansion.
  - 2006-08: Downpayment (only for formal employees)
  - 2009-11: + Interest rate subsidy
  - 2012-15: Focus on extremely poor population (subsidies targeted at 70mMW)
  - 2016-18: + *Mi Casa Ya–MCY* (downpayment **and** interest for informal and formal employees)

The Notch



Transaction Price

P

Developers Price

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

$\delta =$Tax refund

Households price

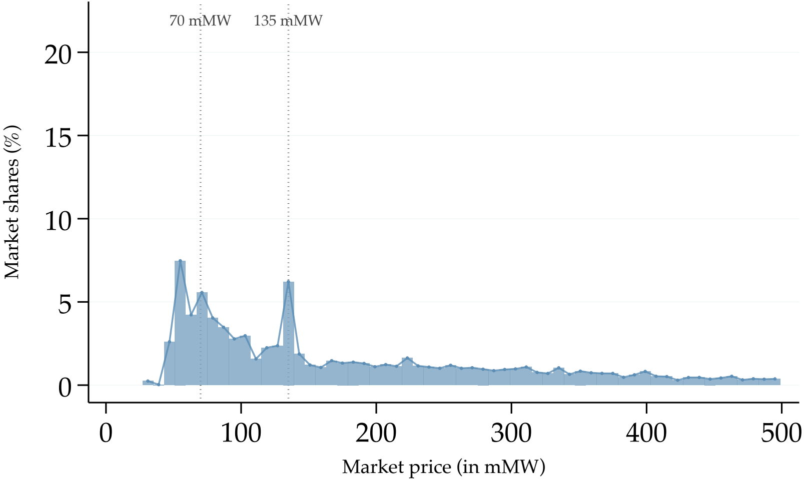
$\mathbf{P}^\tau = P - \tau$

$\tau =$Subsidy

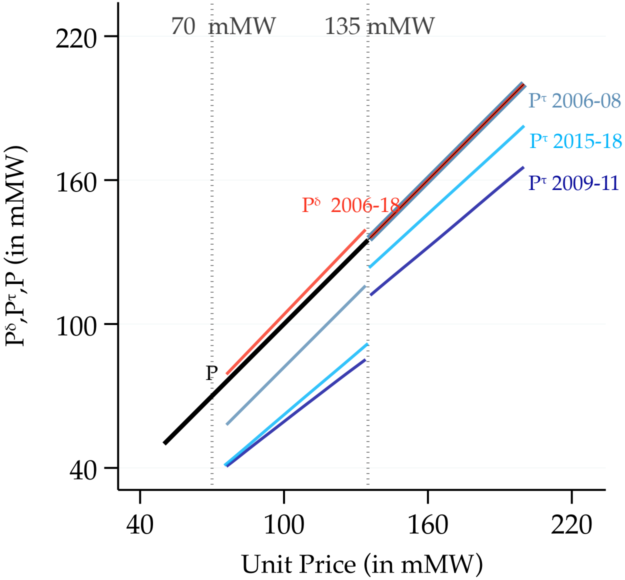
Agents benefit from buying/selling *low cost housing* ($P \leq 135mMW$)

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: 18 mMW

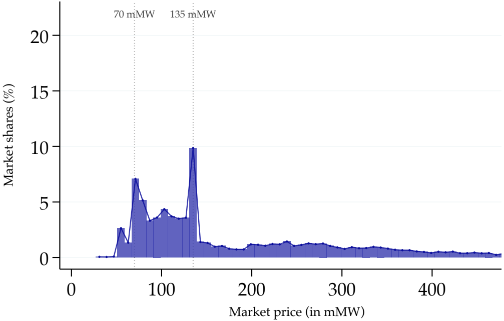
2009-11: 26 mMW

2016-18: 33 mMW

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

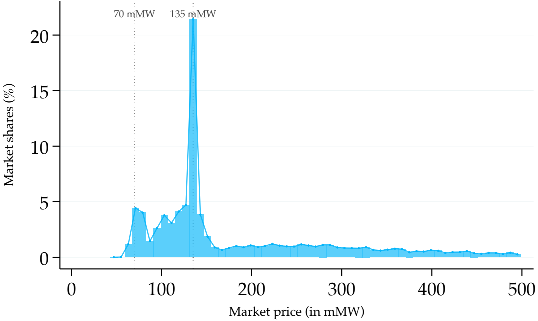
Larger Bunching as Notch Increases

Downpayment and interest rate subsidies
2009-11



Notch: 26 *mMW*

Subsidy expansion
2016-18

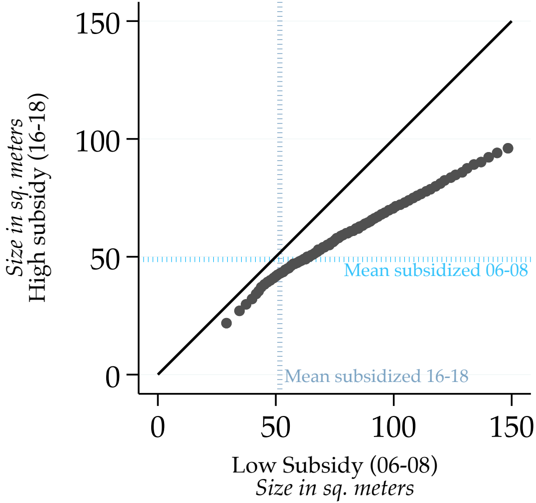


Notch: 33 *mMW*

Changes in Housing Stock Characteristics

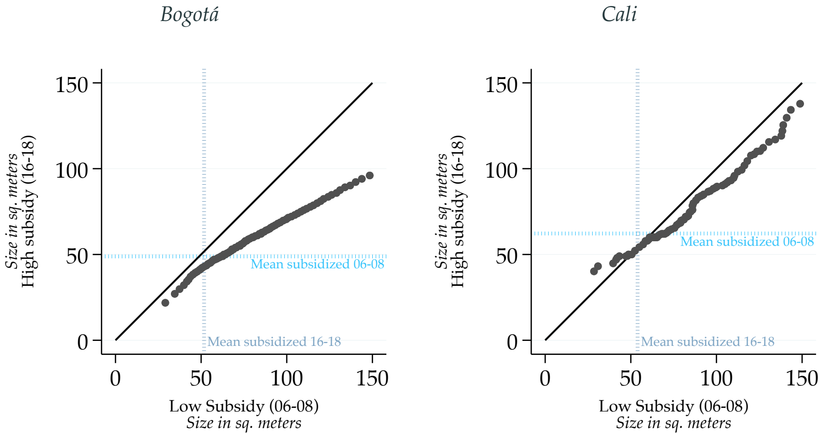
- Changes in unit size (quantile to quantile plot)

Bogotá



Changes in Housing Stock Characteristics

- Changes in unit size



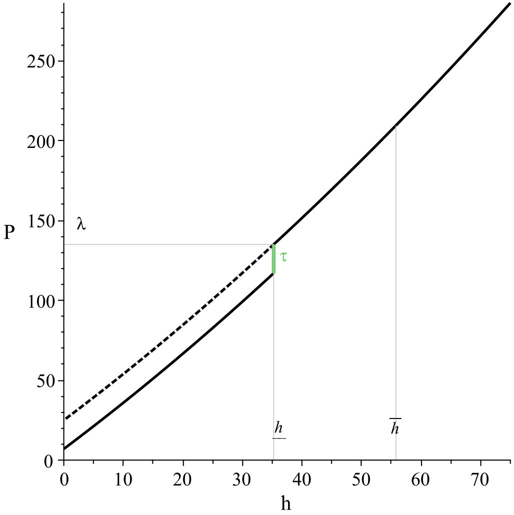
- Why size?
  - Continuous, easy to measure, monotonic relationship with price and income.
  - In contrast to most datasets, I observe it.

