# Under Control? Price Ceiling, Queuing, and Misallocation: Evidence from the Housing Market in China

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# Motivation

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  - e.g., Rent control in New York City, Stockholm, San Francisco

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  - Misallocation (cannot distinguish buyers based on their WTP)

# Motivation

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  - e.g., Rent control in New York City, Stockholm, San Francisco
- The literature uses a **static** approach to analyzes the price control:
  - Under-supply
  - Misallocation (cannot distinguish buyers based on their WTP)
- An important dimension that is often ignored: **waiting costs**
  - In the market with excess demand, buyers who cannot get what they want at the current time need to **re-enter in the future**.
  - The average waiting time to get into a rent-controlled apartment in Stockholm is 10 years (BBC).

BBC

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# The city with 20-year waiting lists for rental homes

17th May 2016, 08:05 EDT

Share

**By Maddy Savage**
Features correspondent
@maddysavage


**Think things are bad where you live? This town's queue for rent-controlled housing is so long it's being considered by the Guinness Book of World Records.**

# Research questions

- ▷ How to model waiting when households face a price ceiling?
- ▷ How to quantify the welfare loss associated with the price ceiling?
- ▷ How does the price ceiling compare with alternative policies?

# This paper

- ▷ Analyze the price ceiling on the housing market in Shanghai
  - New house prices are capped
  - Existing house prices are market-driven
  - A lottery system is used to allocate the new houses
  - This has been implemented in most large cities in China
  - Annual new house sales is 16 % of China's GDP in 2017

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  - A lottery system is used to allocate the new houses
  - This has been implemented in most large cities in China
  - Annual new house sales is 16 % of China's GDP in 2017
- ▷ Specify and estimate a structural model that incorporates waiting
- ▷ Conduct counterfactual exercises:
  - Housing vouchers
  - Increase in supply

# Preview of findings

- Waiting costs play an important role
  - Welfare loss from price ceiling was \$13 billion from 2018 to 2020
  - Waiting costs: \$5 billion; Misallocation: \$8 billion
  - Consumer gains: \$1.3 billion
  - Consumer gains due to lower prices are offset by waiting costs and misallocation.

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  - Consumer gains: $1.3 billion
  - Consumer gains due to lower prices are offset by waiting costs and misallocation.
- ▷ Counterfactual policies: distribute housing vouchers
  - Vouchers can significantly reduce welfare loss
  - They achieve similar policy outcomes in reducing the housing prices faced by consumers
  - They result in more equitable outcomes (by subtle design)

# Literature

▷ Empirical literature on price ceiling in the housing market:

- Allocative costs: Glaeser and Luttmer (2003)
- Under-supply: Sims (2007); Diamond et al. (2019)
- Spillover effects: Autor et al. (2014)
- Renter mobility: Diamond et al. (2019)

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**This paper:**

- ▷ Incorporate **waiting** into the analysis of price ceiling
  - Glaeser (1996) models it in a theoretical framework
  - Most empirical works have not considered waiting seriously
  - A tractable framework to model price ceiling with waiting
- ▷ Use a structural approach to quantify the welfare effects of price ceiling
  - Most existing literature uses a reduced-form approach
  - Better understand the welfare effects
  - Better counterfactual policy experiments

# Literature

- Housing market regulations in China
  - Bai et al. (2014); Agarwal et al. (2020)

  This paper: First work to study the impact of price ceiling on new houses

- Design of allocation mechanisms:
  - Agarwal et al. (2021); Li (2018); Waldinger (2021); Lee et al. (2023); Galiani et al. (2015)

# Background

- ▷ Houses are increasingly unaffordable in large cities in China
  - In Shanghai, a 90 $m^2$ house costs **25** years of a median household's salary (Glaeser et al., 2017)
- ▷ A price ceiling on new houses was introduced in Shanghai in July 2017
  - Existing houses are not subject to this price ceiling
  - A lottery is used to allocate the new houses for each project
  - A household typically needs to participate in **multiple** lotteries to get a new house
  - Different new apartment complexes are subject to varying ceilings

