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Vertical Price Curve in Beijing Residential Market

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Introduction

- The vertical dimension of cities has recently drawn more and more attentions in urban economic and housing literature
- Vertical price/rent curve: price/rent function of floor levels (vertical locations)
  - Commercial contexts: business activities vertical sorting patterns (Liu et al., 2018)
  - Residential contexts: households' preference over vertical locations (Danton and Himbert, 2018; Wong et al., 2011)
- This paper focuses on the residential vertical price curve

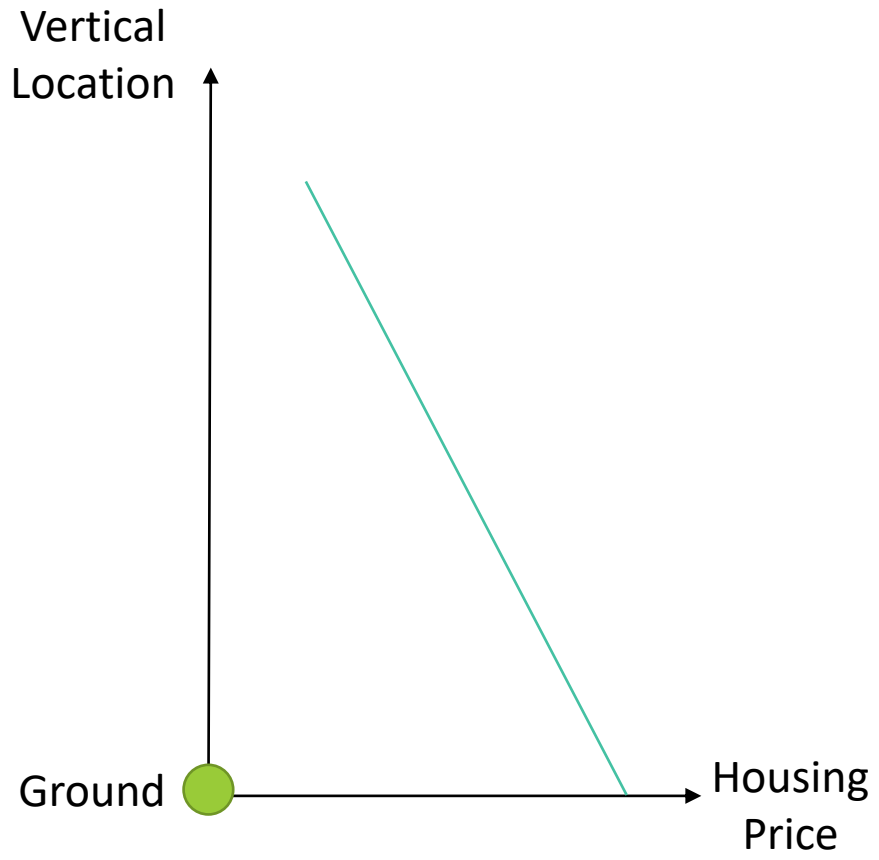
Vertical Price Curve and Gradient

In Theory

- In theory, the price of housing units in a building should vary across floor levels to compensate for the net cost associated with each floor
- If no preferences for vertical locations

→ higher floor levels mean larger **time cost** from vertical transportation

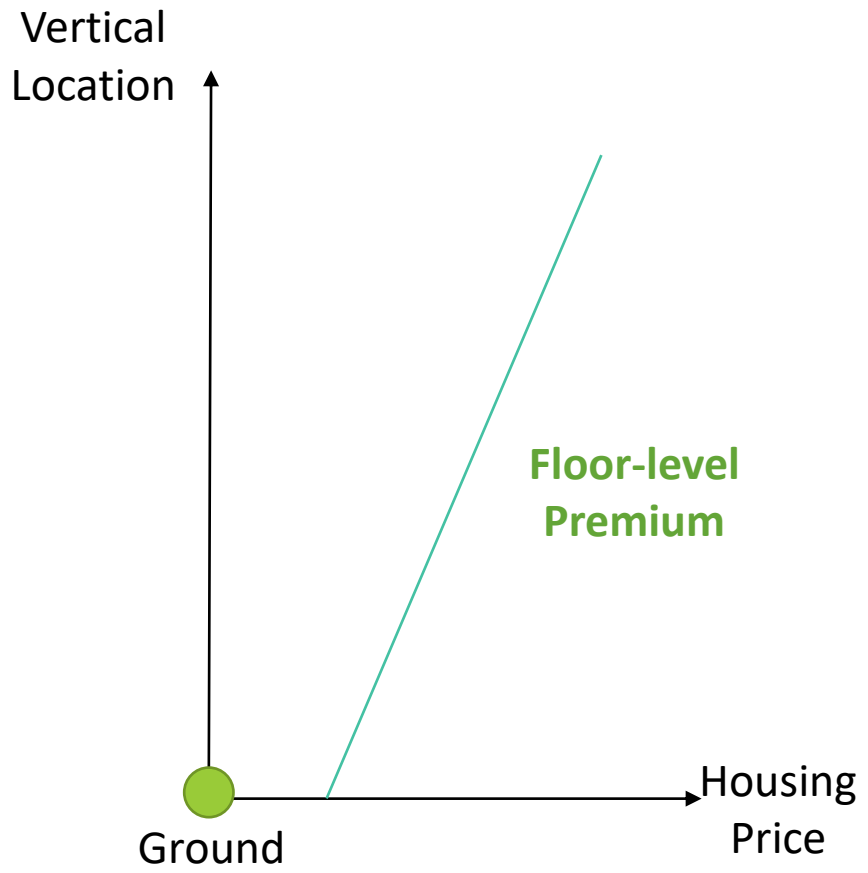
→ vertical price curve would be downward sloping (Wright, 1971)