II. Equilibrium Model of Housing Supply and Demand

Housing Market Equilibrium Model

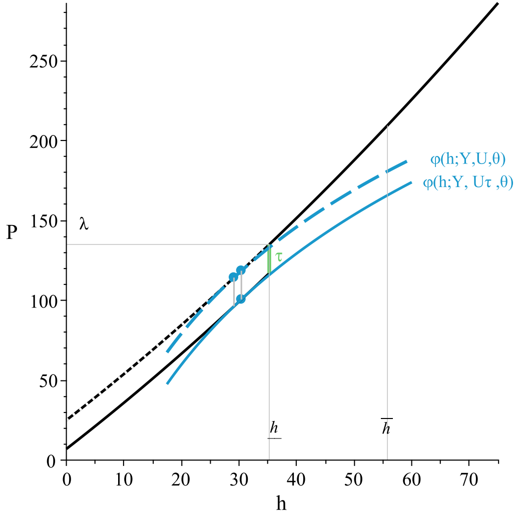
1. **Housing**
   - Differentiated product described by its size $h \in \mathcal{H}$
   - Price depends on size $P(h)$
2. **Households** $i \in I$, Heterogeneous in Income $Y_i \sim F_Y$
   - Choose h_i and consumption C_i to maximize Utility $U(C_i, h_i; \theta)$
3. **Developers** $j \in J$, Heterogeneous 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 $P\left(h\right) \rightarrow$ clears the market $\forall h \in \mathcal{H}$

Households' Optimal Choices



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

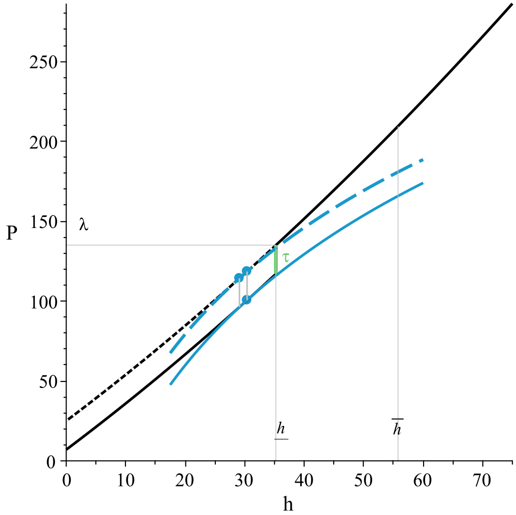
Households' Optimal Choices



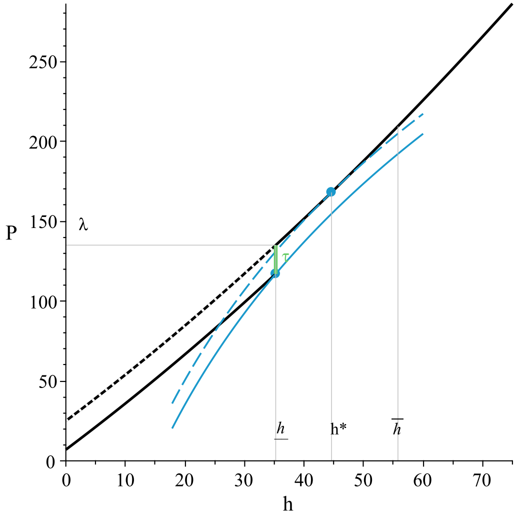
- **Implicit Price Function**
  $P(h)$
- **Subsidy**
  τ
- **Bid functions**
  $\varphi_D\left(h, Y, \bar{U}; \theta\right)$
  - $\bar{U} = U\left(h, Y_i - \varphi_D; \theta\right)$
  - $\bar{U}_\tau = U\left(h, Y_i - \varphi_D + \tau; \theta\right)$

Households' Optimal Choices

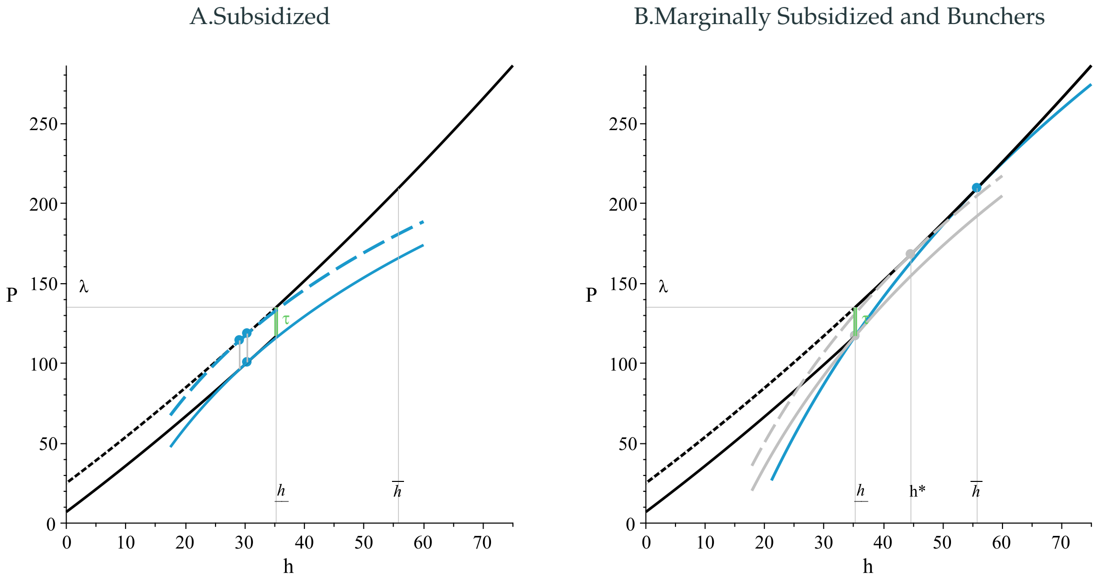
A.Subsidized



B.Marginally Subsidized and Bunchers

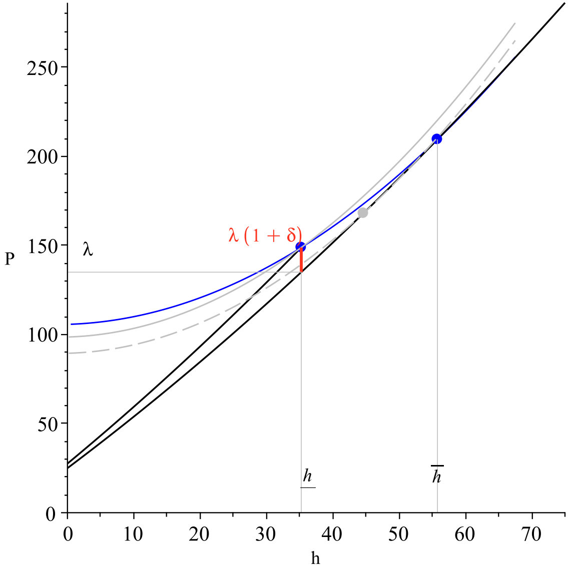


HOUSEHOLDS' OPTIMAL CHOICES



Housing demand function

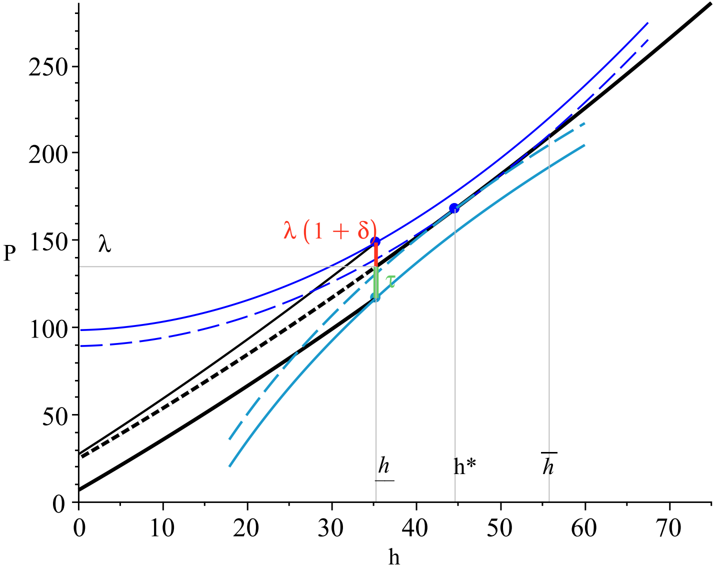
Developers' Optimal Choices



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

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

Equilibrium: Developers and Households Match

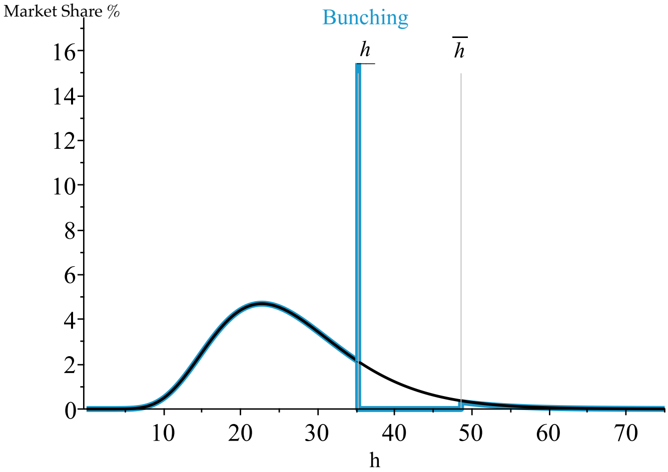


Implicit price: Envelop of offer and bid curves.