# Background

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  - Time cost
  - Pay additional rent and live in undesirable places
  - Psychological anxiety

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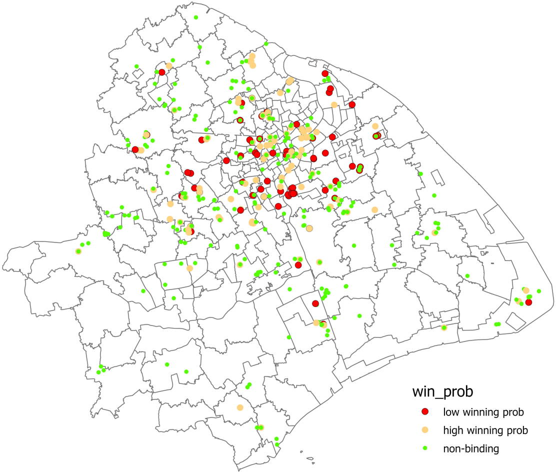
▷ Strict reselling and purchase restrictions
  - New houses are not allowed to resell within 2 years of the purchase
  - An additional 6% transaction tax is imposed on sales after 2 years from the purchase
  - Households owning no more than one houses are eligible to buy
  - Speculations are rare: Less than 1% of price-capped new houses sold in 2018 appeared on the existing house market in 2021

# Price ceiling in Shanghai

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# Demand

- ▷ $i$'s choice set: $\{$new house $j$, existing house $j'$, waiting$\}$
- ▷ $i$'s indirect utility function of **successfully** purchasing house $j$:

$$u_{ij} = x_j\beta_i - \alpha_i p_j + \xi_j + \epsilon_{ij}$$

  - $\epsilon_{ij} \sim$ i.i.d. extreme type 1 value distribution.

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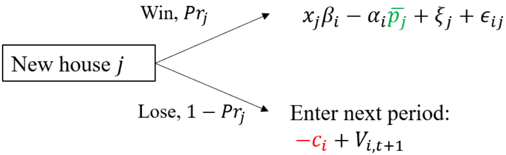
- New versus existing houses:
  - $c_i$: per-period waiting costs (Glaeser, 1996; Johnston et al., 2023)



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- $i$'s indirect utility function of **successfully** purchasing house $j$:

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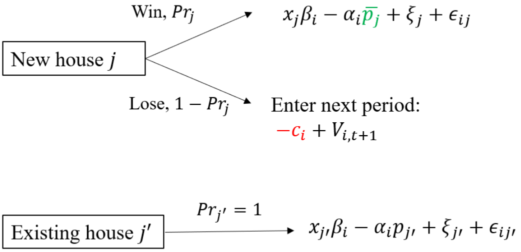
- Tradeoff between new and existing houses:
  - $c_i$ : per-period waiting costs (Glaeser, 1996)



# Demand

- Household i's value function:

$$V_{i,t} = max\left[v_{ij,t}(N); v_{ij',t}(E); v_{i,t}(W); 0\right]$$

- The lottery winning prob is $Pr_{j,t}$:

$$v_{ij,t}(N) = Pr_{j,t}U_{ij,t} + (1 - Pr_{j,t})U_{i,t}(W)$$

$$v_{ij',t}(E) = U_{ij',t}(E)$$

$$v_{i,t}(W) = U_{i,t}(W)$$

- Household $i$'s valuation of purchasing new house $j$:

$$v_{ij,t}(N) = U_{ij,t} - \underbrace{\frac{1 - Pr_{j,t}}{Pr_{j,t}}c_i}_{\text{Waiting costs}} + \underbrace{\frac{1 - Pr_{j,t}}{Pr_{j,t}}\Delta_{i,t+1}}_{\text{Future impact}}$$

Where $\Delta_{i,t+1} = V_{i,t+1} - V_{i,t}$

# Demand: Stability assumption

▷ Stability assumption: Households' expected valuation of being in the pool tomorrow is the same as today: $\Delta_{i,t+1} = 0$

