Regulation and Frontier Housing Supply

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Regulation and Frontier Housing Supply

Introduction

- **Setting:**
  - Urban cities
  - Apartment buildings (multi-floor, multi-family housing)
- **Regulation**:
  - A major driver of housing supply
  - Difficult to directly observe and quantify
- **Goals**:
  - **Frontier housing supply**: supply in the absence of regulation
  - **Regulatory tax**: money-equivalent impact of regulation
  - What is the extent of regulation? How does it vary across space?
  - Separate regulatory tax from housing quality

Introduction

- **Findings:**
  - Regulatory taxes account for about 45% of market prices, but there is substantial dispersion
  - Regulation is higher in expensive cities, closer to city centers, and denser areas
  - Evidence of economies of scale at low heights
  - In 2017, we bound average regulatory tax between 40% (using a 2km radius) and 53%

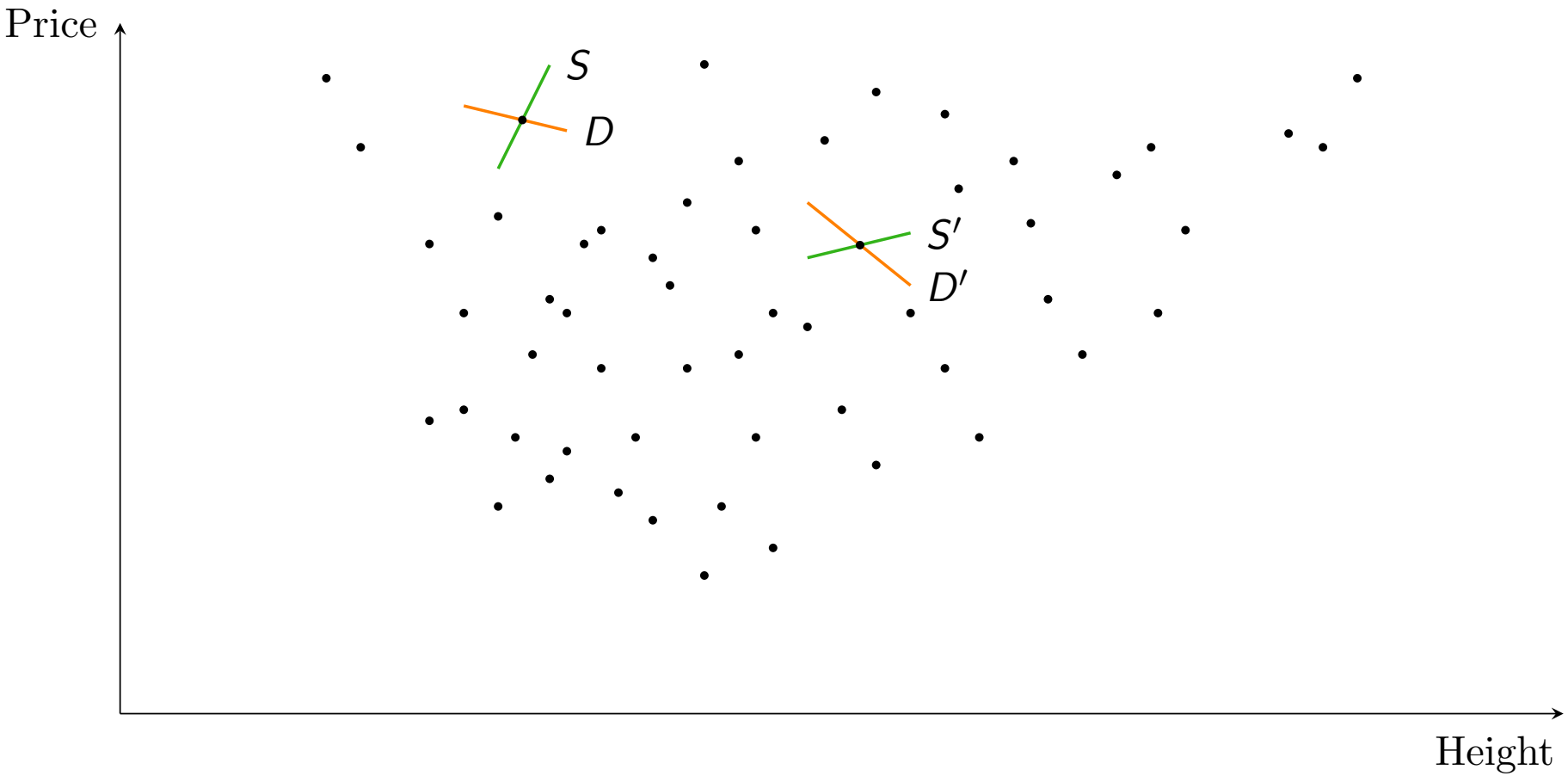
Identification

Assumptions

- We observe only (equilibrium) apartment prices per square meter and building heights (quantity) (think: "equilibrium price and quantity for the location")
- We start with the ideal: perfect competition for homogeneous housing