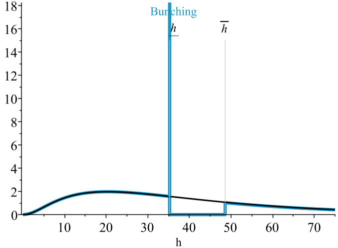
Equilibrium: Aggregate Demand and Supply Density

How to aggregate? $\rightarrow$ Change of variable formula optimal choices (h^*) and the density of households (F_y) and developers (G_y) details

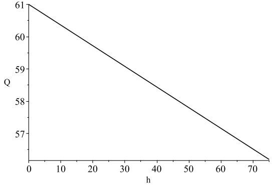
Demand Density Function



Housing types density function $g_h(h)$

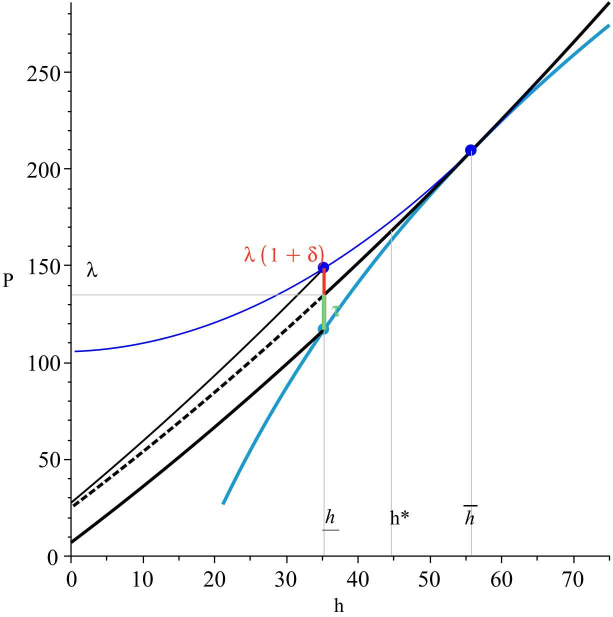


Unit supply function Q(h) (exogenous)



Identification

Marginal Buncher Condition



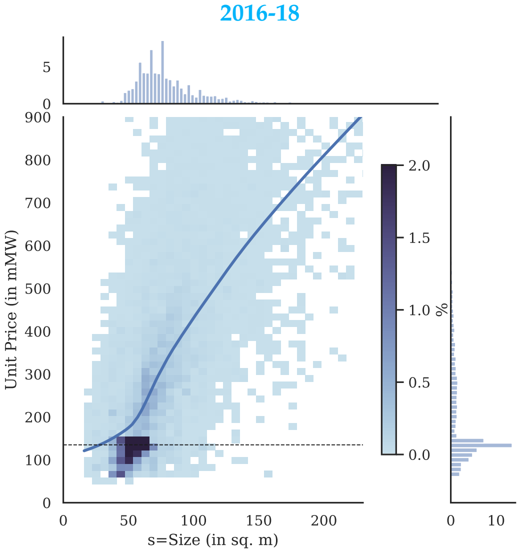
Marginal Buncher Condition

Marginal Buncher Condition	
Household	$V_D = U\left(\overline{Y} - P\left(\overline{h}\right), \overline{h}; \theta\right) - U\left(\overline{Y} - P^{\tau}\left(\underline{h}\right), \underline{h}; \theta\right) = 0$
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	$\overline{Y} = \tilde{Y}\left(\overline{h}; \theta, P(h), \lambda\right)$
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	$U = \left[\frac{1}{2} \cdot C^{\theta} + \frac{1}{2} \cdot h^{\theta}\right]^{\frac{1}{\theta}}$
Unit Supply	$Q = \alpha_0 + \alpha_1 h$
Cost	$B = A_j \cdot Q \cdot h^{\boldsymbol{\beta}}$

details

ESTIMATION

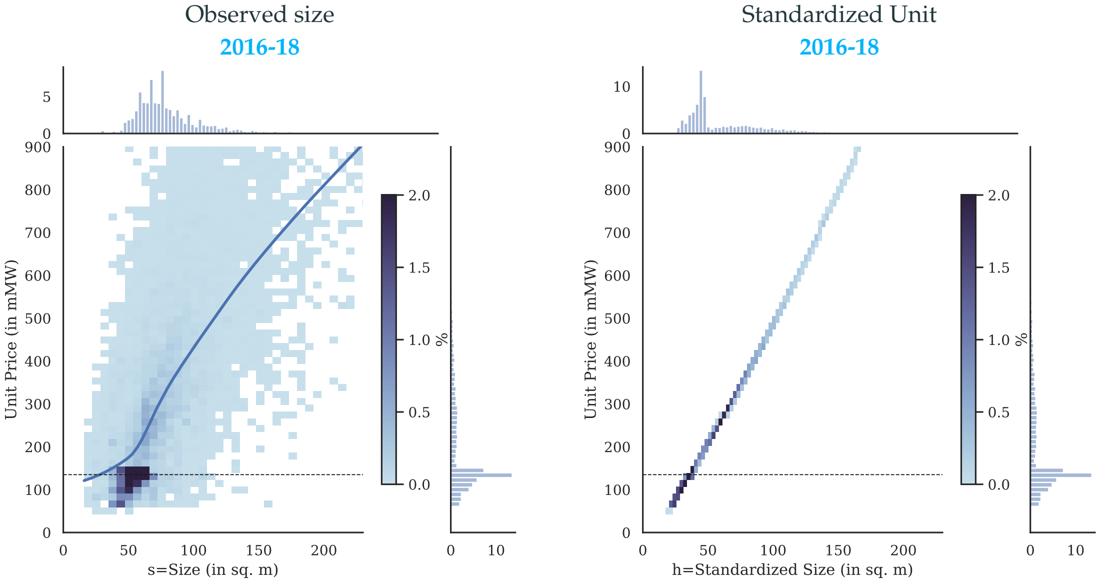
Observed Equilibrium: Prices, Quantities, and Size



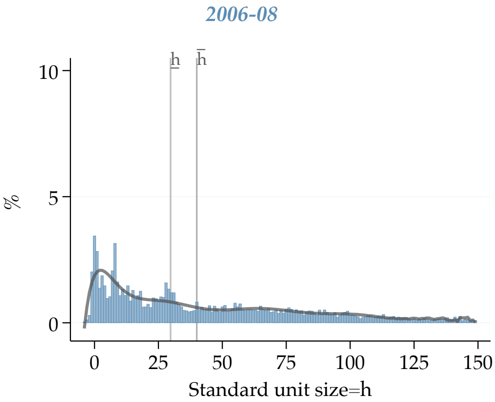
- ▶ Solid line: price vs size
  → hedonic price function
- ▶ Multiple characteristics
  → Reduce to a single characteristic
- ▶ Standard unit size (h):
  → Size of a unit with average characteristics that costs the same price

details

Observed Equilibrium: Prices, Quantities, and Size



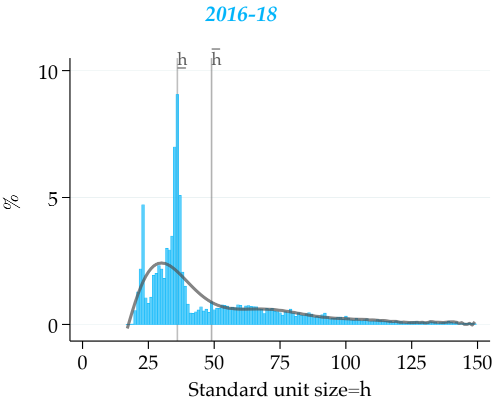
Bunching in Housing Characteristics (Size of std. Unit)



Notch: 19.7 *mMW*

Bunching: 1.53 % *market share*

Δh 11.2 m^2



Notch: 33.1 *mMW*

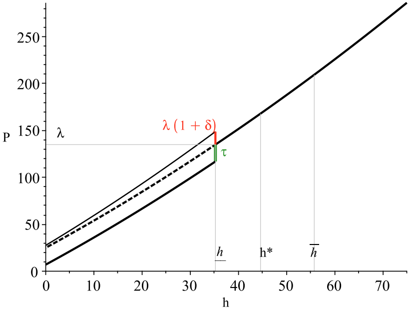
Bunching: 14.2 % *market share*

Δh: 13 m^2

Estimation details

Step I: Equilibrium Characterization

- 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
- Behavioural Responses:
  - Housing size for marginal buncher: $\overline{h}$
- Unit Supply Function:
  - $Q = \alpha_0 + \alpha_1 \cdot h_{ltc}$ see
- Policy Parameters:
  - Notches: τ_t,δ see