Vertical Price Curve and Gradient

In Reality

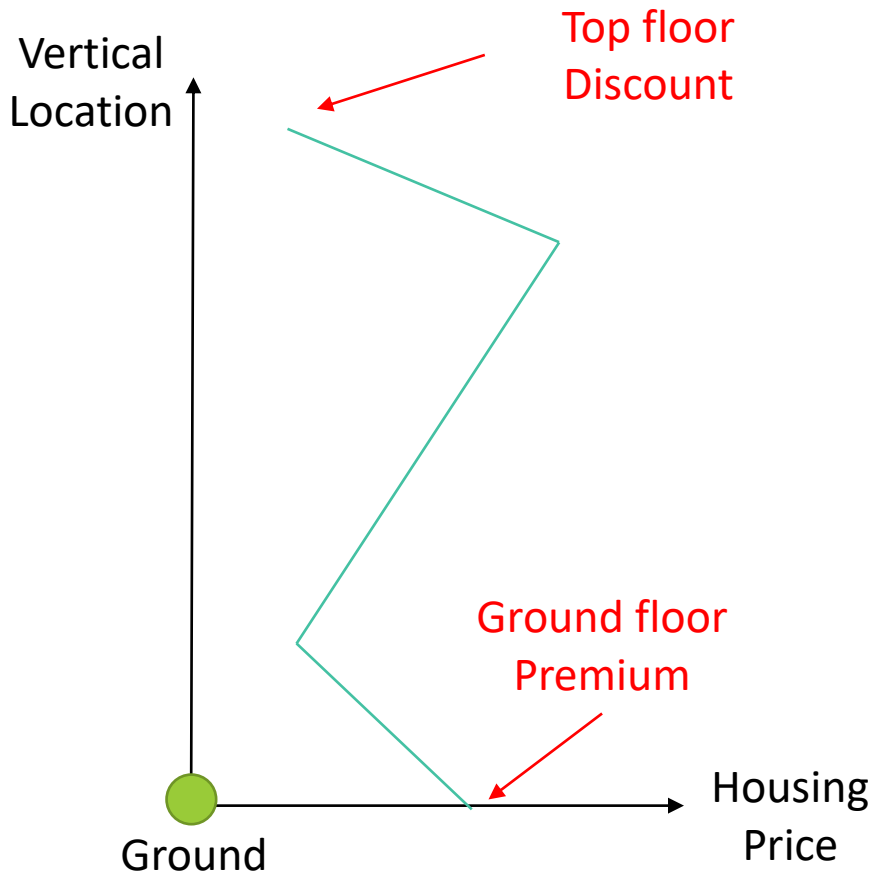
- People have preferences for high floor levels
  - less traffic pollution and noise
  - less security risks
  - better views
- Elevators has significantly reduced the time cost of vertical travels in high buildings
- → Floor-level premium or high-floor premium:
  - Extra price paid for higher vertical location of a housing unit
  - Dominant empirical finding of the vertical curve in many places, such as Hong Kong (Bao and Wan, 2004; Jim and Chen, 2009, 2010), Singapore (Yu, Han, and Chai, 2007), and Los Angles (Mason and Quigley, 1996)



Vertical Price Curve and Gradient

Debates

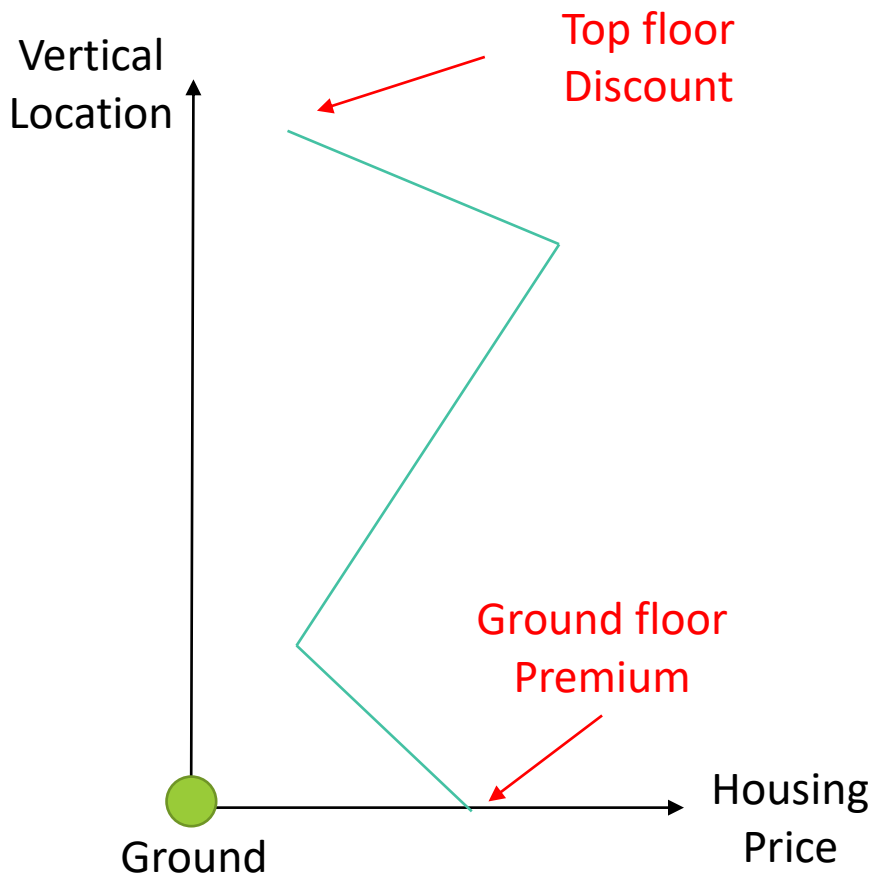
- Floor-level premium has yet to conclude the discussion about the vertical curve
- Two other features of the vertical curve which contradict the floor-level premium (Danton and Himbert, 2018)
- **Ground floor premium (GFP)**: the price/rent of dwelling units on the ground level is higher than the average price/rent on all other levels
  - 1.5-3.5% GFP in Switzerland (accessibility and amenity)
  - GFP decreases with building heights
- **Top floor discount (TFD)**: the top floor units have a lower price/rent than the units on all other levels
  - 1.0-2.8% TFD in Switzerland (running costs, e.g., heating)
  - TFD decreases with building heights