▷ Under the stability assumption, the indirect utility function $u_{ij}$ for **both** new and existing houses:

$$u_{ij} = x_j \beta_i - \alpha_i p_j + \xi_j + \epsilon_{ij} - \underbrace{\frac{1 - Pr_{j,t}}{Pr_{j,t}} c_i}_{\text{Waiting costs}}$$

- e.g., if $Pr_{j,t} = 0.1$, then $\frac{1 - Pr_{j,t}}{Pr_{j,t}} c_i = 9c_i$

▷ Find a mapping between $Pr_{j,t}$ and the expected waiting time

▷ Demand can be estimated using the Berry, Levinson, and Pakes (1995, 2004) standard demand estimation algorithm

More details: demand

# Estimation of a more flexible demand model

- Relax the stability assumption. $\Delta_{i,t+1}$ does not necessarily equal 0
- Following Lee et al., (2023) I assume:
  - Households become active for a maximum of 6 periods
    - Around 5% households stay in the market $> 4$ periods
    - Results remain robust when I use the alternative thresholds
  - Households have perfect foresight

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    - Results remain robust when I use the alternative thresholds
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- **Estimation**:
  - **Inner loop:** Using backward induction, I solve the households' dynamic problem, and obtain the model-predicted choice probability
  - **Middle loop:** Iterate mean utility parameters that equate the observed market share and the model predicted market share.
    Use GMM-IV to find the linear parameters (price, waiting cost, and other covariates), and form a criteria function
  - **Outer loop:** Iterate over non-linear parameters to minimize the criteria function

# Supply

## ▷ New house supply

- Supply of new houses is predetermined: $\bar{K}_j$.

  The average construction time is around 3 to 4 years.
  Sample period: 2018-2020

- Long-term new house supply also tends to be inelastic

  Land is owned by the state

More details: New house supply

## ▷ Existing house supply

- Supply of existing houses is a binary choice problem.
- Current residents decide whether to sell or not based on a given price. (Calder-Wang, 2022; Lee et al. 2023)
- Incorporate forward-looking (Arcidiacono and Miller, 2011):

$$lns_{1jt+1} - (lns_{0jt} - lns_{1jt}) = \gamma + \alpha(p_{j,t+1} - p_{j,t}) + (v_{1jt,s+1} + v_{0jt,s} - v_{1jt+1,s})$$

More details: dynamic supply

# Equilibrium

- **New house:** $\forall j, new$ :

$$\underbrace{D_j(\bar{p}_j, Pr_{j,new}, p_{-j}, Pr_{-j})}_{\text{\# of lottery participants}} = \underbrace{\bar{K}_j}_{\text{Supply}} + \underbrace{L_j(\bar{p}_j, Pr_{j,new}, p_{-j}, Pr_{-j})}_{\text{Equilibrium queuing line}}$$

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▷ **Existing house:** $\forall j, old$ :

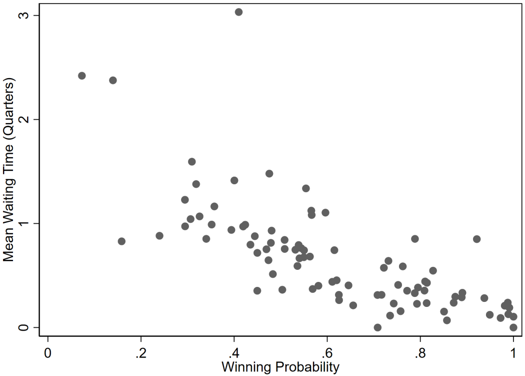
$$\underbrace{D_{j'}(p_{j'}, 1, p_{-j}, Pr_{-j})}_{\text{Existing house demand}} = \underbrace{S_{j'}(p_{j'})}_{\text{Existing house supply}}$$

# Data

- **New house data**
  - Price ceiling; supply of new houses; # of lottery participants
  - Source: Official documents and CRIC (China Real Estate Information Center)
  - Other new house characteristics come from Lianjia dataset
- **Lottery participation data**
  - It comes from Shanghai Oriental Public Lottery Office
  - A unique id to match the buyers across lotteries
- **Existing house data**
  - Lianjia dataset
  - 116,145 transaction records from 2018 to 2020
  - Around 25% of all existing house transactions in Shanghai
  - Houses' hedonic characteristics