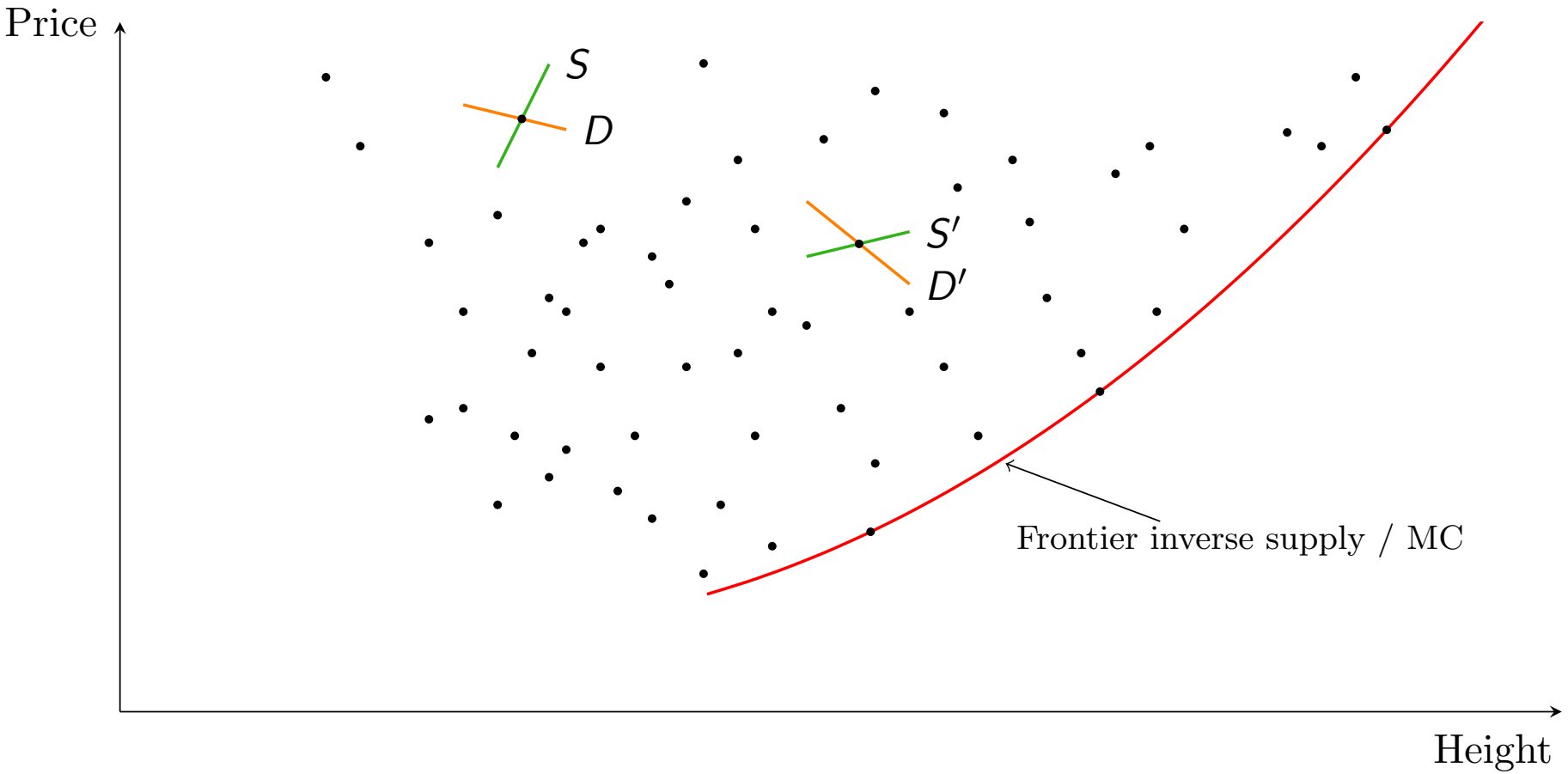
Identifying supply

- Standard approach: mean costs
- Assumption: exogenous variables



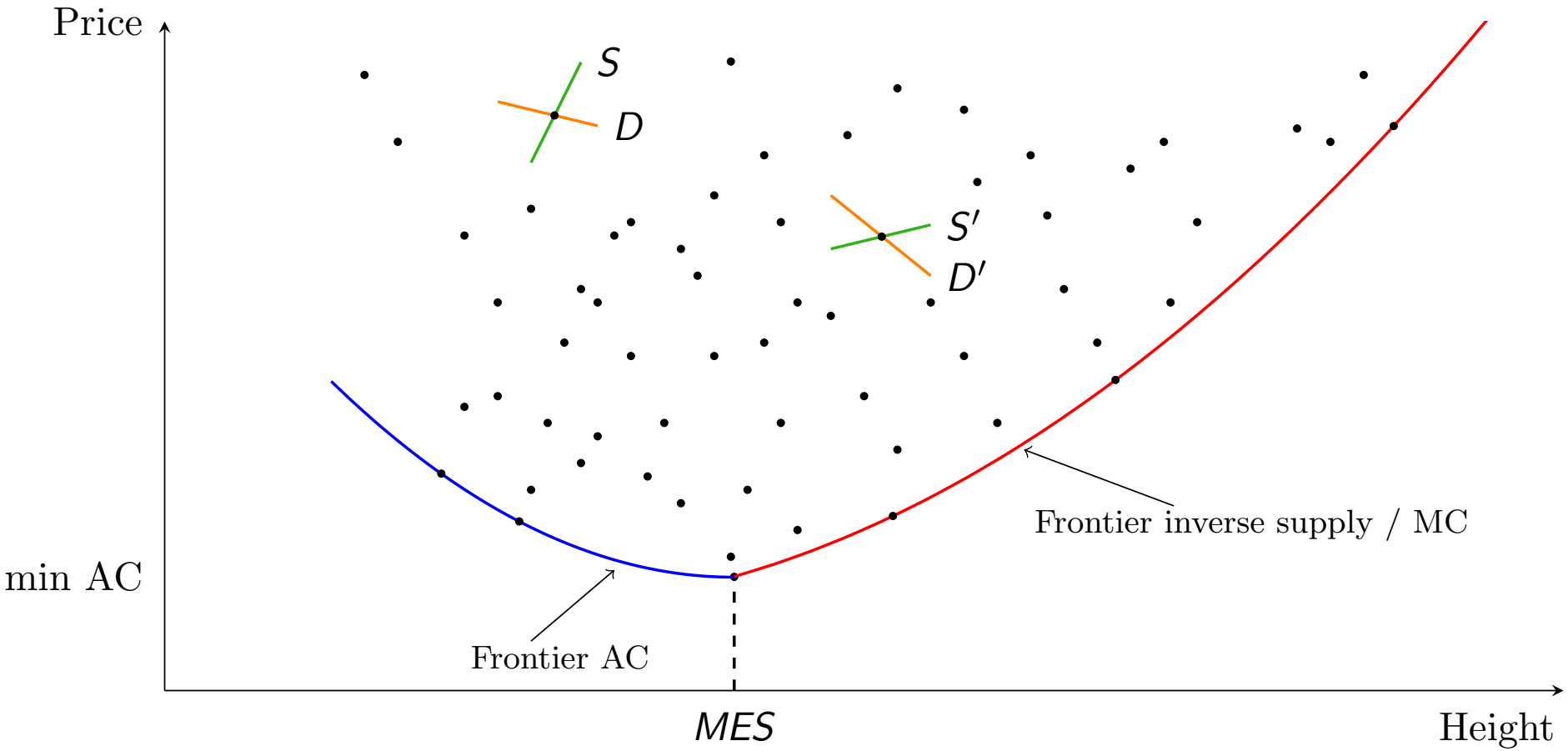
Identifying frontier supply (marginal cost)

- Our approach: frontier costs
- Assumption: support



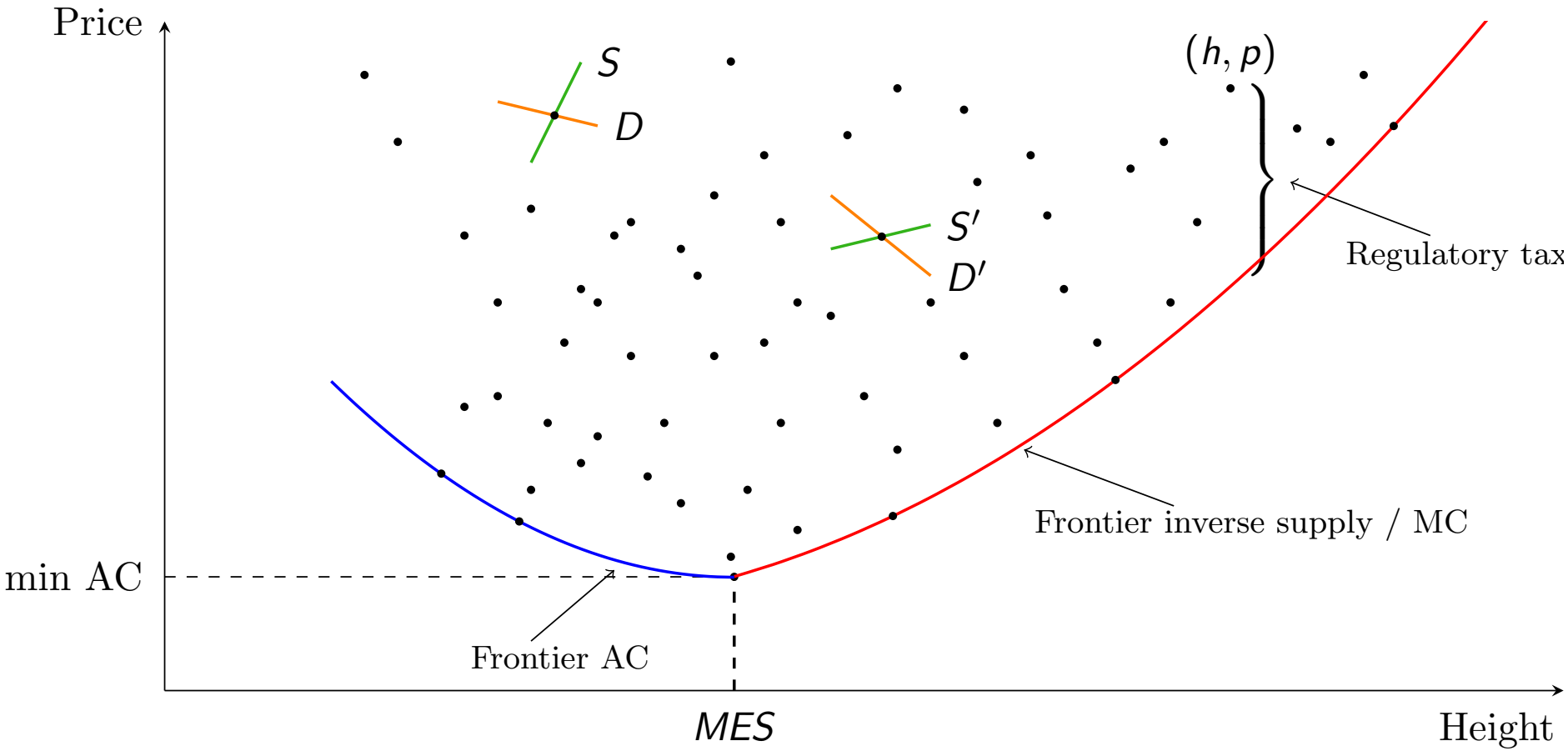
Identifying frontier average cost

- Our approach: frontier costs
- Assumption: support



Regulatory tax (above MES)

- Our approach: frontier costs
- Assumption: support



Regulatory tax (below MES)

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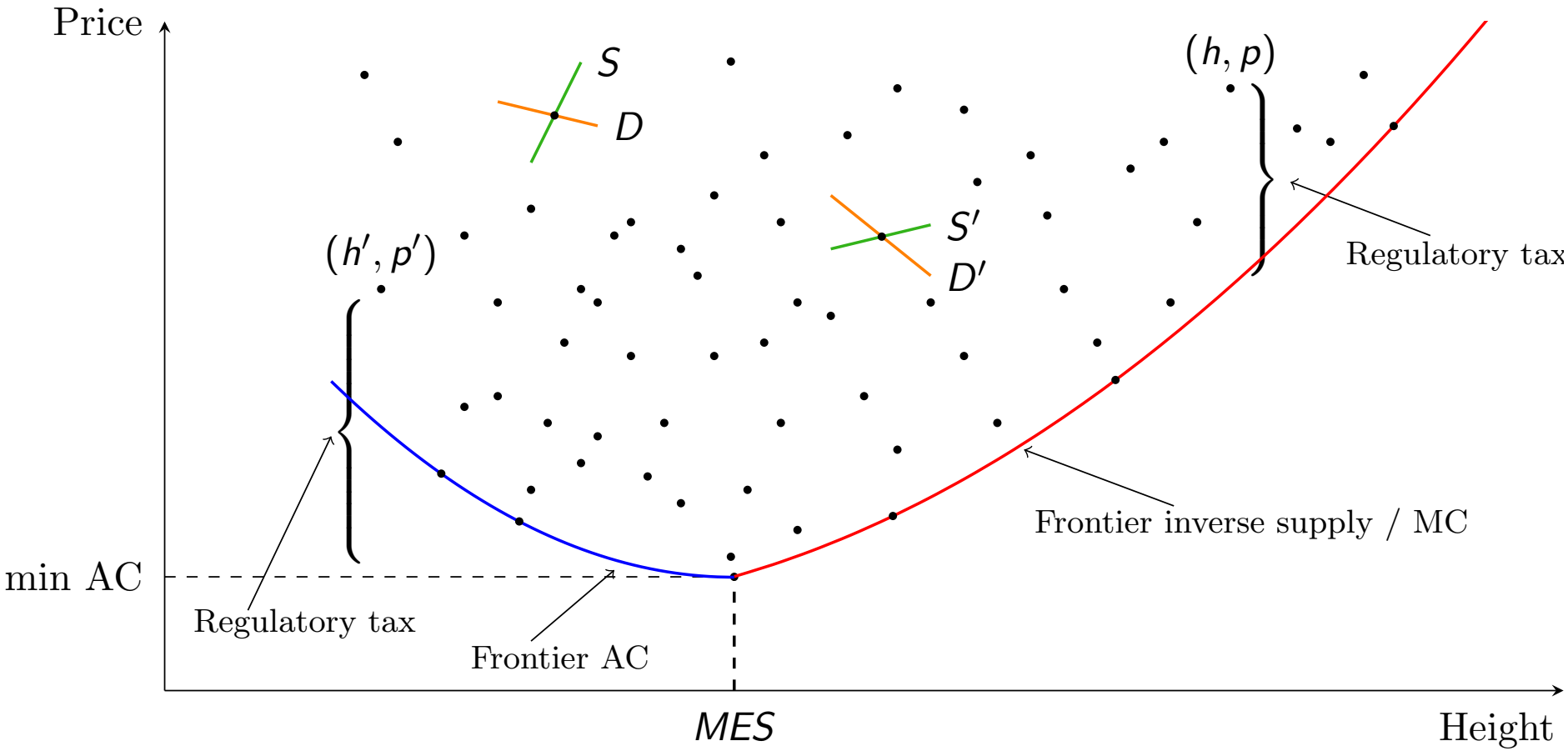


Observables and identifying assumptions

- No constraint on the joint distribution of supply (regulation) shocks and height
- Nor on the joint distribution of supply shocks and some other observed variable (instrument)
- Identification does **NOT** suffer from simultaneous equations or demand correlated with unobserved regulations (so no need for instruments)
- **BUT...**

Identifying assumptions

- Identification assumption is on the support:
  - Marginal cost: positive probability of unregulated supply and appropriate demand
  - Average cost: positive probability of regulated supply and appropriate demand

Discussion of the identifying assumptions

- Discrete height - step function ▸ Discrete supply equilibrium
- Adjusting price for apartment floor and building height ▸ Floor-height premiums
- Measurement error and random quality (stochastic frontier analysis (SFA) methods) ▸ Measurement error
- Support conditions (minimally regulated)
- Perfect competition
  - Cost differences over space are small (experts & robustness checks)
  - Cost over time (adjusted & robustness checks)
  - Perfectly competitive construction industry (environment: urban areas, high density, apartment buildings. Average building location: 1,500 apartments within 500 meter radius)