Step II: Structural Parameters

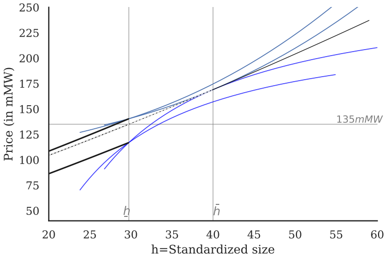
- $B = A_j \cdot Q \cdot h^{\beta}$
- $U = \left[\frac{1}{2} \cdot C^{\theta} + \frac{1}{2} \cdot h^{\theta}\right]^{\frac{1}{\theta}}$
- Elasticity of Substitution: $\sigma = \dfrac{1}{1-\theta}$

Identification equations:

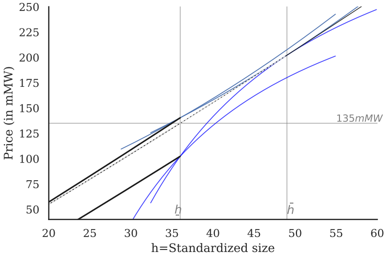
- $V_D\left(\theta | \underline{h}, \bar{h}, P(h), \tau, \lambda\right) = 0$
- $V_S\left(\beta | \underline{h}, \bar{h}, P(h), \boldsymbol{\alpha}, \delta, \lambda\right) = 0$

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

2006-08



2016-18



III. Policy Evaluation:

Counterfactual Policy I: Proposed tax reform

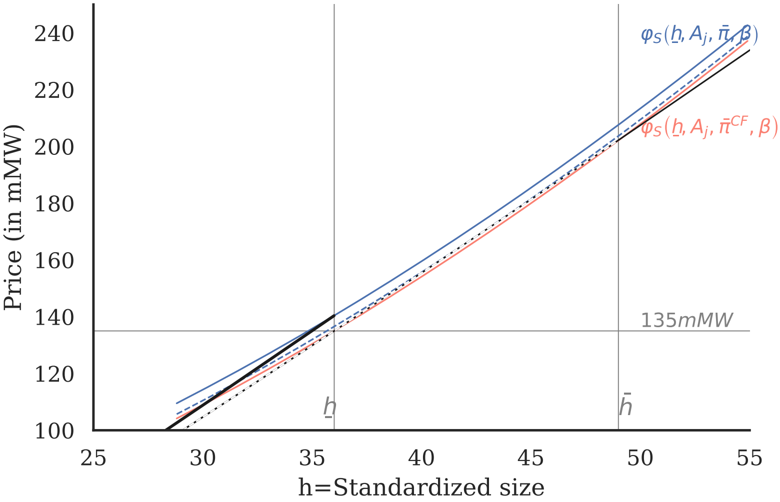
- Policy proposal: Remove the tax incentives to developers
- Developers reaction:

  "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"

  source: El Tiempo (2021)
- Question: What happens to the marginally subsidized developers?

Effect on Marginally Subsidized Developers

2016-18



Changes in profits (%)

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

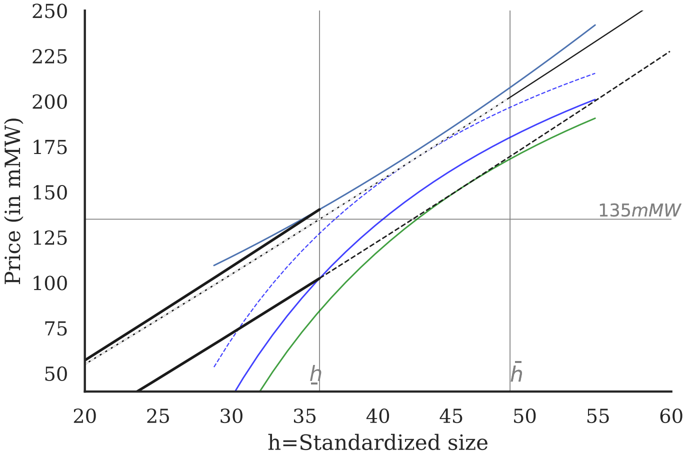
Counterfactual Policy II: Remove Price Cutoff

- Same households get subsidy but they can buy any house.

- Question: How much better off households are?

Effect on Marginally Subsidized Households

2016-18



Changes in welfare (*mMW*)

period	Welfare ↑	Efficiency ↓
2006-08	13.8	-10.2
2009-11	19.5	-12.1
2012-15	22.4	-16.2
2016-18	24.8	-17.9

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

Appendix

References

Abel, J. R., Dey, I., & Gabe, T. M. (2012). Productivity and the density of human capital*. *Journal of Regional Science*, *52*(4), 562-586. link

Anagol, S., Ferreira, F. V., & Rexer, J. M. (2021, October). *Estimating the economic value of zoning reform* (Working Paper No. 29440). National Bureau of Economic Research. link

Autor, D. H., Palmer, C. J., & Pathak, P. A. (2014). Housing market spillovers: Evidence from the end of rent control in cambridge, massachusetts. *Journal of Political Economy*, *122*(3), 661-717. link

Bachas, P., & Soto, M. (2018). *Not(ch) your average tax system: Corporate taxation under weak enforcement*. The World Bank. link

Bajari, P., & Benkard, C. L. (2005). Demand estimation with heterogeneous consumers and unobserved product characteristics: A hedonic approach. *Journal of Political Economy*, *113*(6), 1239-1276. link

Bajari, P., Fruehwirth, J. C., Kim, K. i., & Timmins, C. (2012, May). A rational expectations approach to hedonic price regressions with time-varying unobserved product attributes: The price of pollution. *American Economic Review*, *102*(5), 1898-1926. link

Baum-Snow, N., & Han, L. (2021). *The microgeography of housing supply* (Tech. Rep.). link

Baum-Snow, N., & Marion, J. (2009). The effects of low income housing tax credit developments on neighborhoods. *Journal of Public Economics*, *93*(5), 654 - 666. link

Bayer, P., Ferreira, F., & McMillan, R. (2007). A unified framework for measuring preferences for schools and neighborhoods. *Journal of Political Economy*, *115*(4), 588-638. link

Bertanha, M., McCallum, A. H., & Seegert, N. (2021). *Better bunching, nicer notching*. link

Best, M. C., Cloyne, J. S., Ilzetzki, E., & Kleven, H. J. (2019, 05). Estimating the Elasticity of Intertemporal Substitution Using Mortgage Notches. *The Review of Economic Studies*, *87*(2), 656-690. link

Best, M. C., & Kleven, H. J. (2017, 06). Housing Market Responses to Transaction Taxes: Evidence From Notches and Stimulus in the U.K. *The Review of Economic Studies*, *85*(1), 157-193. link

Bishop, K. C., & Timmins, C. (2019). Estimating the marginal willingness to pay function without instrumental variables. *Journal of Urban Economics*, *109*, 66-83. link

Blomquist, S., Newey, W., Kumar, A., & Liang, C.-Y. (2017, December). *On bunching and identification of the taxable income elasticity* (Working Paper No. 24136). National Bureau of Economic Research. link

Blomquist, S., Newey, W. K., Kumar, A., & Liang, C.-Y. (2021). On bunching and identification of the taxable income elasticity. *Journal of Political Economy*, *129*(8), 000–000.

Brown, J. N., & Rosen, H. S. (1982). On the estimation of structural hedonic price models. *Econometrica*, *50*(3), 765–768. link

Camacho, A., Caputo, J., & Sanchez, F. (2020). *Un nuevo comienzo: impacto del programa vivienda gratuita sobre las condiciones de vida de los hogares beneficiarios* (Tech. Rep.).

Camacol. (2016). *Actividad edificadora y contexto tributario* (Tech. Rep.). link (Mimeo)

Carozzi, F., Hilber, C., & Yu, X. (2020). *On the economic impacts of mortgage credit expansion policies: Evidence from help to buy* [CEP Discussion Paper No 1681]. link

Cengiz, D., Dube, A., Lindner, A., & Zipperer, B. (2019, 05). The Effect of Minimum Wages on Low-Wage Jobs*. *The Quarterly Journal of Economics*, *134*(3), 1405-1454. link

Chay, K. Y., & Greenstone, M. (2005). Does air quality matter? evidence from the housing market. *Journal of Political Economy*, *113*(2), 376-424. link

Chen, Z., Liu, Z., Suárez Serrato, J. C., & Xu, D. Y. (2021, July). Notching rd investment with corporate income tax cuts in china. *American Economic Review*, *111*(7), 2065-2100. link

Chernozhukov, V., Galichon, A., Henry, M., & Pass, B. (2021). *Identification of hedonic equilibrium and nonseparable simultaneous equations*.

Chetty, R., Friedman, J. N., Olsen, T., & Pistaferri, L. (2011, 05). Adjustment Costs, Firm Responses, and Micro vs. Macro Labor Supply Elasticities: Evidence from Danish Tax Records *. *The Quarterly Journal of Economics*, *126*(2), 749-804. link

Chetty, R., Friedman, J. N., & Saez, E. (2013, December). Using differences in knowledge across neighborhoods to uncover the impacts of the eitc on earnings. *American Economic Review*, *103*(7), 2683-2721. link

Cohen, M., Carrizosa, M., & Gutman, M. (2019). *Urban policy in latin america: Towards the sustainable development goals?* Routledge.