# Lottery winning probability and average waiting time

Figure 1: Lottery winning probability and waiting time




Under the stability assumption, the expected waiting time is: $\dfrac{1 - Pr_{j,t}}{Pr_{j,t}}$

# Instruments

- ▷ **IV for price ceiling:** land price
  - The government sets the price ceiling based on the land price
  - Unobserved location effects are absorbed by subdistrict fixed effects
- ▷ **IV for existing house price:** The number of listings for existing houses in adjacent zipcodes with similar characteristics
  - Bayer, Ferreira and Mcmillan (2007); Calder-Wang (2023)

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  - Bayer, Ferreira and Mcmillan (2007); Calder-Wang (2023)
- **IV for waiting line** $\frac{1 - Pr_{j,new}}{Pr_{j,new}}$: Supply of new houses $\bar{K}_j$
  - $Pr_{j,new} = \frac{\bar{K}_j}{D_j}$
  - $\bar{K}_j$ is a pre-determined variable
- **Supply-side IV:** The aggregate number of link clicks of the same type house in Lianjia website in previous periods

# Demand estimation results

| | | (1) | (2) | (3) | (4) |
|---|---|---|---|---|---|
| | | Stability Assumption | | Dynamic Model | |
| Price (10K yuan) | | -0.946*** | -0.801*** | -0.855*** | -0.696*** |
| | | (0.298) | (0.253) | (0.127) | (0.070) |
| | *Price · rich* | | 0.344** | | 0.247** |
| | | | (0.144) | | (0.090) |
| Waiting | | -0.30*** | -0.326*** | -0.323*** | -0.383*** |
| | | (0.113) | (0.108) | (0.058) | (0.017) |
| | *Waiting · rich* | | 0.080 | | 0.122 |
| | | | (0.164) | | (0.189) |
| Subdistrict by house type FE | | X | X | X | X |
| Quarter FE | | X | X | X | X |
| District by year FE | | X | X | X | X |

# Supply of the existing houses

| | |
|---|---|
| Price (10K yuan) | 0.543*** |
| | (0.193) |
| Subdistrict by house type FE | X |
| Quarter FE | X |
| District by year FE | X |

Model fit

Implied supply elasticity: 2.7

The magnitude is similar to Lee et al., (2023) in Singapore

# Welfare calculation without price ceiling

| in billion USD | CS | PS | SS | total surplus | price |
|---|---|---|---|---|---|
| w/o price ceiling | 100.94 | 109.69-C | 115.77 | 326.40-C | |
| with price ceiling | 102.25 | 96.17-C | 114.87 | 313.29-C | |
| price ceiling impact | 1.3 | -13.5 | -0.9 | -13.1 | -0.016 |

Notes: CS: Consumer Surplus; PS: Producer (developer) surplus; SS: Existing house seller surplus.

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Notes: CS: Consumer Surplus; PS: Producer (developer) surplus; SS: Existing house seller surplus.

- ▷ Waiting cost: **5.1** billion USD; Misallocation: **8** billion USD
- ▷ Consumer surplus: **+ $1.3 billion**; Producer surplus: **- $ 13.5 billion**.
  - Consumer gains from lower prices were offset by waiting and misallocation.

demand results

# Housing vouchers

- Distributing housing vouchers can also improve affordability.
- Conceptually, vouchers can significantly increase welfare.
  - No waiting
  - Less misallocation
- If designed properly, they can also achieve more equitable outcomes (Ludwig et al., 2013)
- This paper considers two types of vouchers:

  A 4% voucher to all house buyers

  A 6% voucher to buyers of houses below 90 $m^2$

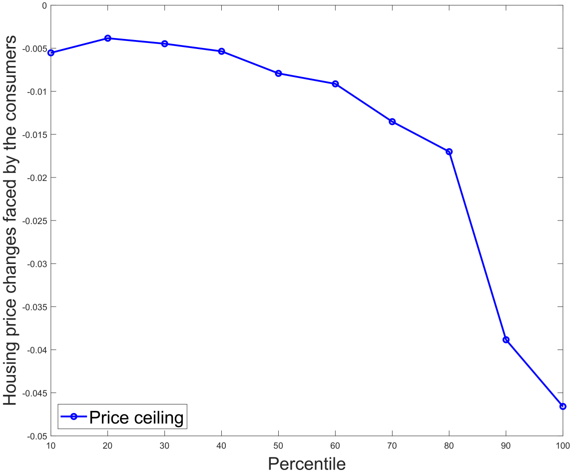
# Housing vouchers

| in billion USD | CS | PS | SS | subsidy | total surplus | $\Delta$ welfare | $\Delta p$ |
|---|---|---|---|---|---|---|---|
| w/o price ceiling (benchmark) | 100.94 | 109.69-C | 115.77 | 0 | 326.40-C | | |
| with price ceiling (current) | 102.25 | 96.17-C | 114.87 | 0 | 313.29-C | -13.11 | -0.016 |
| 4% voucher to all houses | 106.44 | 114.12-C | 122.74 | 17.43 | 325.87-C | -0.53 | -0.016 |
| 6% voucher to houses $\leq 90m^2$ | 105.88 | 110.27-C | 121.81 | 12.18 | 325.77-C | -0.63 | -0.018 |

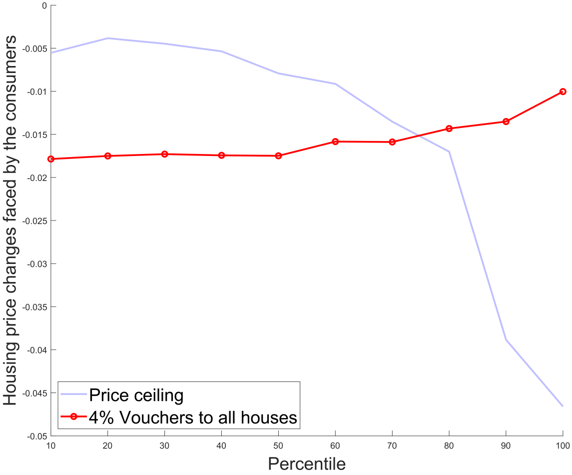
- ▷ The government can finance these vouchers by levying a lump-sum tax from the developers
  - The developers are willing to pay the tax $T$ as long as: $T < PS_{voucher} - PS_{w/pc}$ (loss from price ceiling)
  - Quasi Pareto Improvement