Bounding Regulatory Tax for Systematic Quality

- The difference between price and the frontier could be regulation or quality
- The problem: households prefer higher quality when purchasing in better locations
- Prices:

$$P_i = G(h_i) + U_i + z_i.$$

where P_i is price, $G(h_i)$ is frontier, U_i is regulation, z_i is quality

- Upper bound (at $z_i = 0$):

$$U_i \leq P_i - G(h_i).$$

- Lower bound: The difference between prices for buildings i and j:

$$\begin{aligned} U_i &\geq (P_i - P_j) - (G(h_i) - G(h_j)) - (z_i - z_j) \\ &= (P_i - P_j) - (G(h_i) - G(h_j)) - (z_i - z(a_j, t_i)) - (z(a_j, t_i) - z_j). \end{aligned}$$

Bounding Regulatory Tax for Systematic Quality

- Lower bound:

$$U_i \geq \min_{\kappa_{Si} \in [0,1]} \max_{j \in \Omega_i(d)} \{G(h_j) - G(h_i + 1) - (P_j - P_i) + \kappa_T(P_j - T_{ij}P_j) + \kappa_{Si}(T_{ij}P_j - P_i)\}$$

- P_i and P_j are building prices
- $T_{ij}P_j$ is building j's price deflated to building i's time period
- $G(h) = \max\{MC(h), AC(h)\}$ is the frontier
- $\Omega_i(d) = \{j : \text{dist}(i,j) \leq d\}$ comparison set of nearby buildings
- κ_T responsiveness of structural quality to prices over time
- κ_{S_i} responsiveness of structural quality to prices over space

Estimation

Model for Estimation of Frontier

- Consider the log prices of apartments in buildings of height h:

$$\log p_{kij} = g + u_k + w_{ki} + v_{kij},$$

  - p_{kij} - price in apartment j, building i, bloc k, (observed)
  - h_{ki} - (discrete) height of building i in bloc k, (observed)
  - g - frontier,
  - $0 \leq u_k$ - nonnegative deviation from frontier (regulation),
  - w_{ki} - building-level measurement error / quality,
  - v_{kij} - apartment-level measurement error / quality

- Notes:
  - The distributions of u_k, w_{ki}, and v_{kij} **depend** on height h
  - Identification by hierarchical structure (Kotlarski, 1967)

Estimators (conditioned on discrete height)

- Conditional on height, we use an MLE estimator of the model,

$$\log p_{kij} = g + u_k + w_{ki} + v_{kij}$$

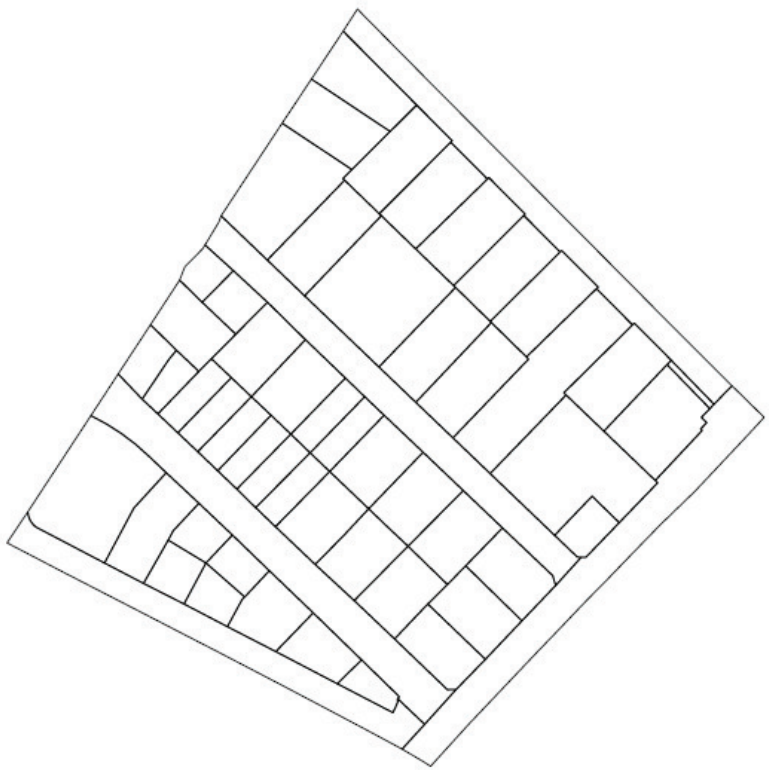
$$v_{kij} \sim N(0, \sigma_v^2), \qquad w_{ki} \sim N(0, \sigma_w^2), \qquad u_k \sim TN(\mu_u, \sigma_u^2)$$

- As robustness checks, we also obtained estimates using some other methods e.g., spatial, building-level regulation, different distributions for u, ...

Data

Data

- **Price per square meter** (adjusted for inflation and costs)
- **Number of floors in building**
- Apartment floor
- Parcel (building) identifier (address)
- Transaction (TY) and construction years (CY) (1998-2017), $|\text{CY} - \text{TY}| \leq 1$
- 283,000 apartments and 18,700 parcels



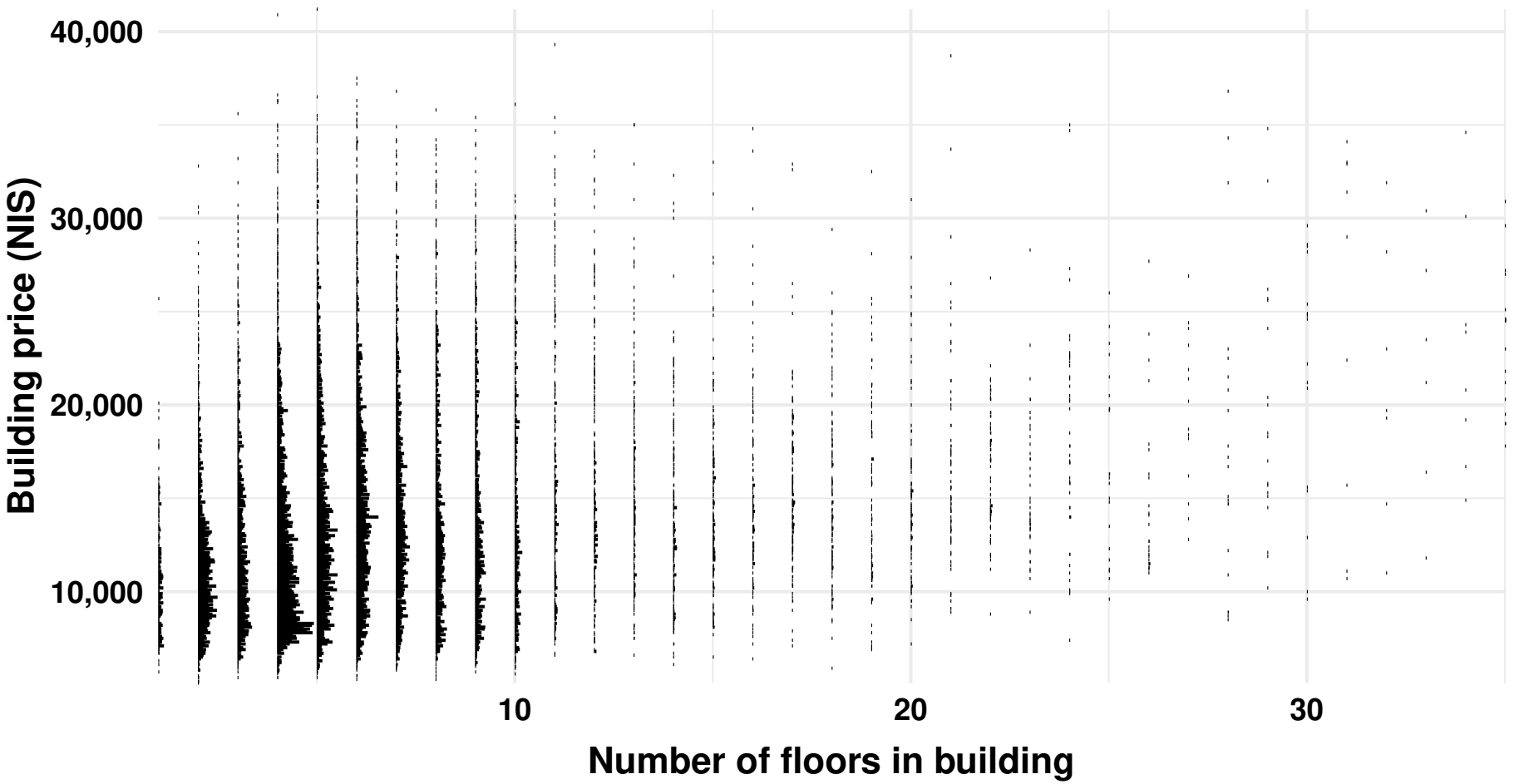
Data

Table: Summary statistics

	Mean	St. Dev.	Min	Med	Max
			Apartment		
Log price	9.35	0.38	8.40	9.34	10.53
Price	12,369	5,056	4,457	11,423	37,371
Number of floors	9.36	5.87	1	8	40
			Building		
Log price	9.36	0.39	8.49	9.35	10.50
Price	12,529	5,205	4,852	11,461	36,329
Number of floors	6.65	4.51	1	6	40