Collinson, R., & Ganong, P. (2018, May). How do changes in housing voucher design affect rent and neighborhood quality? *American Economic Journal: Economic Policy*, *10*(2), 62-89. link

DeFusco, A. A., & Paciorek, A. (2017, February). The interest rate elasticity of mortgage demand: Evidence from bunching at the conforming loan limit. *American Economic Journal: Economic Policy*, *9*(1), 210-40. link

Diamond, R., McQuade, T., & Qian, F. (2019, September). The effects of rent control expansion on tenants, landlords, and inequality: Evidence from san francisco. *American Economic Review*, *109*(9), 3365-94. link

Einav, L., Finkelstein, A., & Schrimpf, P. (2015, 02). The Response of Drug Expenditure to Nonlinear Contract Design: Evidence from Medicare Part D *. *The Quarterly Journal of Economics*, *130*(2), 841-899. link

Ekeland, I. (2010, 02). Existence, uniqueness and efficiency of equilibrium in hedonic markets with multidimensional types. *Economic Theory*, *42*(2), 275-315. link (Copyright - Springer-Verlag 2010; Document feature - ; Equations; Last updated - 2021-02-16)

Ekeland, I., Heckman, J. J., & Nesheim, L. (2004). Identification and estimation of hedonic models. *Journal of Political Economy*, *112*(S1), S60-S109. link

Epple, D. (1987). Hedonic prices and implicit markets: Estimating demand and supply functions for differentiated products. *Journal of Political Economy*, *95*(1), 59-80. link

Epple, D., Quintero, L., & Sieg, H. (2020). A new approach to estimating equilibrium models for metropolitan housing markets. *Journal of Political Economy*, *128*(3), 948-983. link

Franklin, S. (2019). *The demand for government housing: Evidence from lotteries for 200,000 homes in ethiopia*. link (Library Catalog: www.dropbox.com)

Galiani, S., Murphy, A., & Pantano, J. (2015, November). Estimating neighborhood choice models: Lessons from a housing assistance experiment. *American Economic Review*, *105*(11), 3385-3415. link

Geyer, J. (2017). Housing demand and neighborhood choice with housing vouchers. *Journal of Urban Economics*, *99*, 48-61. link

Gilbert, A. (2014, June). *Housing policy in Colombia*. link (Library Catalog: www.taylorfrancis.com Pages: 282-296 Publisher: Routledge)

Gilbert, A. G. (2014). Free housing for the poor: An effective way to address poverty? *Habitat International*, *41*, 253 - 261. link

Glaeser, E., & Shapiro, J. M. (2003). The benefits of the home mortgage interest deduction. *Tax Policy and the Economy*, *17*, 37-82. link

Glaeser, E. L., & Luttmer, E. F. P. (2003, September). The misallocation of housing under rent control. *American Economic Review*, *93*(4), 1027-1046. link

Goff, L. (2021). *Treatment Effects in Bunching Designs: The Impact of the Federal Overtime Rule on Hours* (Tech. Rep.).

Goncalves, F., & Mello, S. (2021). A few bad apples? racial bias in policing. *American Economic Review*. link

Greenstone, M. (2017). The continuing impact of sherwin rosen's "hedonic prices and implicit markets: Product differentiation in pure competition". *Journal of Political Economy*, *125*(6), 1891-1902. link

Gruber, J., Jensen, A., & Kleven, H. (2021, May). Do people respond to the mortgage interest deduction? quasi-experimental evidence from denmark. *American Economic Journal: Economic Policy*, *13*(2), 273-303. link

Harasztosi, P., & Lindner, A. (2019, August). Who pays for the minimum wage? *American Economic Review*, *109*(8), 2693-2727. link

Heckman, J. J., Matzkin, R. L., & Nesheim, L. (2010). Nonparametric identification and estimation of nonadditive hedonic models. *Econometrica*, *78*(5), 1569-1591. link

Jales, H. (2018). Estimating the effects of the minimum wage in a developing country: A density discontinuity design approach. *Journal of Applied Econometrics*, *33*(1), 29-51. link

Kleven, H. J. (2016). Bunching. *Annual Review of Economics*, *8*(1), 435-464. link

Kleven, H. J., & Waseem, M. (2013, 04). Using Notches to Uncover Optimization Frictions and Structural Elasticities: Theory and Evidence from Pakistan *. *The Quarterly Journal of Economics*, *128*(2), 669-723. link

Kopczuk, W., & Munroe, D. (2015, May). Mansion tax: The effect of transfer taxes on the residential real estate market. *American Economic Journal: Economic Policy*, *7*(2), 214-57. link

Kumar, T. (2021). The housing quality, income, and human capital effects of subsidized homes in urban india. *Journal of Development Economics*, *153*, 102738. link

Kuminoff, N. V., Smith, V. K., & Timmins, C. (2013, December). The new economics of equilibrium sorting and policy evaluation using housing markets. *Journal of Economic Literature*, *51*(4), 1007-62. link

McMillen, D., & Singh, R. (2020). Fair market rent and the distribution of rents in los angeles. , *80*, 103397. link

OECD. (2021). *Ph1.2 housing policy objectives and obstacles* (Working Paper). link

Palmquist, R. B. (2006). Property value models. In K. G. Mäler & J. R. Vincent (Eds.), *Handbook of environmental economics* (1st ed., Vol. 2, p. 763-819). Elsevier. link

Persson, P. (2020). Social insurance and the marriage market. *Journal of Political Economy*, *128*(1), 252-300. link

Poterba, J. M. (1992). Taxation and housing: Old questions, new answers. *The American Economic Review*, *82*(2), 237–242. link

Quigley, J. M. (1982). Nonlinear budget constraints and consumer demand: An application to public programs for residential housing. *Journal of Urban Economics*, *12*(2), 177 - 201. link

Rosen, H. S. (1985). Chapter 7 housing subsidies: Effects on housing decisions, efficiency, and equity. In (Vol. 1, p. 375 - 420). Elsevier. link

Rosen, S. (1974). Hedonic prices and implicit markets: Product differentiation in pure competition. *Journal of Political Economy*, *82*(1), 34-55. link

Saez, E. (2010). Do taxpayers bunch at kink points? *American economic Journal: economic policy*, *2*(3), 180–212.

Saiz, A. (2010). The geographic determinants of housing supply*. *The Quarterly Journal of Economics*, *125*(3), 1253-1296. link

Sinai, T., & Waldfogel, J. (2005). Do low-income housing subsidies increase the occupied housing stock? *Journal of Public Economics*, *89*(11), 2137 - 2164. link

Slemrod, J., Weber, C., & Shan, H. (2017). The behavioral response to housing transfer taxes: Evidence from a notched change in d.c. policy. *Journal of Urban Economics*, *100*, 137 - 153. link

Soltas, E. (2020). The price of inclusion: Evidence from housing developer behavior.. link (Library Catalog: www.dropbox.com)

Uribe, J. P. (2021). ***The effect of location based subsidies on the housing market***.

van Dijk, W. (2019). The socio-economic consequences of housing assistance. *University of Chicago Kenneth C. Griffin Department of Economics job market paper, 0–46 i–xi, 36*.

Wooldridge, J. M. (2010). *Econometric analysis of cross section and panel data*. MIT press.

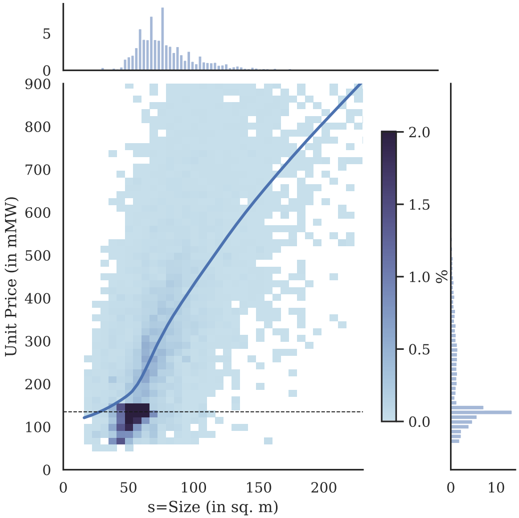
World Bank Group, P. P. (1993). *Housing : enabling markets to work (english)* (Working Paper No. 27704). link

Yinger, J. (2015). Hedonic markets and sorting equilibria: Bid-function envelopes for public services and neighborhood amenities. *Journal of Urban Economics*, *86*, 9-25. link