Different vouchers

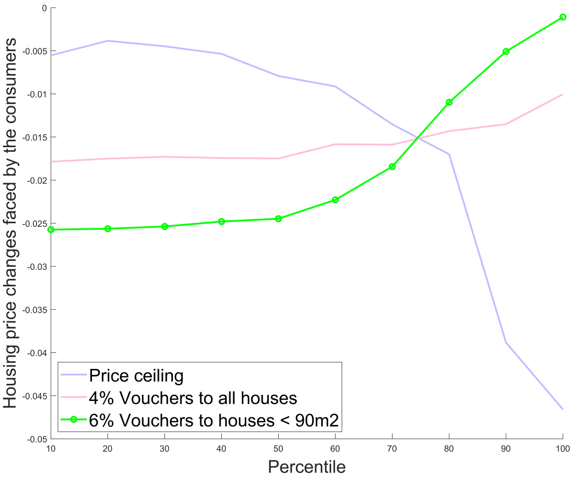
# Distributional impact: Price ceiling



# 4% voucher to all buyers



# 6% voucher to buyers of houses $\leq 90m^2$

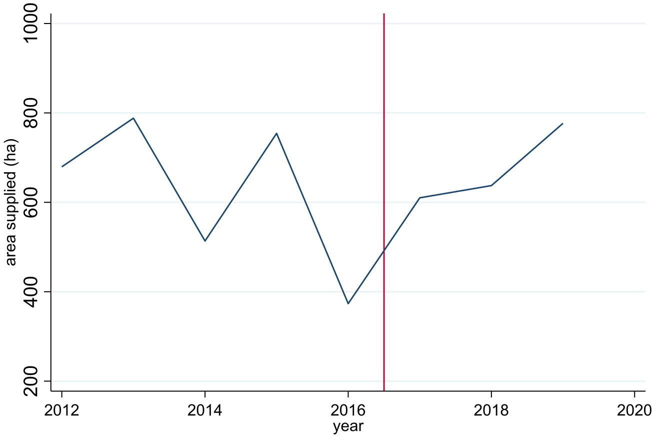


# Conclusion

- ▷ I study the equilibrium impact of price ceiling.
  - Waiting cost plays a pivotal role
- ▷ Welfare loss due to the price ceiling in Shanghai from 2018 to 2020 is around 13 billion US dollars (4% of the total surplus)
  - Waiting costs: $ 5 billion; Misallocation: $ 8 billion
- ▷ Housing vouchers are more efficient and more equitable
  - No waiting, and less misallocation
- ▷ The framework developed in this paper can be applied in other settings:
  - e.g., Rent control; healthcare market in Canada; H1B lottery

# Land market outcomes

Figure 2: Residential land supply

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# Demand model details

Re-write the indirect utility function:

- ▷ Mean utility: $\delta_j = x_j\beta + p_j\bar{\alpha} + \frac{1 - Pr_{j,new}}{Pr_{j,new}}\bar{c}$
- ▷ Heterogeneous part: $\lambda_{ij} = u_{ij} - \delta_j$
- ▷ i's prob of choosing j:

$$s_{ij} = \frac{exp(\delta_j + \lambda_{ij})}{1 + \sum_{j,old} exp(\delta_{j,old} + \lambda_{ij,old}) + \sum_{j,new} exp(\delta_{j,new} + \lambda_{ij,new})}$$

- ▷ Berry inversion: market share $s_j = \int\int s_{ij} dG(\alpha_i, c_i)$
  - Note that the market share $s_j$ can be directly observed from the data.
- ▷ $Pr_{j,new} = \frac{\bar{K}_j}{N * s_j}$

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# Dynamic supply model

- Every period, the owner of type $j$ house chooses whether to sell or not.
  - If she sells, she leaves the market. Utility: $\omega_{1jt} = \alpha p_{j,t} + v_{1j,t} + v_{1jt,s}$
  - If not, she continues to the next period. Utility: $\omega_{0jt} = EV_{st+1} + v_{0j,t} + v_{0jt,s}$
- Relative utility of selling against not selling: $lns_{1jt} - lns_{0jt} = \alpha p_{j,t} - EV_{st+1} + v_{1j,t} - v_{0j,t}$
- The inclusive value: $EV_{st+1} = \gamma + ln(exp(\omega_{1jt+1}) + exp(\omega_{0jt+1})) = \gamma + \omega_{1jt+1} - ln(s_{1jt+1})$
- Finally, the dynamic supply problem can collapse to a static one (Arcidiacono and Miller, 2011):

$$lns_{1jt+1} - lns_{0jt} + lns_{1jt+1} = \gamma + \alpha(p_{j,t+1} - p_{j,t}) + (v_{1jt,s+1} + v_{0jt,s} - v_{1jt+1,s})$$

  - Intuition: The model incorporates the forward-looking behavior by leveraging the next periods' market shares.