Vertical Price Curve and Gradient

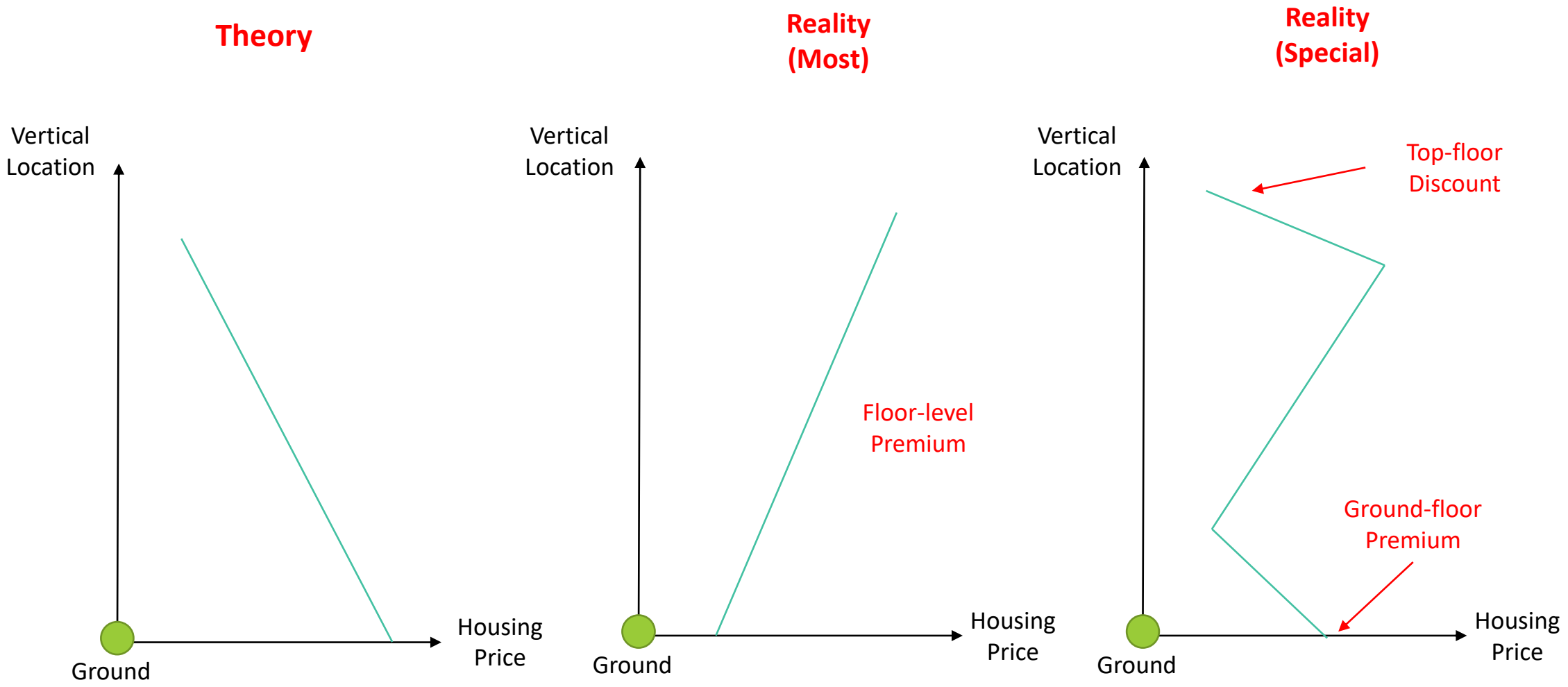
Debates

- In the commercial literature, Liu et al. (2018) found the GFP in commercial buildings
- Negative impact of the ground floor on housing prices:
  - Israel (Borukhov, Ginsberg,and Werczberger, 1978)
  - Japan (Shimizu, Takatsuji, Ono, and Nishimura, 2010)



Vertical Price Curve and Gradient

- New empirical evidence is needed for this strand of literature



This Paper

- Provides new empirical evidence of the vertical curve in Beijing based on home resale data (2012-2019)

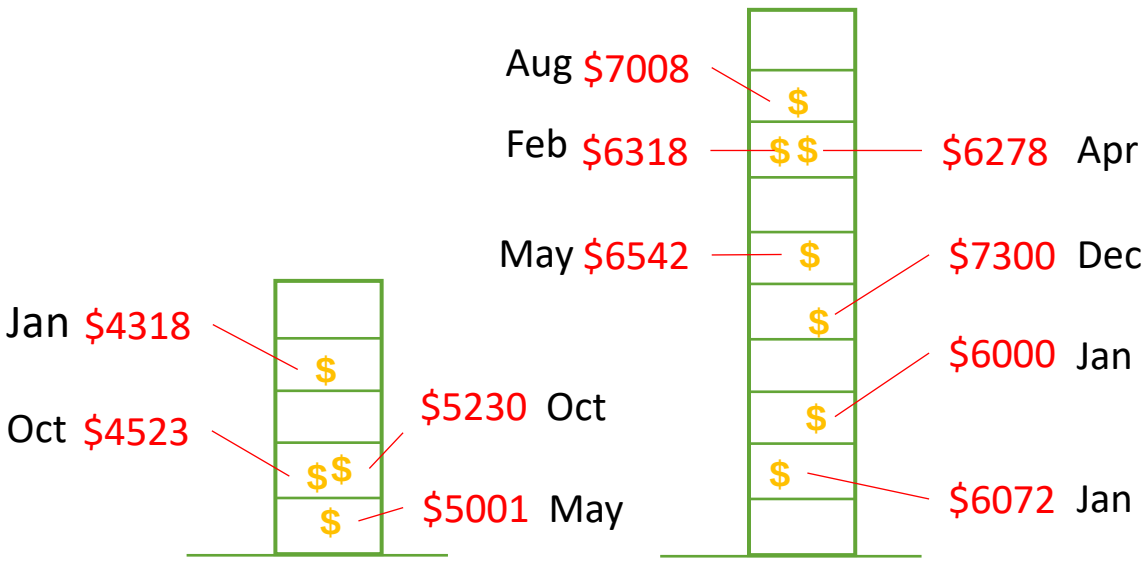
- Both GFP and TFD existed in Beijing housing markets
  - On average, the GFP is about 5% and the TFD is 6.5%
  - Both GFP and TFD decrease with building heights
  - Top floor level never has a premium in Beijing; even in tall buildings exists 1-2% TFD

- Elevators play an essential role in determining the shape of the vertical curve

- Building quality (proxy by building age at purchase) explains the prevailing TFD in Beijing

Data

- Beijing home resales from Lianjia.com, the largest home agency in Beijing
- 2012-2019 After cleaning, 594,506 transactions