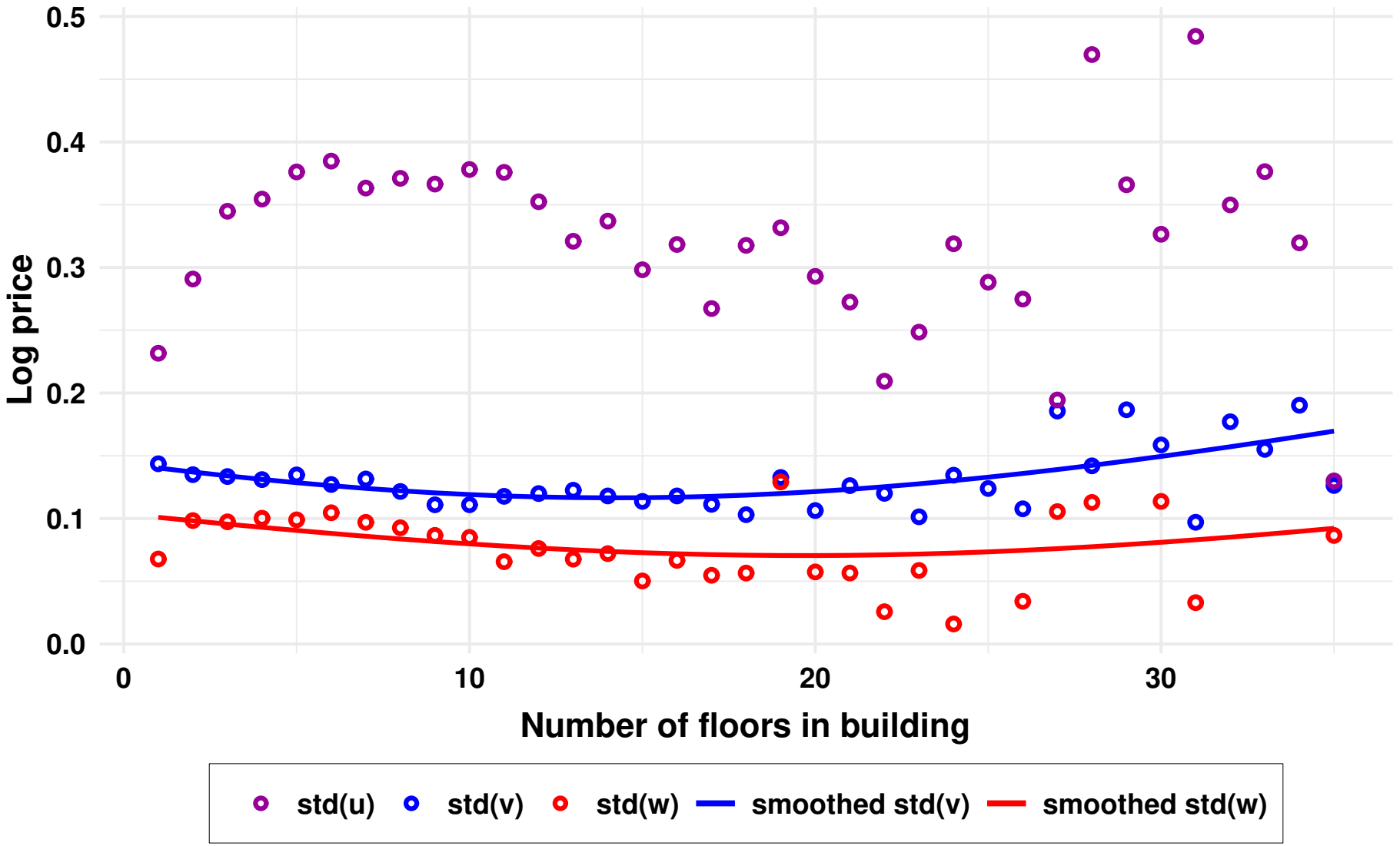
Note: Prices per square meter in real 2017 NIS (1 NIS $\approx$ 0.25 USD)

Data

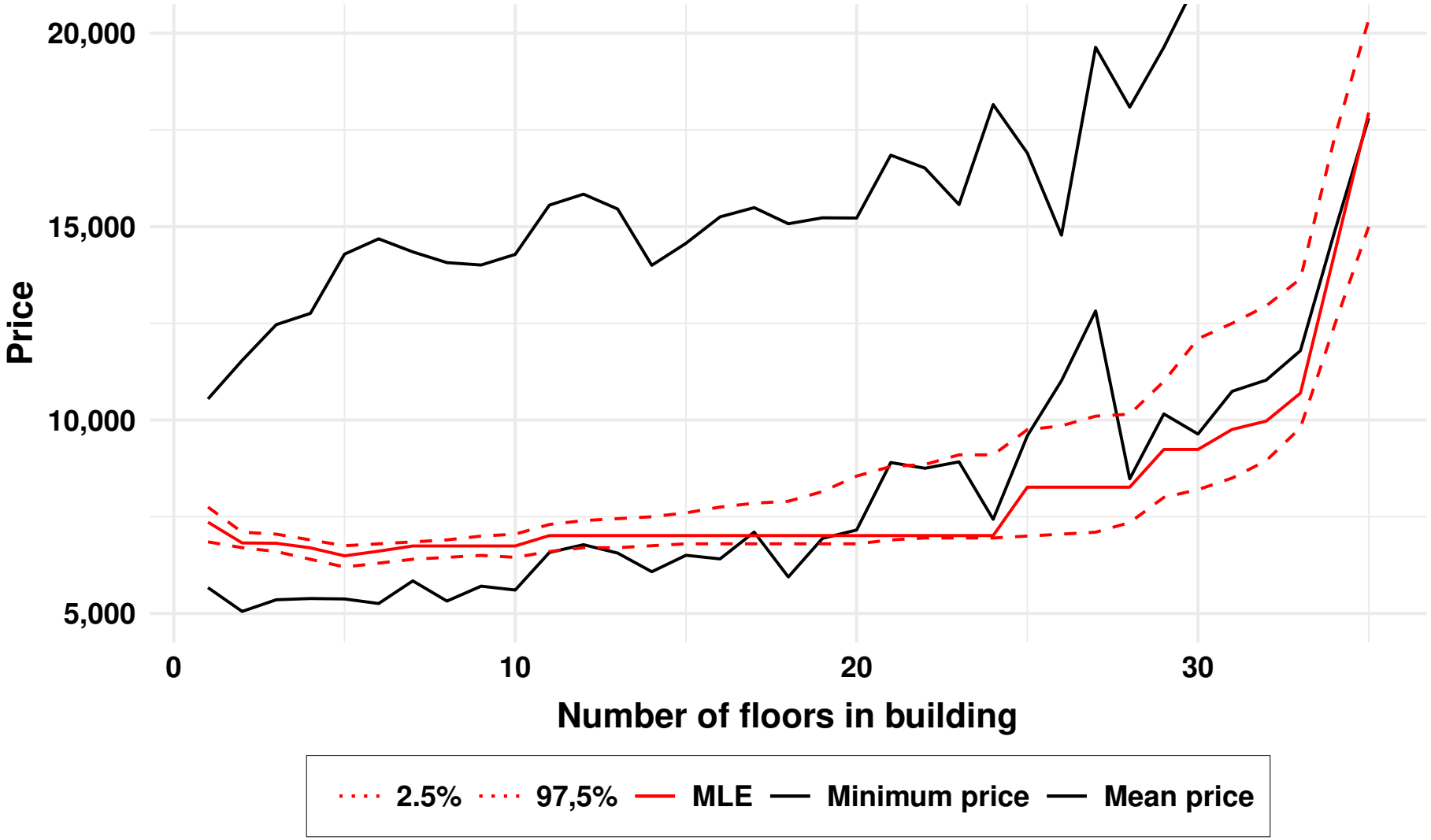

40,000
30,000
20,000
10,000
Building price (NIS)
10
20
30
Number of floors in building

Empirical Results

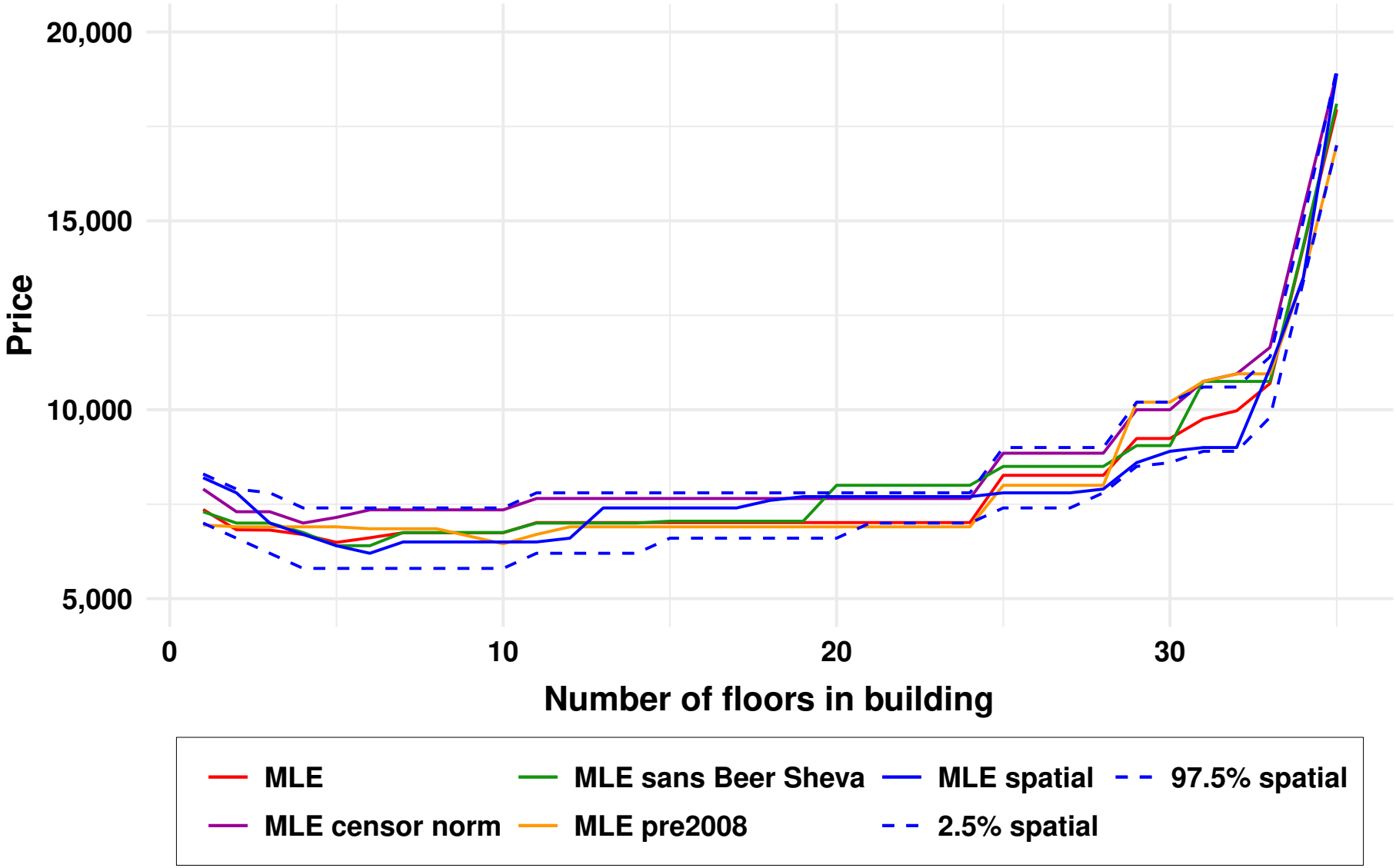
Standard deviations



Frontier: MLE



Frontier: MLE (robustness)