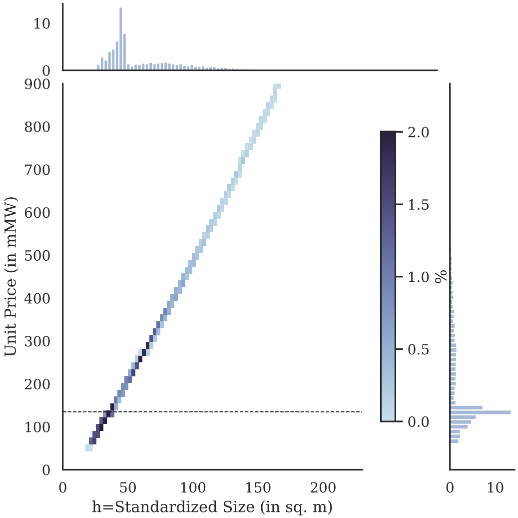
From size s to Standardized Size h

Subsidy expansion **2016-18**

Observed size



Standardized Unit



back

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

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

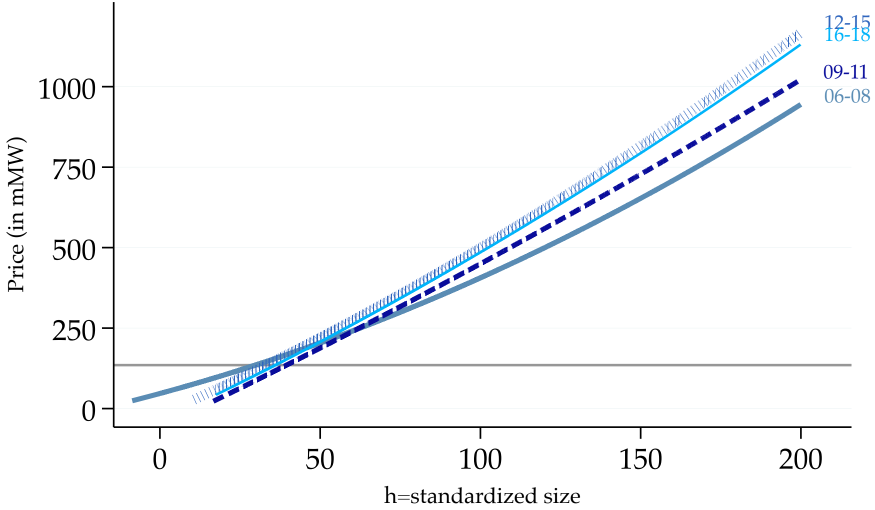
- Standard Unit Size h_{ltc}

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

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

figures

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)

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

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

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

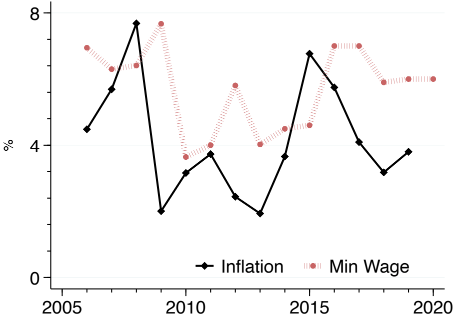
Figures

EQUILIBRIUM: DEVELOPERS AGGREGATE SUPPLY DENSITY

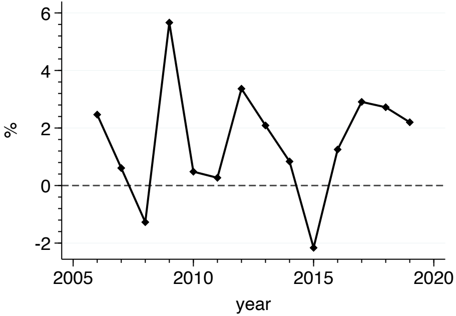
$$D(h) = \begin{cases} f_{h^*}(h)\,\mathrm{d}h & \text{if } h < \underline{h} \\ f_{h^*}(h)\,\mathrm{d}h \\ \qquad + \int_{\underline{h}}^{\overline{h}} f_{h^*}(h)\,\mathrm{d}h & \text{if } \underline{h} = h \\ 0 & \text{if } h \in \left(\underline{h}, \overline{h}\right) \\ f_h^*(h)\,\mathrm{d}h & \text{if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

Equilibrium Figures

Inflation and minimum wages.



a. Min wage and Inflation

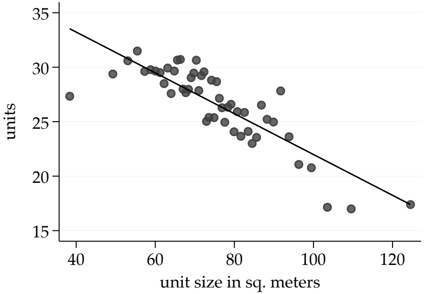


b. Min wage and Inflation

Data

Developers Choices of Size and Unit Supply

All data

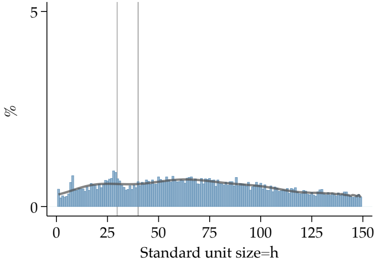


$$Q_{ltc} = \alpha_0 + \alpha_1 s_{ltc} + \alpha_x' X_{ltc} + \epsilon_{ltc}^Q$$

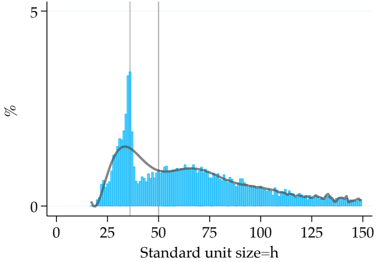
	06-08	09-11	12-15	16-18
α_0	70.5	12.7	81.1	33.3
α_1	-0.068	-0.020	-0.020	-0.042

Product type density (g_h)

2006-08



2016-18



Step I

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

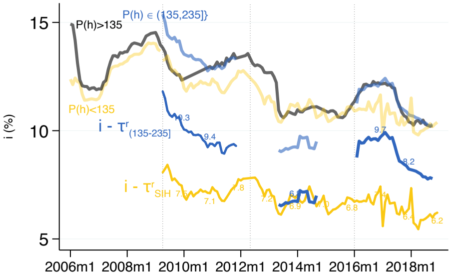
Step I

DATA: MORTGAGES AND INTEREST RATES

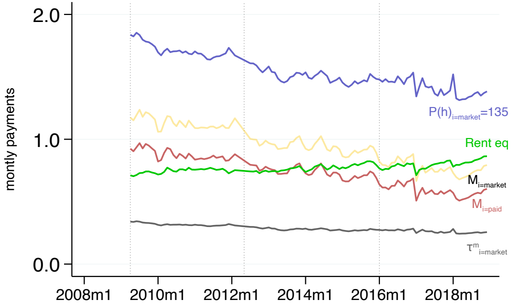
rent equivalent ((?, ?), (Bishop & Timmins, 2019) assume it is 0.05)

- 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:

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

Households' Demand Function

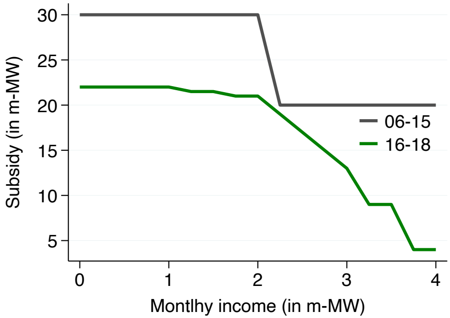
$$h^{\mathrm{D}}(Y_i) = \begin{cases} h^*(Y_i, \tau; \theta, \boldsymbol{\rho}, \lambda) & \text{if } Y_i \leq \underline{Y} \\ \underline{h} & \text{if } \underline{Y} < Y_i < \overline{Y} \\ h^*(Y_i, \tau; \theta, \boldsymbol{\rho}, \lambda) & \text{if } \overline{Y} \leq Y_i \end{cases}$$