Summary Statistics

Variable	Unit	Mean	Std. Dev.	Min.	Max.
Housing Price	$10{,}000RMB/m^2$ (2009=100)	3.85	1.76	0.17	16.04
Floor level	0-Ground 1-Low 2-Mid 3-High 4-Top	2.08	1.09	0	4
Ground floor	1-Yes 0-No	0.08	0.27	0	1
Lower floor	1-Yes 0-No	0.21	0.41	0	1
Middle floor	1-Yes 0-No	0.38	0.49	0	1
Higher floor	1-Yes 0-No	0.22	0.42	0	1
Top floor	1-Yes 0-No	0.11	0.32	0	1
Number of bedrooms		2.03	0.74	0	4
Number of living rooms		1.18	0.49	0	2
Number of bathrooms		1.19	0.41	1	3
Floor area	m^2	84.42	34.69	20	398
South facing	1-Yes 0-No	0.71	0.45	0	1
South and north facing	1-Yes 0-No	0.47	0.50	0	1
Building height	Number of floors	13.49	7.88	3	40
Building type	1-Slab 2-Tower 3-Mixed	1.63	0.78	1	3
Year built		1999.67	8.86	1950	2018
Heating	1-Yes 0-No	1.85	0.36	1	2
Elevator	1-Yes 0-No	0.61	0.49	0	1
Transaction month		6.36	3.44	1	12
Transaction year		2015.71	2.03	2012	2019
Number of observations			594,506		

Model

Ideally, a clean identification could be achieved in the following model.

$$lnP_{iblt} = \alpha + \beta_1 GF_i + \beta_2 GF_i \times BH_b + \beta_3 TF_i + \beta_4 TF_i \times BH_b + \boldsymbol{\mu Z}_i + \delta_b + \delta_{lt} + \epsilon_{iblt} \qquad (1)$$

- P_{iblt} is the sale price per square meter of unit i in building b of community l at time t ;
- GF_i is the ground floor dummy variable;
- TF_i is the top floor dummy variable;
- BH_b is the building height variable;
- $\boldsymbol{Z}_i$ is a vector containing a variety of dwelling controls such as floor area, number of rooms, south-facing, both north and south facing;
- δ_b is the building fixed effect;
- δ_{lt} is the community-time fixed effect;
- ϵ_{iblt} is the error term.

Data Limitation

- The biggest challenge of the data is the lack of accurate building identifiers
- The most detailed identifier corresponds to either a complex or an estate project with clear borders (called *Xiaoqu* in Chinese)

Model

Ideally, a clean identification could be achieved in the following model.

$$lnP_{iblt} = \alpha + \beta_1 GF_i + \beta_2 GF_i \times BH_b + \beta_3 TF_i + \beta_4 TF_i \times BH_b + \boldsymbol{\mu Z}_i + \delta_b + \delta_{lt} + \epsilon_{iblt} \quad (1)$$

However, due to the data limitation, we use the following model in practice.

$$lnP_{iblt} = \alpha + \beta_1 GF_i + \beta_2 GF_i \times BH_b + \beta_3 TF_i + \beta_4 TF_i \times BH_b + \boldsymbol{\mu Z}_i + \boldsymbol{\theta B}_b + \delta_{lt} + \epsilon_{iblt} \quad (2)$$

- $\boldsymbol{B}_b$ is a vector of building controls including total number of floors, elevator, heating, building type, and year built;
- Standard errors are clustered at the community level.