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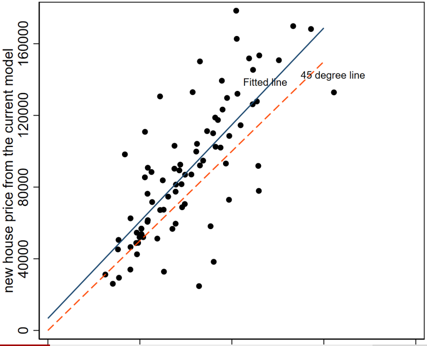
# Estimation details

- Product definition:
  - Existing house: own/subdistrict (similar to zipcode) by house type
  - New house: apartment complex
  - House types: **small** ($< 60\ m^2$, 35 % of the transaction); **medium** (60-90 $m^2$, 40 % of the transaction); **large** ($> 90\ m^2$, 25 % of the transaction)
- Subdistrict
  - Similar to zipcode
  - Area: around 4-5 $km^2$ in downtown, larger in suburban;
  - Around 100,000 population
  - Little variation in the school district
  - 218 subdistricts in Shanghai

# Model fit

- ▷ y-axis: New house prices predicted by the structural model when the price ceiling is removed.
- ▷ x-axis: Mean of the nearby existing house price (adjusted for hedonic characteristics).

Figure 3: Demand model fit



# Impact on the existing house market

Figure 4: Impact of the new house price ceiling on the existing house market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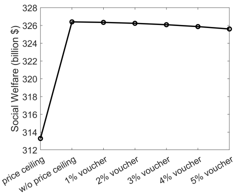
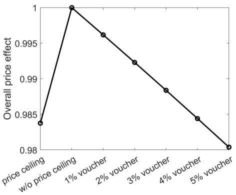
# Housing voucher to all houses

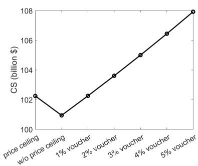
Figure 5: Housing vouchers to all houses



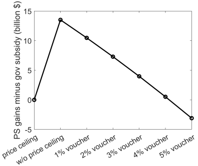

(a) Social Surplus



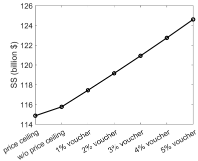

(b) Price Reduction Effect




(c) Consumer Surplus

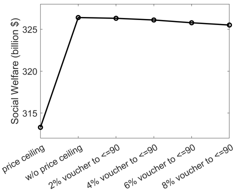



(d) Net Producer Surplus




(e) Seller surplus

# Housing vouchers to houses $\leq 90\ m^2$

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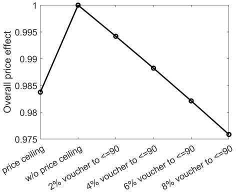


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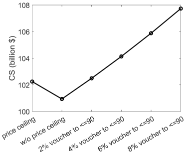
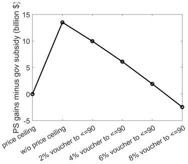
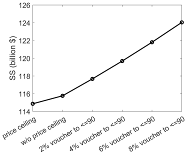



(c) Consumer Surplus




(d) Producer Surplus




(e) Seller surplus

back

# Waiting to sorting

| in billion USD | CS | SS | PS | total surplus | welfare decomposition | |
|---|---|---|---|---|---|---|
| | | | | | waiting cost | misallocation |
| waiting cost=0 | 109.27 | 111.19 | 96.17-C | 316.62-C | 0 | 9.8 |
| with price ceiling | 102.25 | 114.87 | 96.17-C | 313.29-C | 5.1 | 8.0 |

▷ When the waiting cost goes to 0:
- Misallocation increases (waiting to sorting).
- Total welfare loss decreases.

back

# Elastic new house supply

| in billion USD | CS | PS | SS | total surplus | $\Delta$ welfare |
|---|---|---|---|---|---|
| w/o price ceiling (elastic K) | 104.22 | 111.62-C | 115.63 | 331.47-C | 18.18 |
| w/o price ceiling ($K = \bar{K}$) | 100.94 | 109.69-C | 115.77 | 326.40-C | 13.11 |
| with price ceiling | 102.25 | 96.17-C | 114.87 | 313.29-C | |

Notes: (1) CS: Consumer Surplus; PS: Developer surplus; SS: Seller surplus. (2) 20% of the sales revenue becomes the PS.

- Assumption: New house supply elasticity=1.5
- Welfare loss enlarges from \$ 13.1 billion to \$ 18.18 billion.
- Due to the supply reduction effect of the price ceiling, CS decreases.
- Price ceiling reduces new house supply by 14%.