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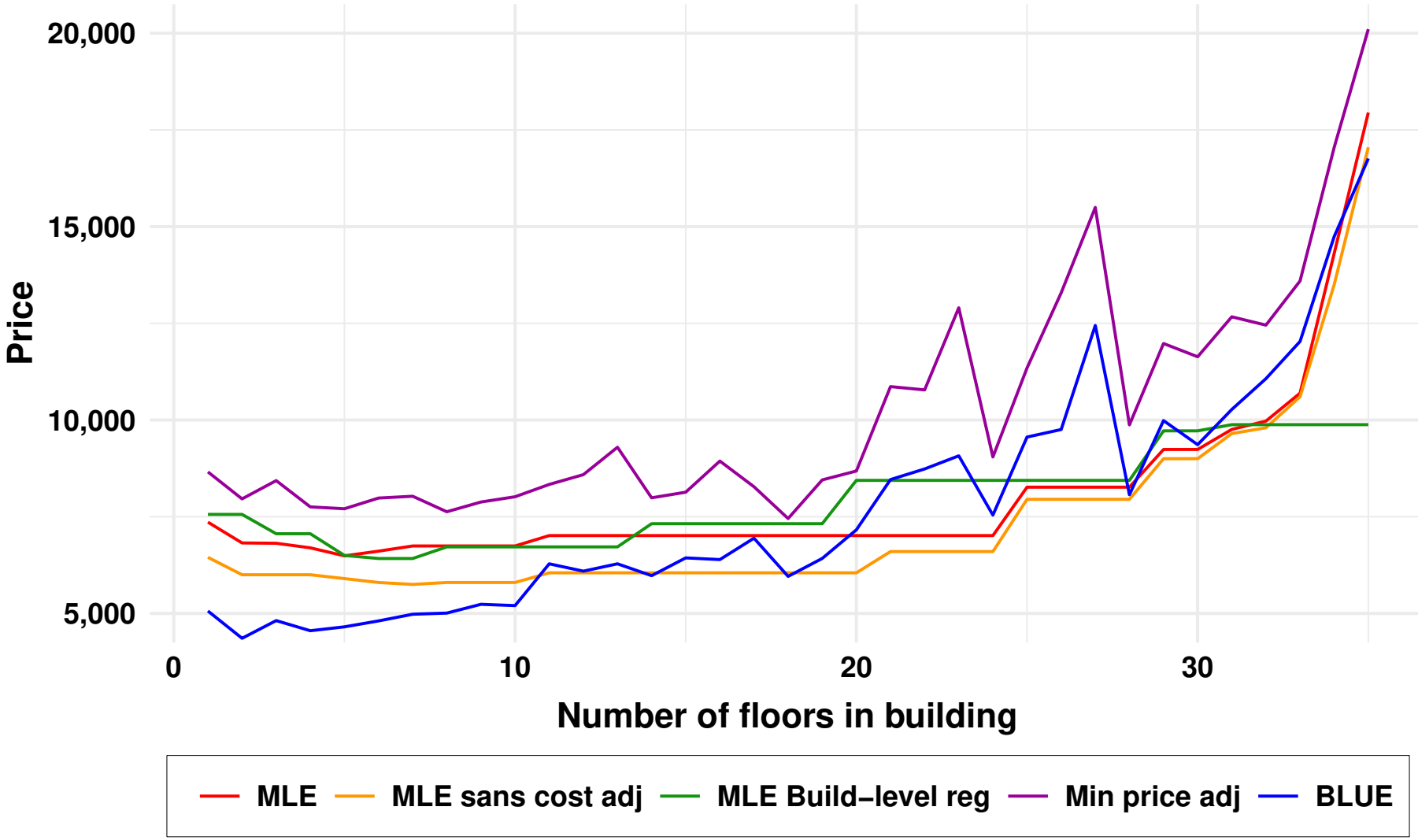
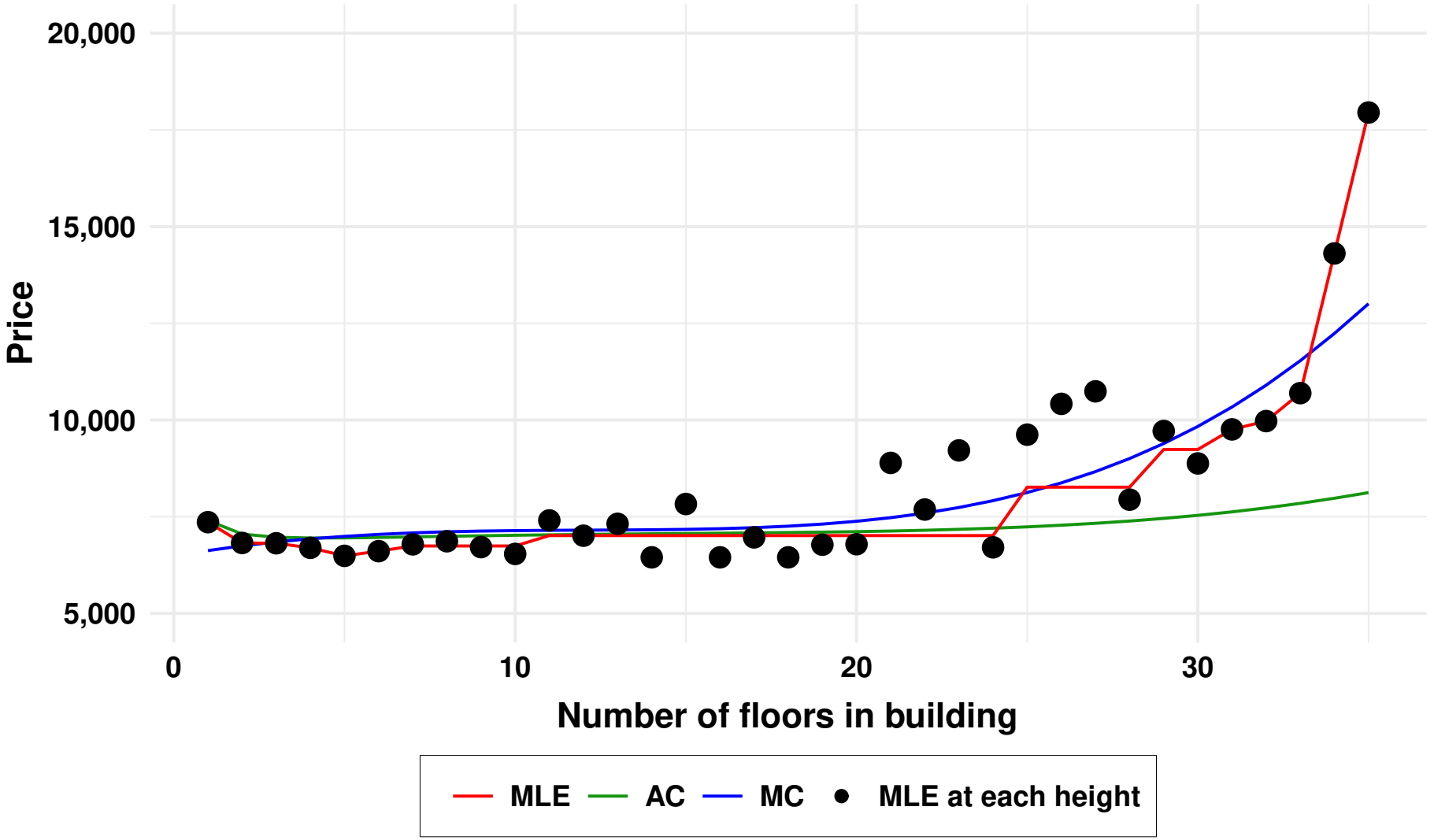
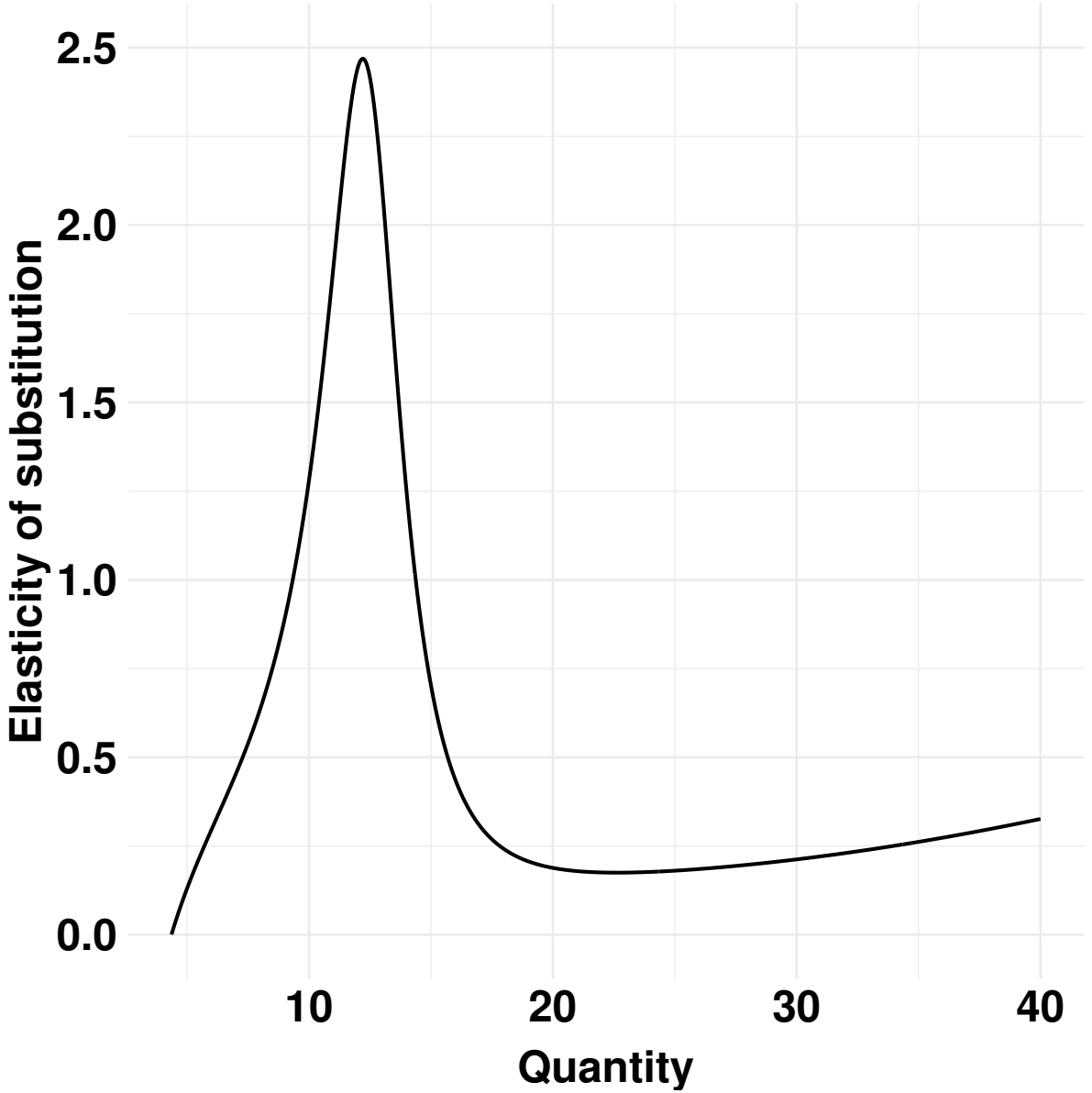