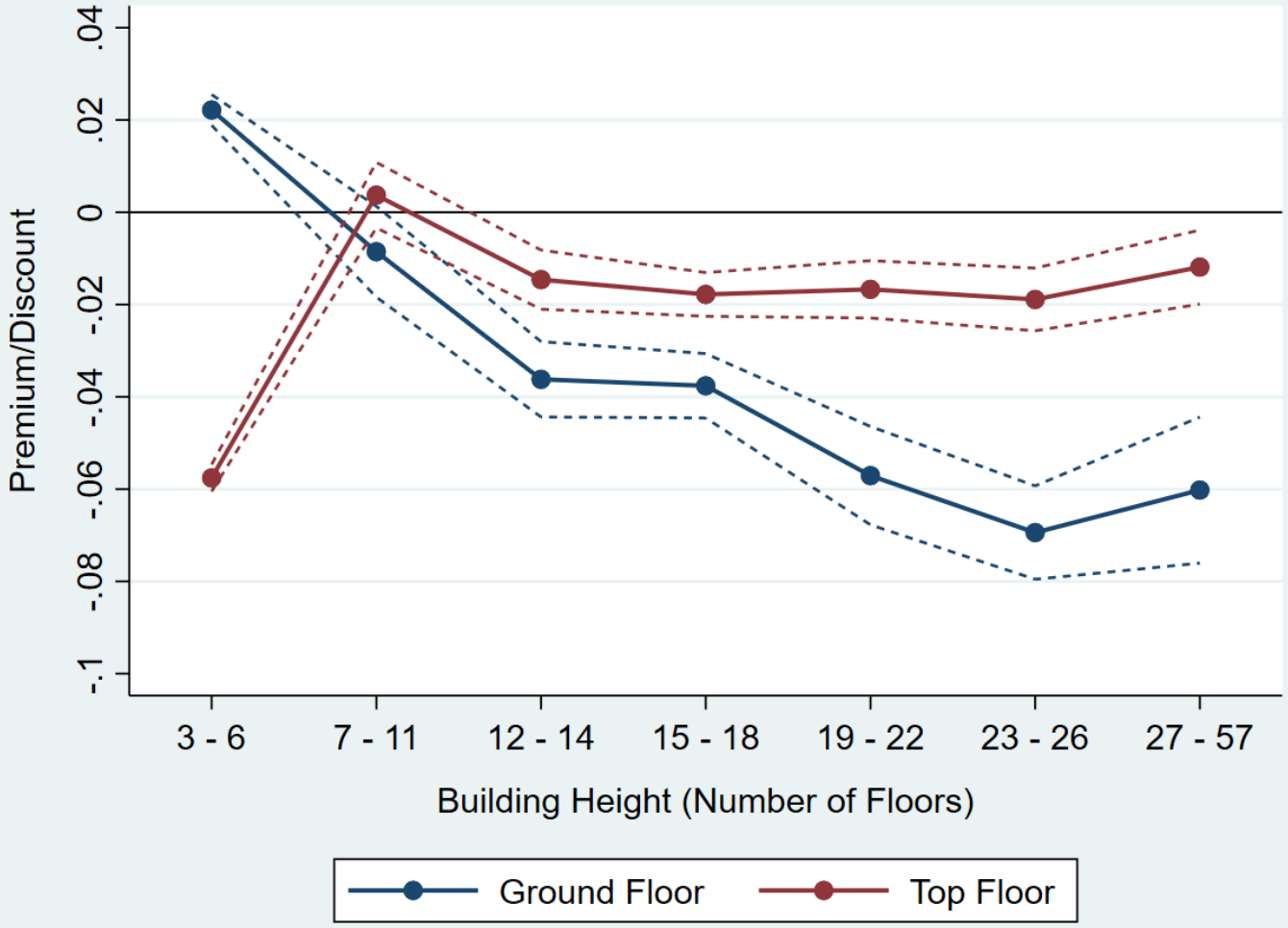
Baseline Results

- Both Ground Floor Premium (GFP) and Top Floor Discount (TFD) exist in Beijing
- Both GFP and TFD decrease with building heights
- Coefficients remain stable across column (1)-(3) with different specifications in time dummies

Table: Ground Floor Premium and Top Floor Discount

	(1)	(2)	(3)
Ground floor	0.055***	0.049***	0.049***
	(0.004)	(0.002)	(0.003)
Ground floor × Building height	-0.005***	-0.005***	-0.005***
	(0.000)	(0.000)	(0.000)
Top floor	-0.085***	-0.064***	-0.066***
	(0.003)	(0.002)	(0.002)
Top floor × Building height	0.003***	0.002***	0.002***
	(0.000)	(0.000)	(0.000)
Dwelling Controls	Y	Y	Y
Building Controls	Y	Y	Y
Community × Month FE	Y		
Community × Year FE		Y	
Community × Year × Month FE			Y
Observations	585923	590417	499893
R^2	0.625	0.917	0.957
Adjusted R^2	0.593	0.913	0.943

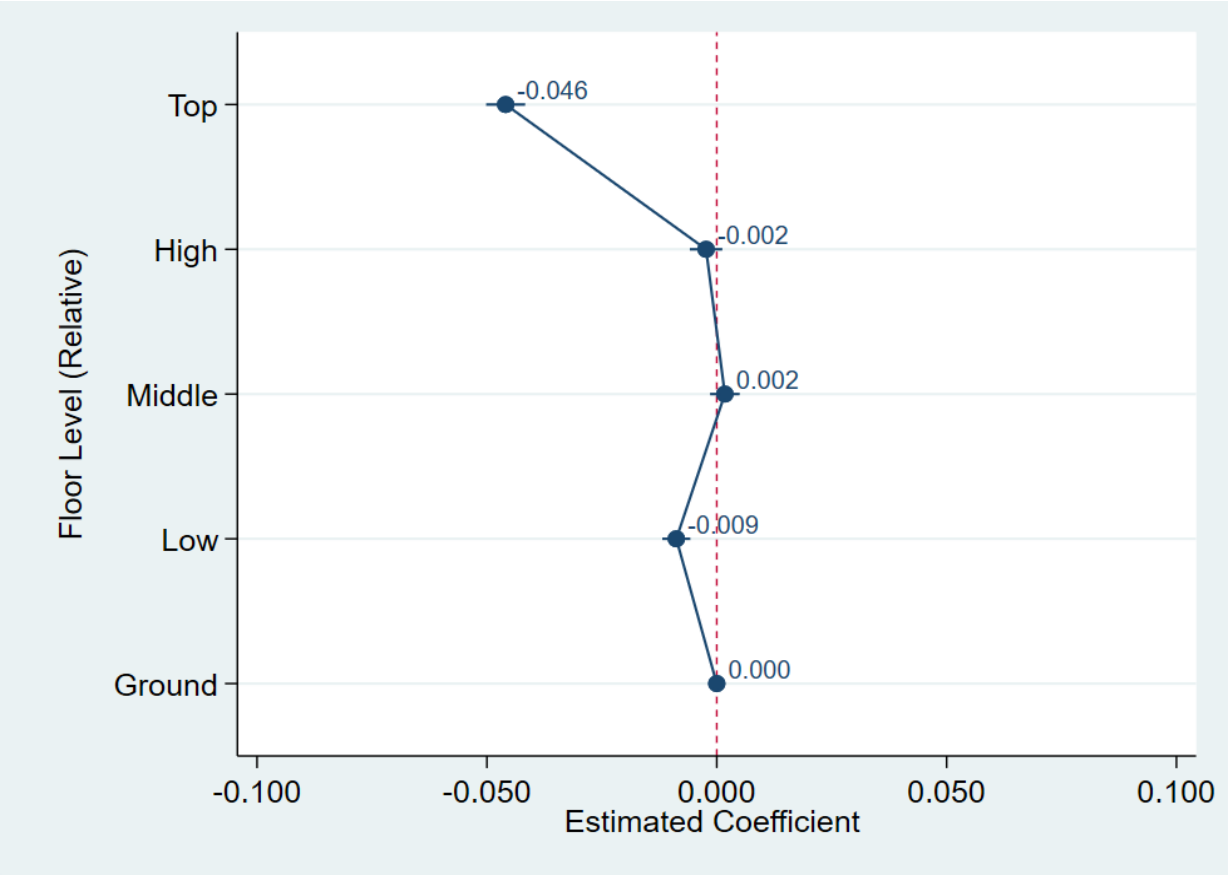
Nonlinear Building Height Effect



- Categorizing the building height into seven groups
- GFP decreases in an approximately linear way
- GFP only exists in small buildings and disappears from the 7-11 stories building
- TFD prevails in all buildings except for the 7-11 story ones