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

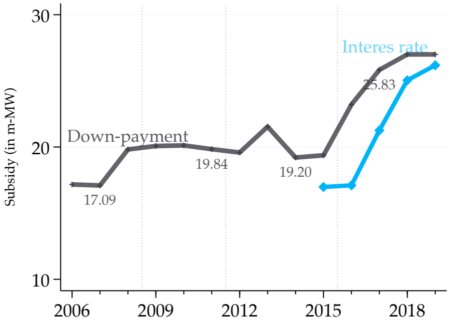
Graphs

The Notch: Down Payment Subsidy

Subsidy by household income

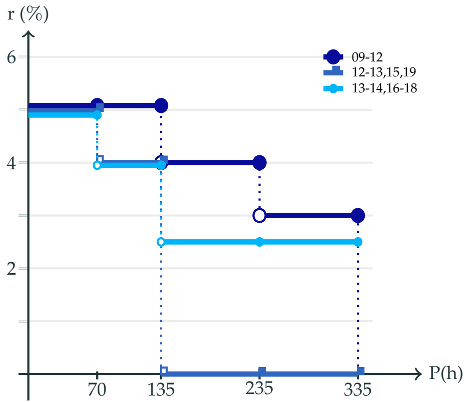


Average subsidy over time

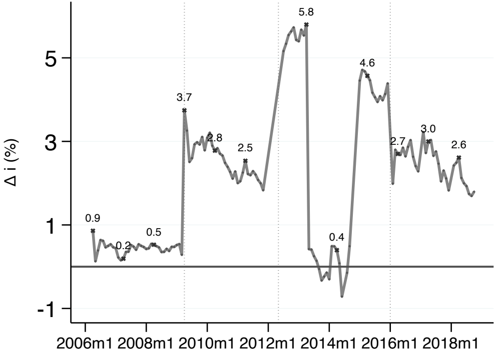


- Varies by income.
- Increase in 2016.
- Expanded trough *mi casa YA*

THE NOTCH: INTEREST RATE SUBSIDY

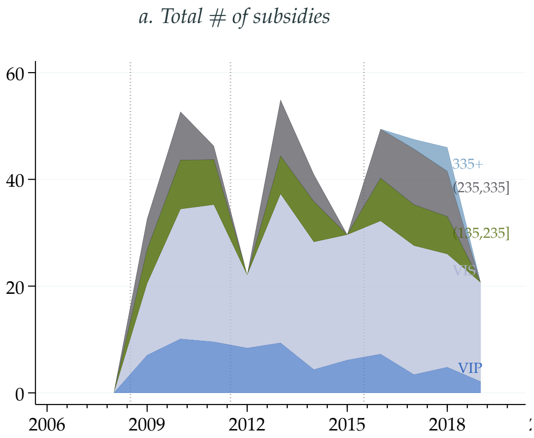


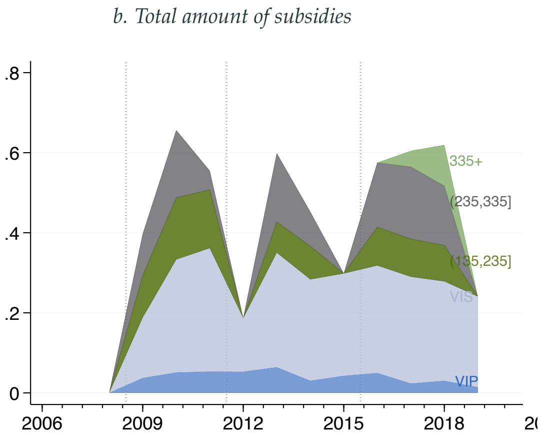
Comparing monthly payments around P(h)=135 m-MW



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

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

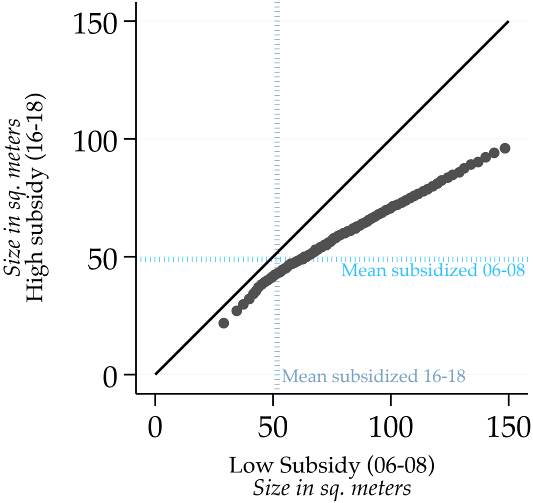




Changes in Housing Stock Characteristics

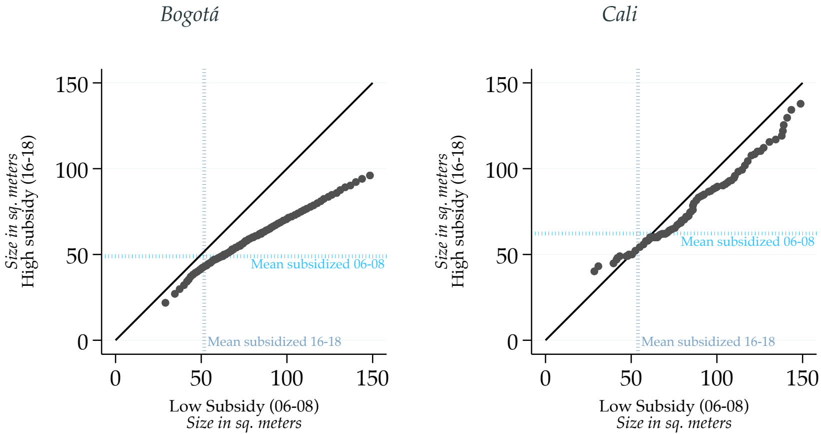
- Changes in unit size (quantile to quantile plot)

Bogotá



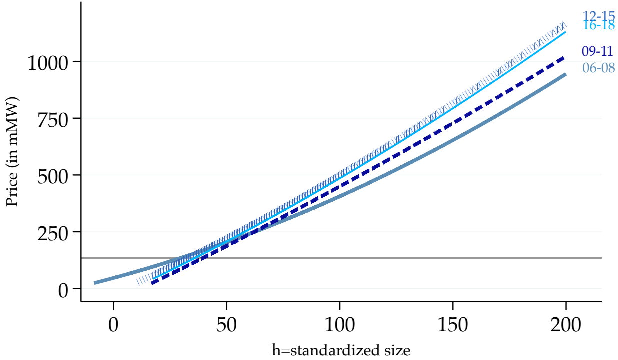
Changes in Housing Stock Characteristics

- Changes in unit size

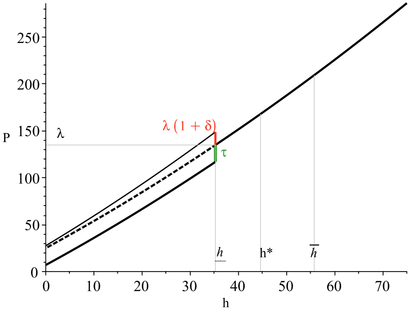


- Why size?
  - Continuous, easy to measure, monotonic relationship with price and income.
  - In contrast to most datasets, I observe it.

Prices



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



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

back

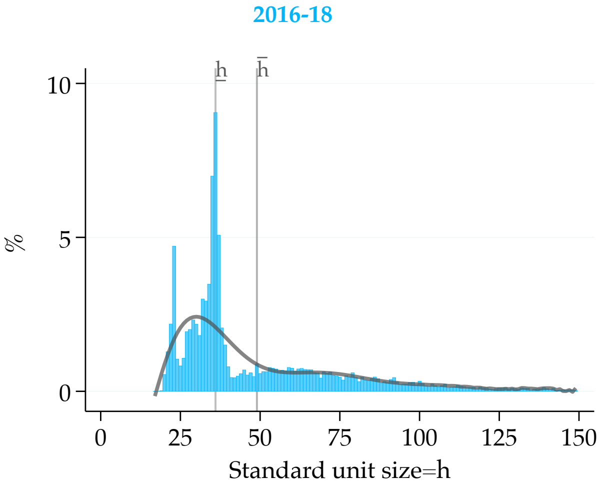
The Policy Effect on Observed Outcomes

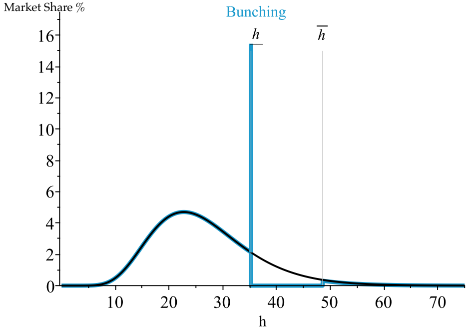
Table 1: Behavioral Responses Estimates'