Frontier: MLE



Elasticity of substitution

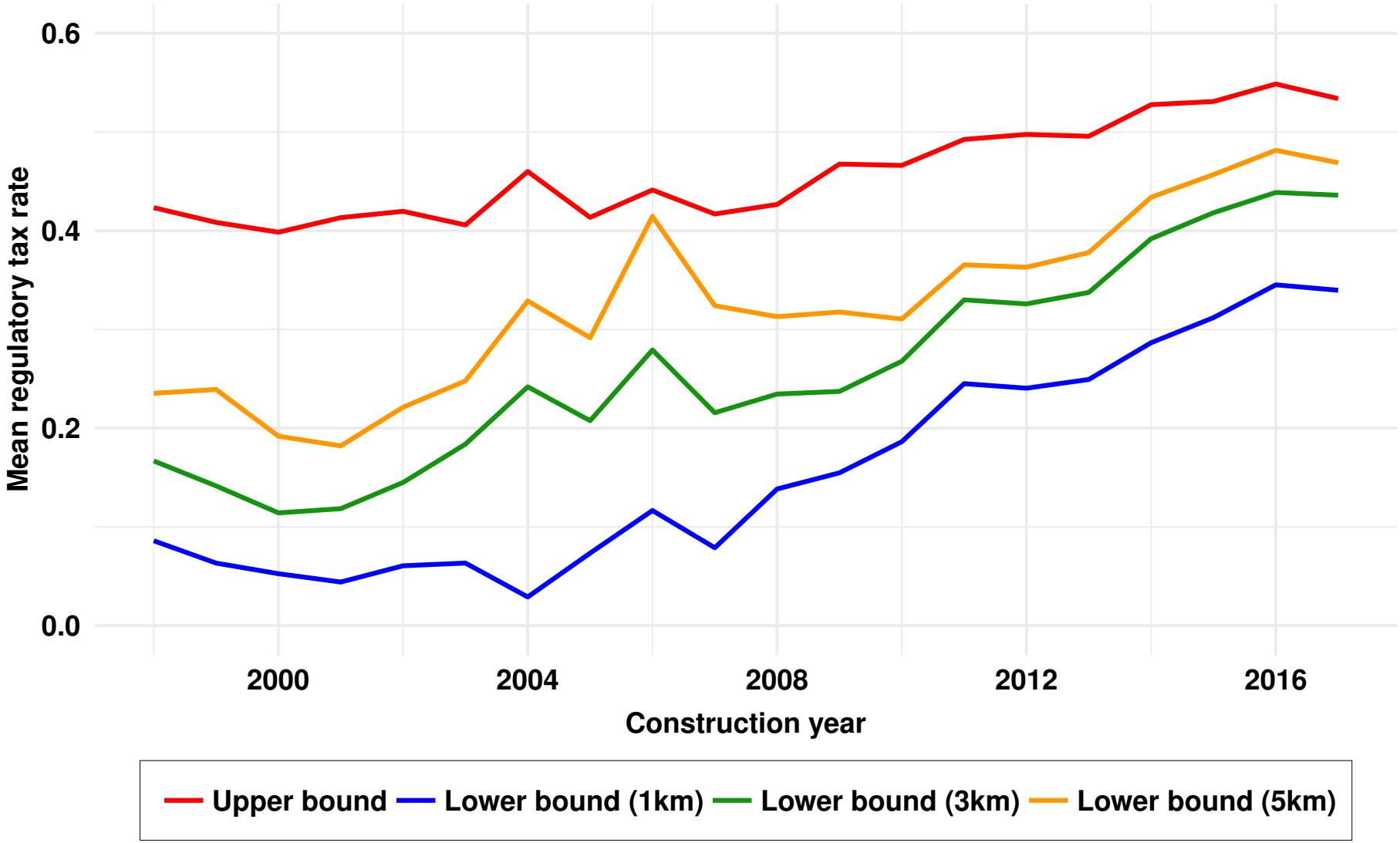


Frontier

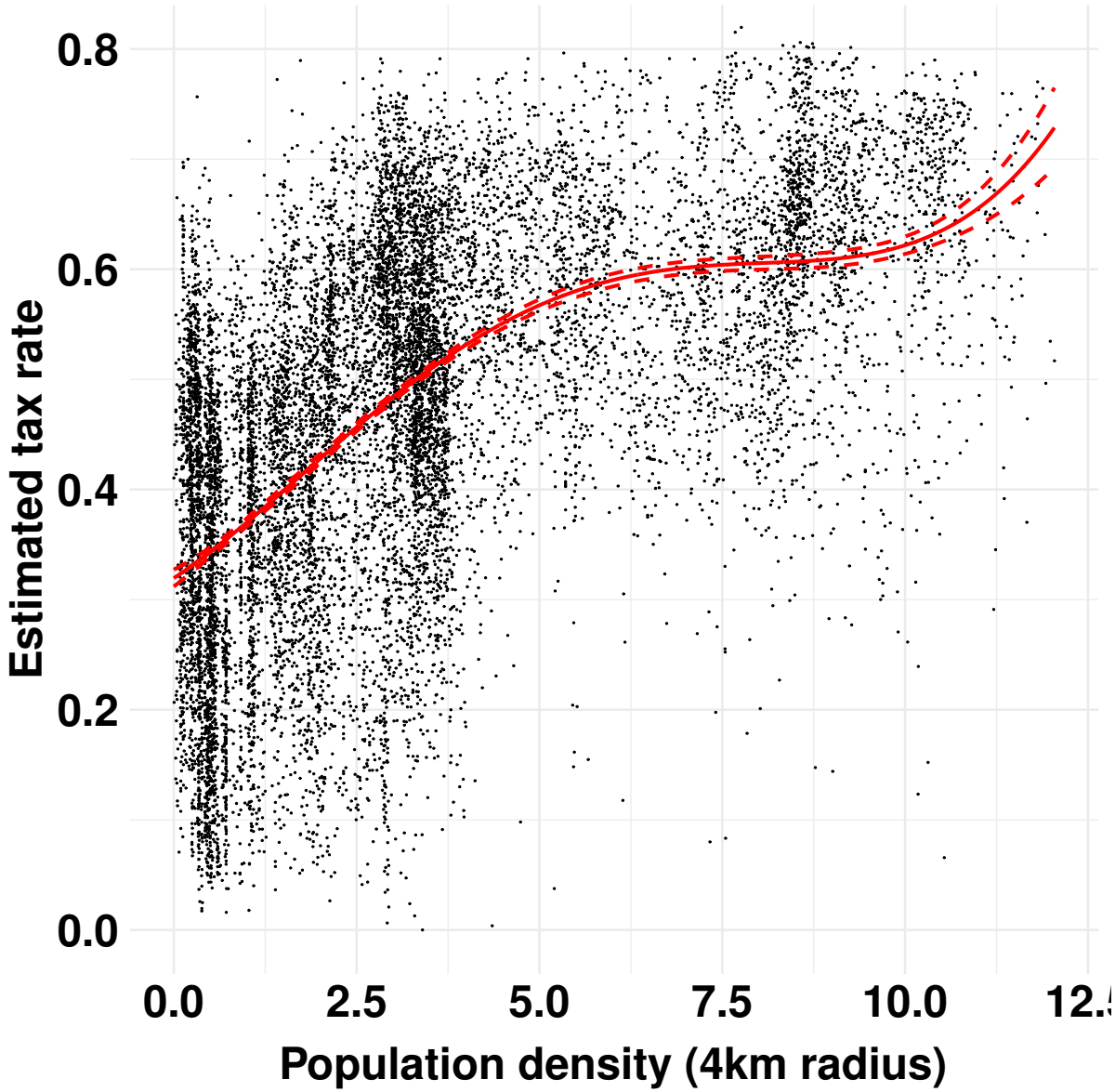
Table: Comparison of full sample and near frontier

	Full sample		Near Frontier	
	Mean	St. Dev.	Mean	St. Dev.
		Apartment		
Regulatory tax rate	0.45	0.16	0.12	0.04
Distance to city center	2.43	1.56	1.89	1.22
Density (1km radius)	5.01	4.98	3.13	2.71
Density (4km radius)	3.17	2.66	1.42	1.38
Distance to Tel Aviv city (km)	37.74	35.58	70.64	29.46
		Building		
Regulatory tax rate	0.47	0.17	0.09	0.04
Distance to city center	2.43	1.57	1.85	1.38
Density (1km radius)	6.24	5.68	2.56	2.17
Density (4km radius)	3.50	2.89	0.97	0.97
Distance to Tel Aviv city	37.89	38.50	80.05	28.63