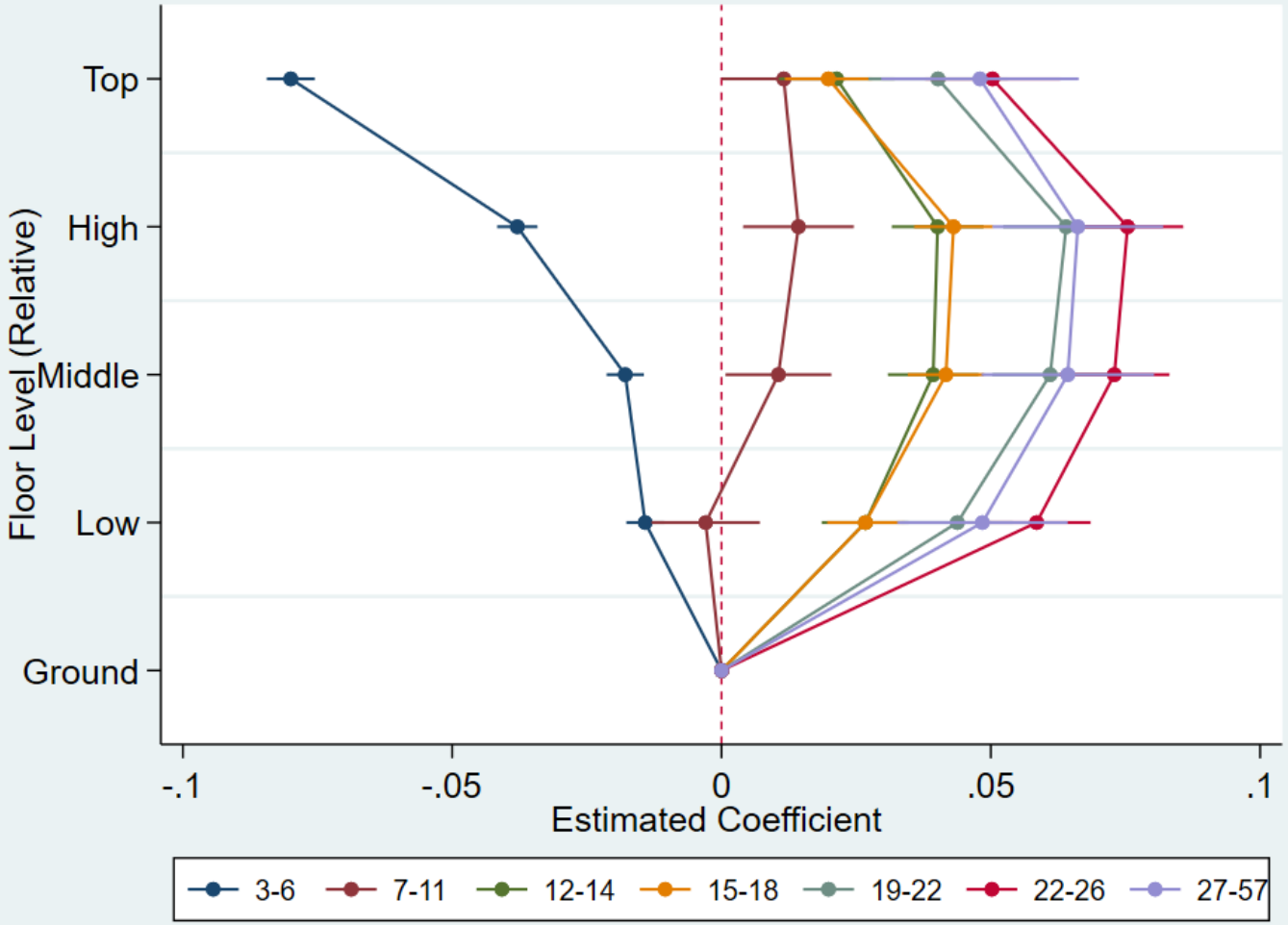
Vertical Price Gradient

- Base group: ground floor
- Almost a downward sloping curve except that the middle and high floors have higher values than expected



	(1)	(2)
Lower level	-0.009***	-0.043***
	(0.002)	(0.003)
Middle level	0.002	-0.045***
	(0.002)	(0.003)
Higher level	-0.002	-0.064***
	(0.002)	(0.003)
Top floor	-0.046***	-0.115***
	(0.002)	(0.003)
Lower level × Building height		0.004***
		(0.000)
Middle level × Building height		0.005***
		(0.000)
Higher level × Building height		0.006***
		(0.000)
Top floor × Building height		0.007***
		(0.000)
Dwelling Controls	Y	Y
Building Controls	Y	Y
Community × Year × Month FE	Y	Y
Observations	499893	499893
R^2	0.956	0.957
Adjusted R^2	0.943	0.943