	06-08	09-11	12-15	16-18
$\int_{h_{min}}^{\underline{h}^{-}} T(h)\mathrm{d}h$	1.03	0.86	3.80	7.28
$\hat{T}\left(\underline{h}\right)$	0.50	2.02	4.01	6.97
$\int_{h_{min}}^{\underline{h}} T(h)\mathrm{d}h$	1.54	2.88	7.81	14.2
$\int_{\underline{h}}^{\bar{h}} T(h)\mathrm{d}h$	-0.12	-6.23	-4.27	-3.38
$h_{h^0}\left(\underline{h}\right)$	0.73	1.28	1.07	1.43
h_{min}	26	37	29	32
$\underline{h}$	29.8	39.4	33.0	36.0
$\bar{h}$	40	53	45	49

back

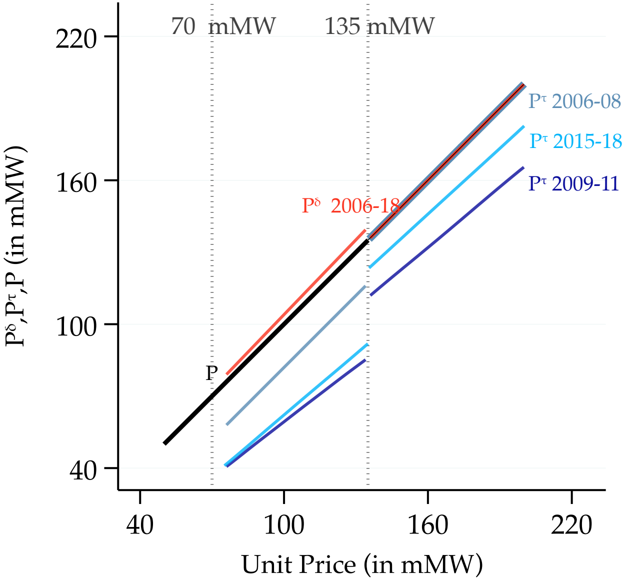
BEHAVIORAL RESPONSES





back

The Demand Notch Increases Over Time



Supply Notch δ

2006-18 4%

Demand Notch τ_t

2006-08: 19.7 *mMW*

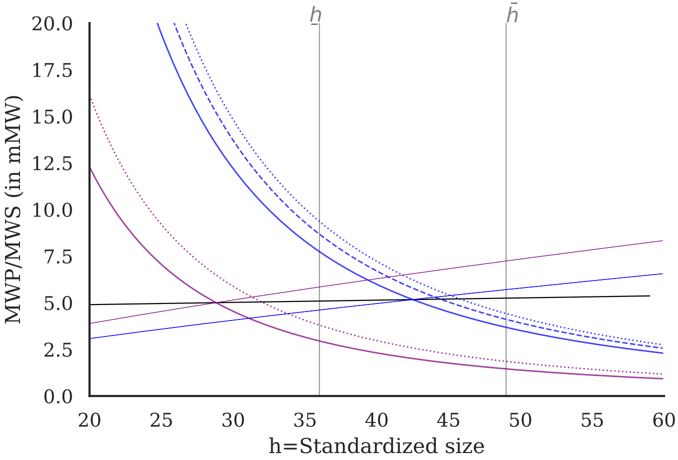
2009-11: 26.4 *mMW*

2016-18: 33.1 *mMW*

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

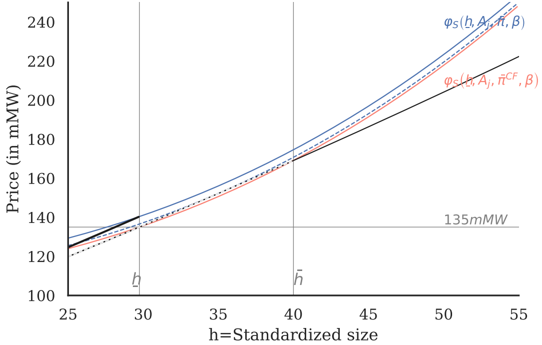
Alternative Representation of the Equilibrium. Demand and Supply for Size

Expansion period Mi Casa Ya **2016-18**

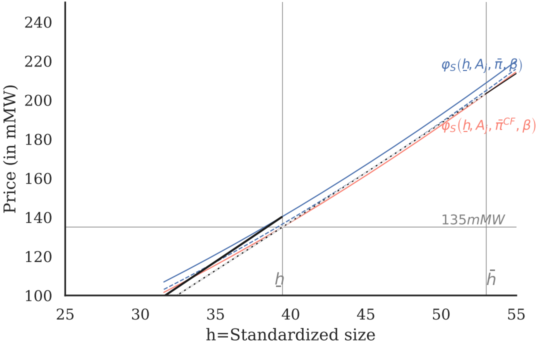


Effect on Marginally Subsidized Developers

2006-08



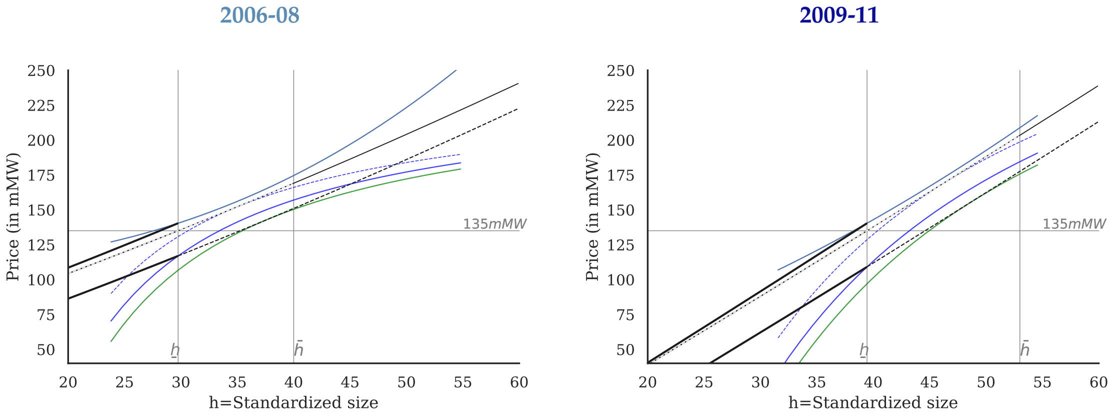
2016-18



Changes in profits (%)

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

Effect on Marginally Subsidized Households



Optimality Conditions	
Income	$\overline{Y} = (2 \cdot h \cdot \rho_2 + \rho_1)^{-\dfrac{1}{\theta - 1}} \cdot h + h^2 \cdot \rho_2 + h \cdot \rho_1 + \rho_0$
Productivity	$\overline{A} = \dfrac{3 \cdot (\delta + 1) \cdot (h \cdot \alpha_1 + \alpha_0) \cdot \left(\left(h^2 \cdot \rho_2 + \frac{2}{3} \cdot h \cdot \rho_1 + \frac{1}{3} \cdot \rho_0 \right) \cdot \alpha_1 + \frac{2 \cdot \left(h \cdot \rho_2 + \frac{\rho_1}{2} \right) \cdot \alpha_0}{3} \right)}{h^{\beta_1 + 1} \cdot \alpha_1^2 + h^{\beta_1} \cdot \alpha_0 \cdot \alpha_1 + 2 \cdot h \cdot (h \cdot \alpha_1 + \alpha_0)^2}$
Marginal Buncher Condition	
Household	$0 = \left(\dfrac{\underline{h}^{\theta} + \left(\bar{h}^2 \rho_2 - \rho_2 \underline{h}^2 + \bar{h}\rho_1 + \bar{h}\left(2\bar{h}\rho_2 + \rho_1\right)^{\frac{1}{1-\theta}} - \rho_1 \underline{h} + \tau \right)^{\theta}}{2} \right)^{\frac{1}{\theta}} - \left(\dfrac{\left(\left(2\bar{h}\rho_2 + \rho_1\right)^{\frac{\theta}{1-\theta}} + 1 \right) \bar{h}^{\theta}}{2} \right)^{\frac{1}{\theta}}$
Developer	$0 = \dfrac{\bar{h}^{\beta_1+1}\alpha_1 - \underline{h}^{\beta_1+1}\alpha_1 + \alpha_0\left(\bar{h}^{\beta_1} - \underline{h}^{\beta_1}\right)}{\bar{h}^{\beta_1+1}\alpha_1^2 + \bar{h}^{\beta_1}\alpha_0\alpha_1 + 2\bar{h}\left(\bar{h}\alpha_1 + \alpha_0\right)^2} - \dfrac{\left(-\rho_2(1+\delta)\underline{h}^3 - \rho_1(1+\delta)\underline{h}^2 - \rho_0(1+\delta)\underline{h} + \bar{h}\left(\bar{h}^2\rho_2 + \bar{h}\rho_1 + \rho_0\right)\right)\alpha_1 + \alpha_0\left(-\rho_2(1+\delta)\underline{h}^2 - \rho_1(1+\delta)\underline{h} + \bar{h}^2\rho_2 + \bar{h}\rho_1 - \delta\rho_0\right)}{3\left(\left(\bar{h}^2\rho_2 + \frac{2}{3}\bar{h}\rho_1 + \frac{1}{3}\rho_0\right)\alpha_1 + \frac{2\left(\bar{h}\rho_2 + \frac{\rho_1}{2}\right)\alpha_0}{3}\right)\left(\bar{h}\alpha_1 + \alpha_0\right)}$

Main table