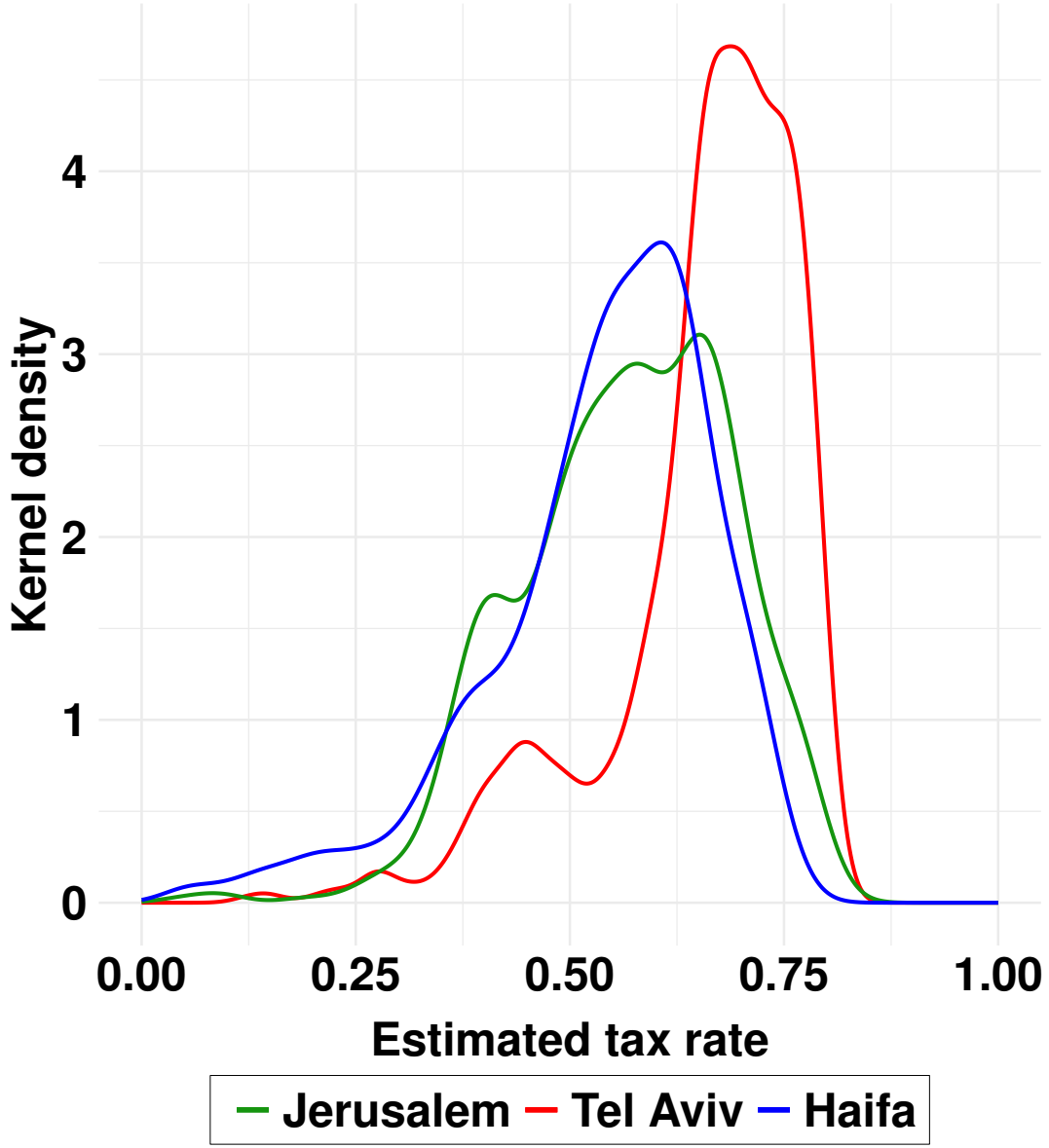
Estimated regulatory tax rate and bound over time



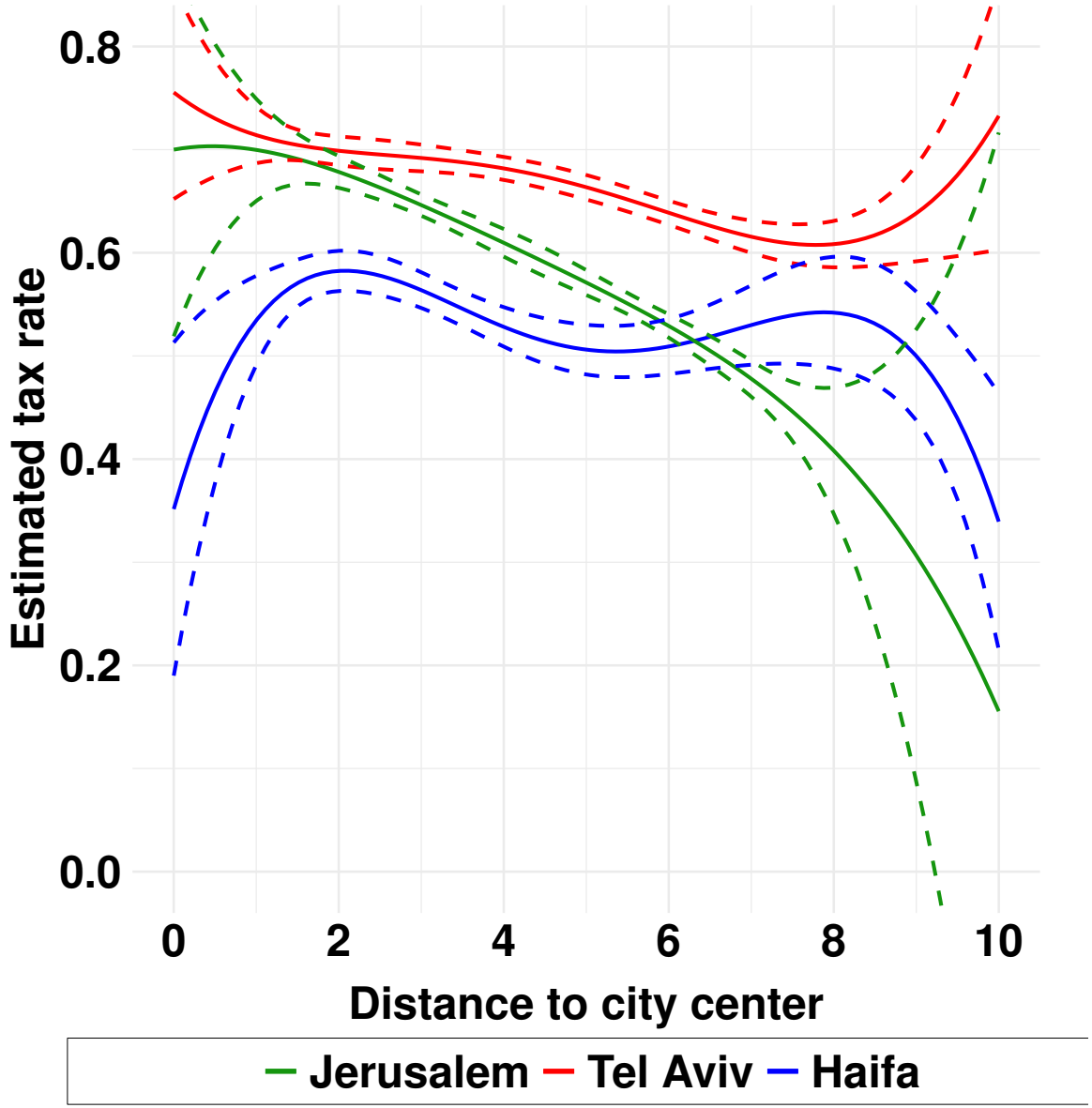
Characterizing Regulations by Density



Characterizing Regulations by City



Characterizing Regulations by Distance to City Center

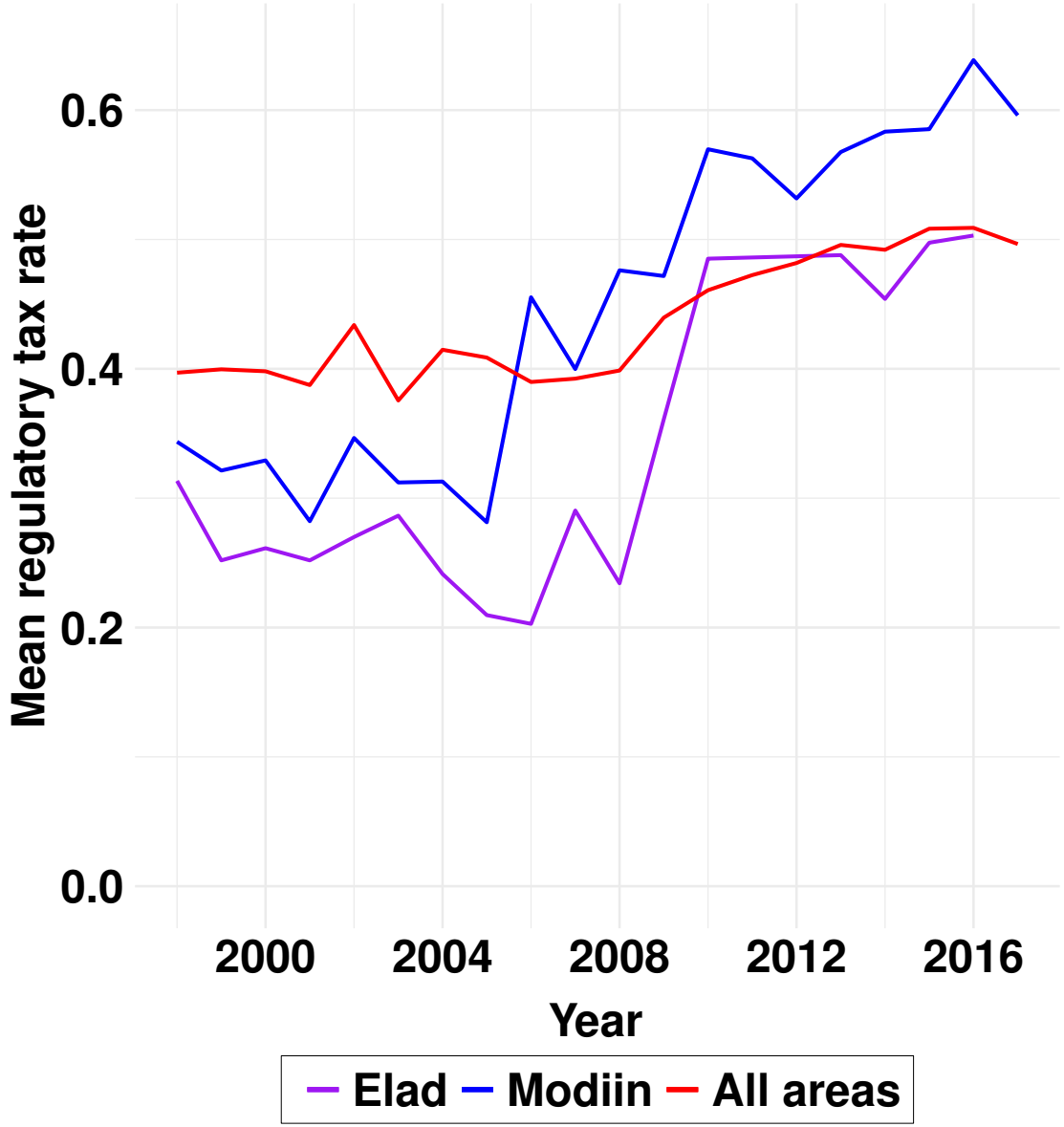


Regulatory tax Regressions

Table: Regressions

	Estimated regulatory tax rate				
	(1)	(2)	(3)	(4)	(5)
			Apartment		
Distance to city center	-	-	-0.0031 (0.0002)	-	-
Density - 1km radius	0.0092 (0.0001)	-	-	0.0011 (0.0001)	-
Density - 4km radius	-	0.0283 (0.0001)	-	-	0.0063 (0.0003)
City fixed effects	No	No	Yes	Yes	Yes
R^2	0.0858	0.2296	0.5540	0.5523	0.5531
			Building		
Distance to city center	-	-	-0.0042 (0.0006)	-	-
Density - 1km radius	0.0107 (0.0002)	-	-	0.0016 (0.0002)	-
Density - 4km radius	-	0.0324 (0.0004)	-	-	0.0088 (0.0009)
City fixed effects	No	No	Yes	Yes	Yes
R^2	0.1309	0.3099	0.6713	0.6675	0.6688