Nonlinear Building Effect on Vertical Price Gradient



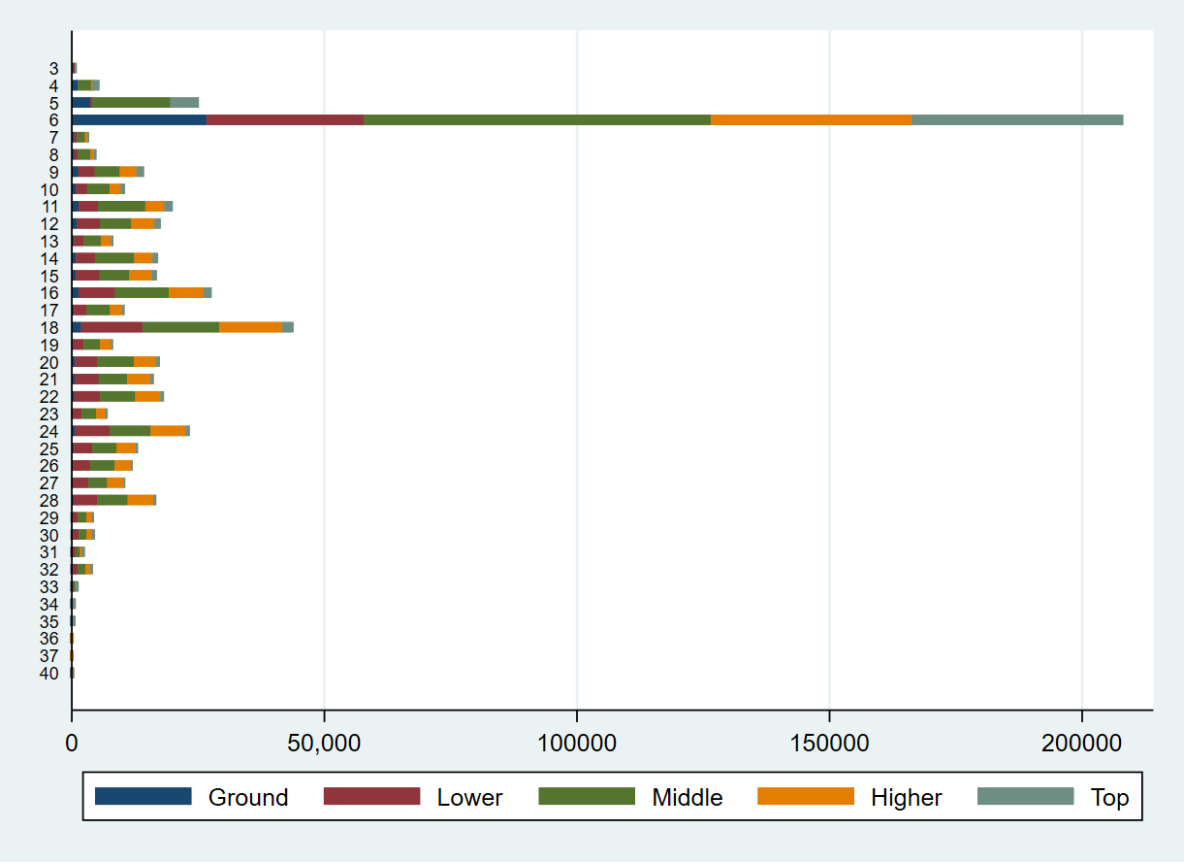
- Vertical price gradients for different building groups
- As the building gets taller, the prices of all non-ground floor levels increase
- Only in small buildings with less or equal to six stories exists a downward sloping curve
- In other taller buildings, the vertical price curves are concave with middle or high floor levels being the most valuable choices

Two More Stories behind GFP and TFD

- Question 1: why do GFP and TFD exist in small buildings in Beijing?
  - Value of elevators: 6-story building evidence
- Question 2: why does TFD prevail in Beijing, even in tall buildings?
  - Building quality concern

Value of Elevators

- The 6-story building is dominant in Beijing residential markets as well as our sample
- We use the sub-sample of 6-story buildings for investigation
- In Beijing, buildings with seven or more stories are required to install elevators, so it is uncommon for 6-story buildings to have elevators, but there are some in our sample



$$lnP_{iblt} = \alpha + \beta_1 GF_i + \beta_2 GF_i \times ELEVATOR_b + \beta_3 TF_i + \beta_4 TF_i \times ELEVATOR_b + \boldsymbol{\mu Z}_i + \boldsymbol{\theta B}_b + \delta_{lt} + \epsilon_{iblt}$$

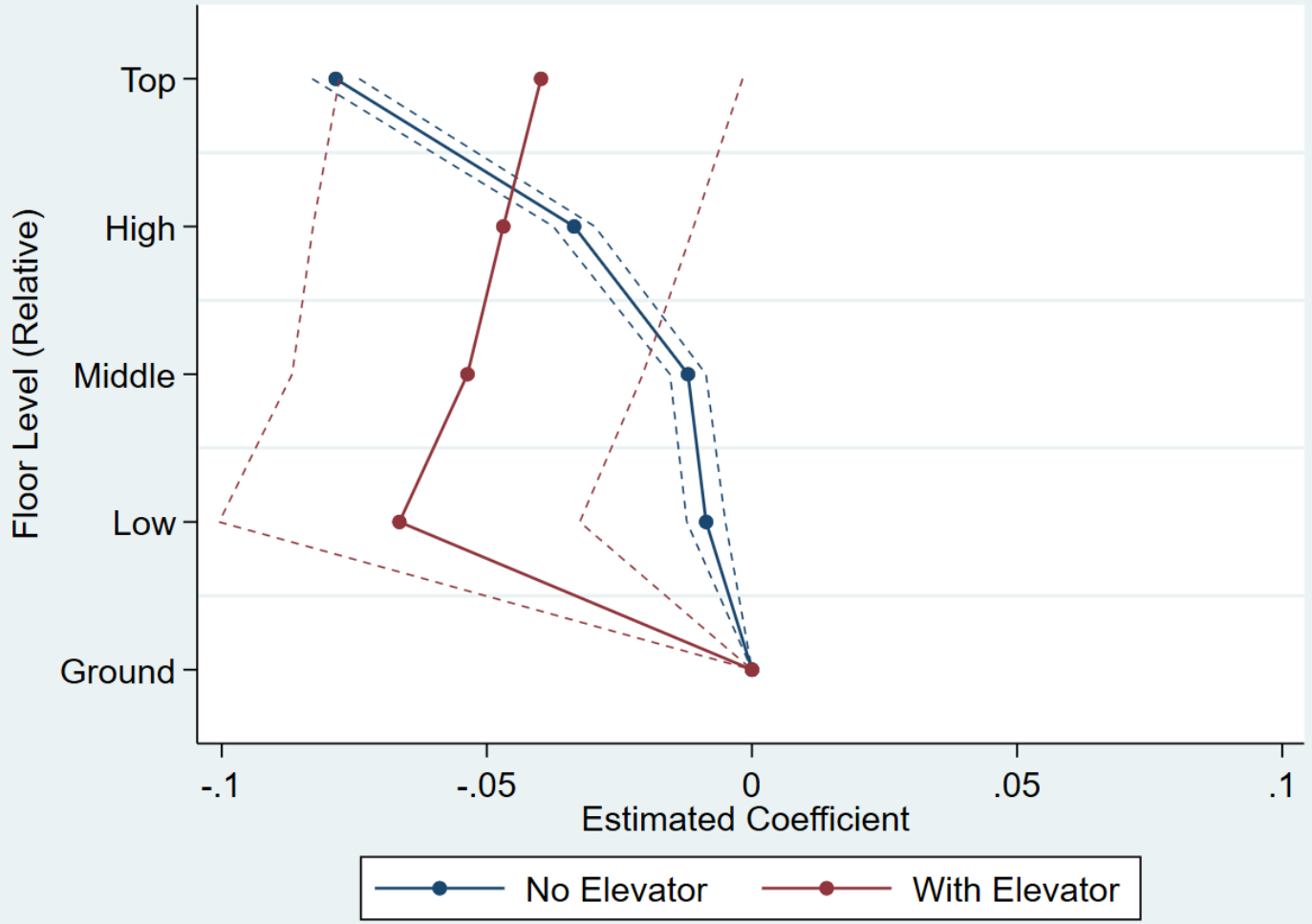
Value of Elevators

- An elevator could change the top floor discount into a premium in 6-story buildings
- The elevator does not change the ground floor premium