Regulatory tax over time in new cities



Summary

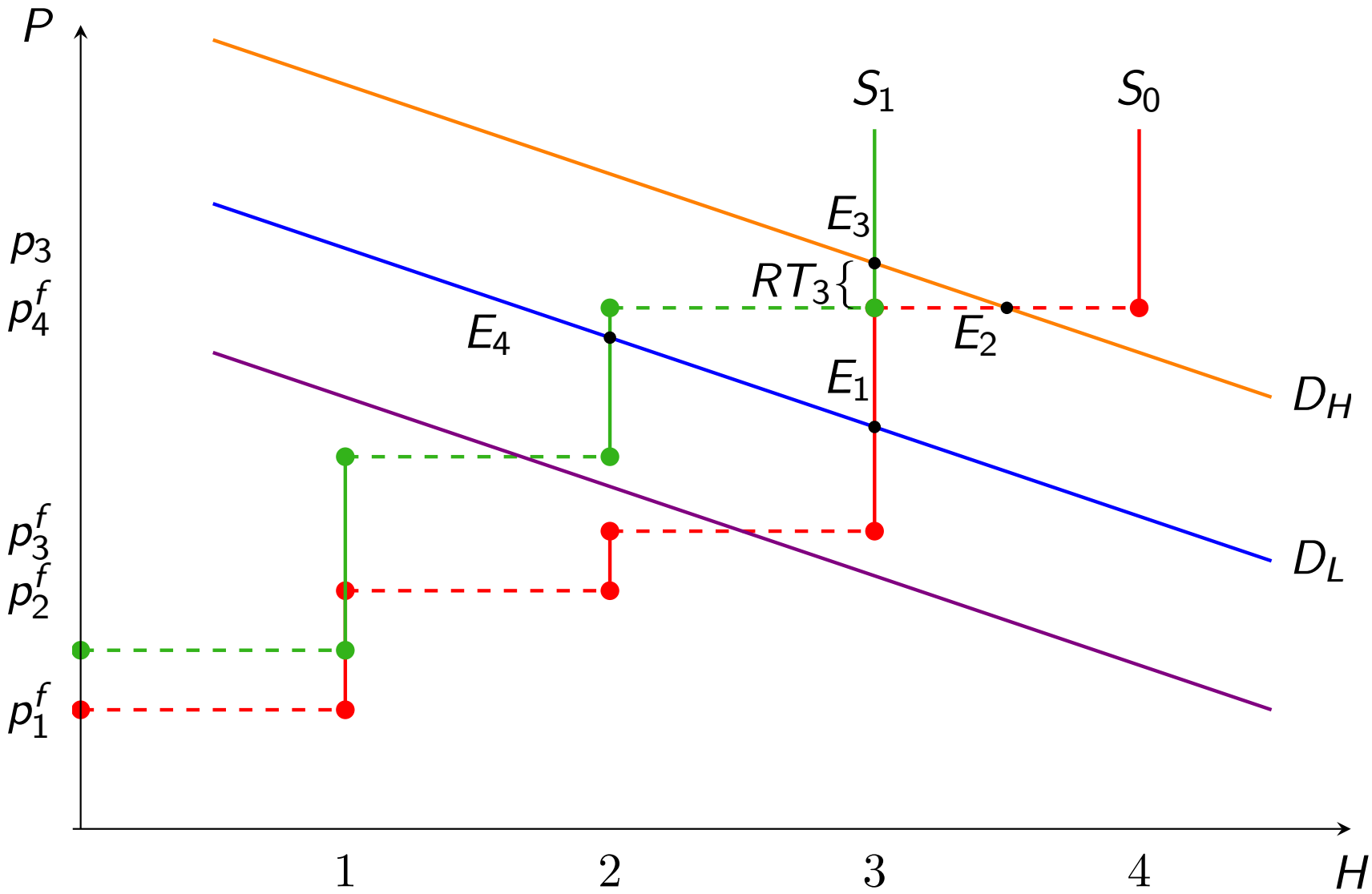
- Connect the housing production function literature to the techniques in the stochastic frontier literature
- Identify frontier supply using just prices and quantities:
  - frontier marginal costs (supply curve) from variation in demand in unregulated markets
  - frontier average costs from variation in demand and regulations
- Allow for nonhomogeneous housing units based on observed apartment floor and building height
- Allow apartment and building level measurement error, including random quality and other unobservables
- When structural and locational quality are systematically related, then bound regulatory tax

Summary (continued)

- Estimate the frontier and regulatory tax in Israeli housing market using new construction from 1998-2017:
  - Regulatory tax is about 50% of housing prices
  - Higher regulatory tax rate in more expensive, denser areas, closer to city center
  - Measurement error is small compared to regulations
  - Elasticity of substitution (beyond minimum efficient scale): hard at low and high heights, easy at medium heights. Suppliers want to build higher
  - Evidence of economies of scale at low heights
  - Accounting for systematic relationship between locational and structural quality, regulatory tax during high price period is bounded between 45% and 55%

Thanks for your time!

Discrete Height



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Identification: floor and height premia

- What about apartment floor and building height premiums?

Solution:

- Hedonic regression of prices on apartment floor, building height, and a location fixed effect
- Identification by variation in apartment floor within a building and variation in building height within a parcel
- Basically strip out floor and height premium from prices

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Identification: measurement errors and quality

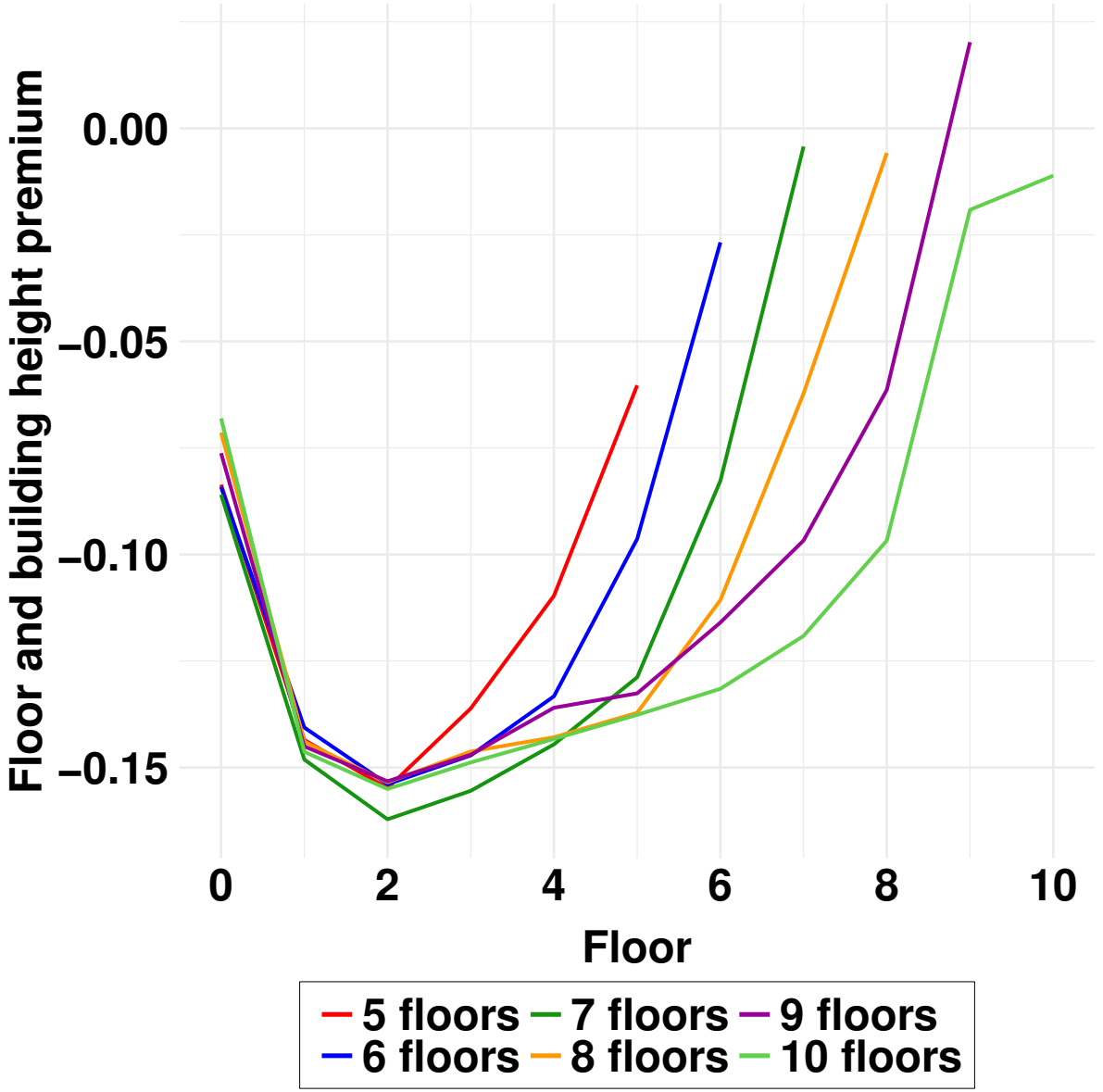
- What about apartment and building level random error and quality

Solution:

- Use within-building price variance
- Use between buildings that are close price variance (within-bloc)

back

Apartment-floor, building-height adjusted prices



Apartment-floor, building-height adjusted prices