Table: GFP and TFD in 6-Story Buildings

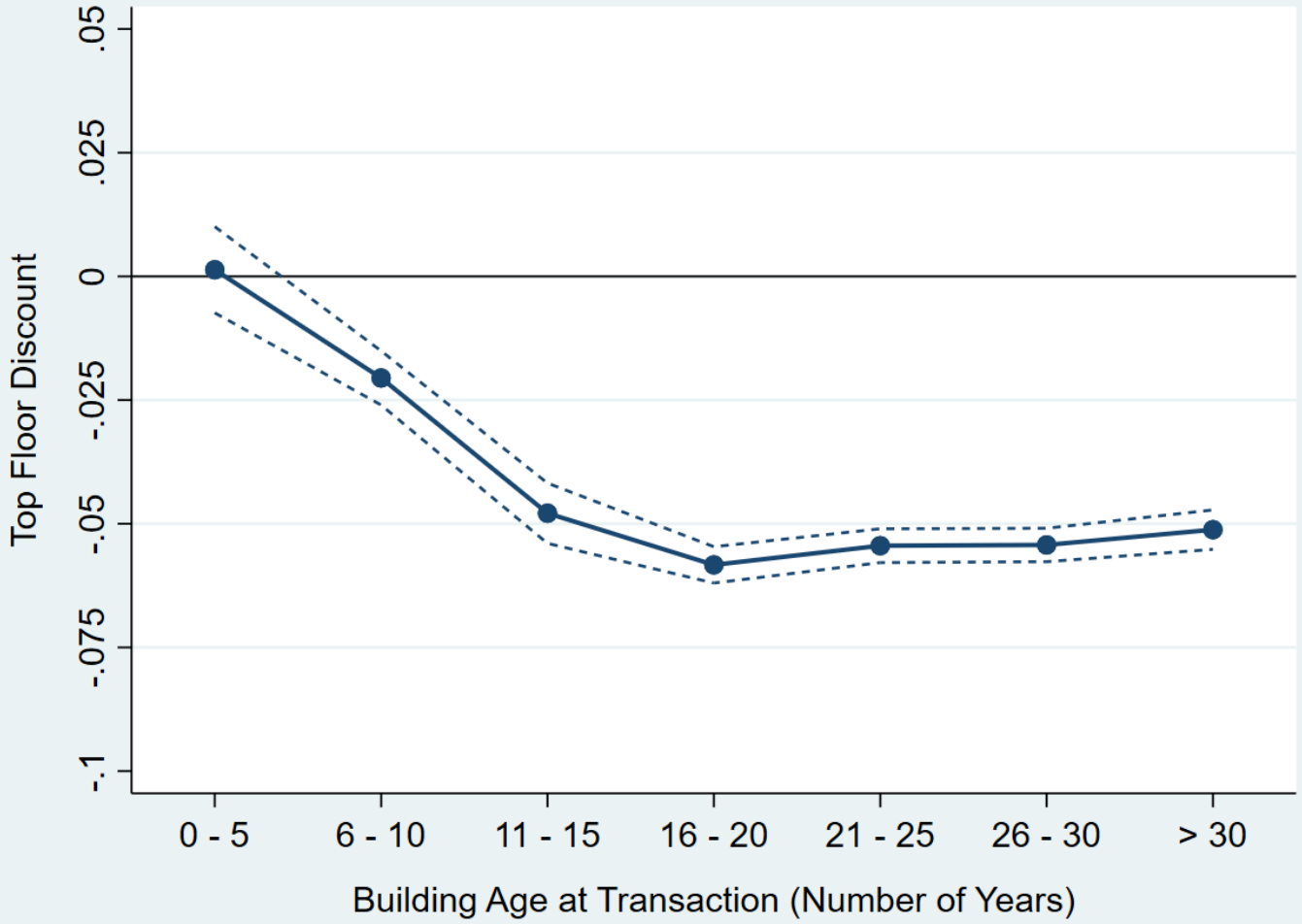
	(1)	(2)	(3)
Ground floor	0.032***		0.018***
	(0.002)		(0.002)
Ground floor × Elevator	0.021		0.038*
	(0.016)		(0.017)
Top floor		-0.064***	-0.061***
		(0.001)	(0.001)
Top floor × Elevator		0.069***	0.076***
		(0.015)	(0.016)
Elevator	0.040*	0.030	0.023
	(0.017)	(0.017)	(0.017)
Dwelling Controls	Y	Y	Y
Building Controls	Y	Y	Y
Community × Year × Month FE	Y	Y	Y
Observations	157652	157652	157652
R^2	0.967	0.969	0.969
Adjusted R^2	0.954	0.956	0.957

Elevator Effect on Vertical Curve (Subsample of 6-Story Buildings)



- Elevator reshapes the vertical price gradient in 6-story buildings
- With elevators in a 6-story building, the middle and lower levels become less valuable relative to the ground floor, while the top floor becomes more valuable

Value of Building Quality



- **Building age at the transaction** as a proxy for building quality
- A bad building quality puts the living condition on the top floor at risk
- When buying a house, people need to be compensated for this uncertainty by a lower price for the top floor units
- This compensation is essentially the top floor discount
- Typically, the water-proof layer of the building construction has a 5-year warranty. The risk of uncertainty may increase after the warranty.

Conclusion and Discussion

- Both GFP and TFD existed in Beijing housing markets
- Both GFP and TFD decreases by building heights
- Top floor level never has a premium in Beijing; even in tall buildings exists 1-2% TFD
- Elevators play an essential role in determining the shape of the curve
- Building quality could explain the prevailing TFD in Beijing

Thank You

Elevator Policy for Old Walk-up Buildings

- 6-story buildings
- Vertical travel convenience
- Quantify people's preference for elevators using housing prices