From Samurai to Skyscrapers: How Transaction Costs Shape Tokyo

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Motivation

- City is the center of economic activities.
- Efficient use of the scarce land in the CBD can have a sizable impact on the functioning of the economy.
- Land ownership should be continuously allocated to the best usage at that time.
- One key type of land transaction is to change lot size by split or assembly. But, transaction costs might exist:
  - Land splitting may be costly because demolishing the buildings and finding multiple buyers to sell split land are needed.
  - Land assembling will also be costly because negotiation with multiple landowners is needed.

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- If transaction costs > benefit of optimal land use
  → lot size can persist and affect urban development in the long run
- Lot size persistence
  - Rural areas: lot size persistence disappears in 150 years (Bleakley and Ferrie, 2014; Smith, 2020; Finley et al., 2021)
  - Can we expect the same pattern in cities? (Coase, 1960)
    - Benefit of optimal land use ↑ → Less persistent?
    - Transaction costs ↑ → More persistent?
- Urban development
  - Consequence of lot size persistence for urban development is understudied and can be different in space and time
    - Once tall buildings become available: tall buildings require large footprints and generate agglomeration benefits → premia

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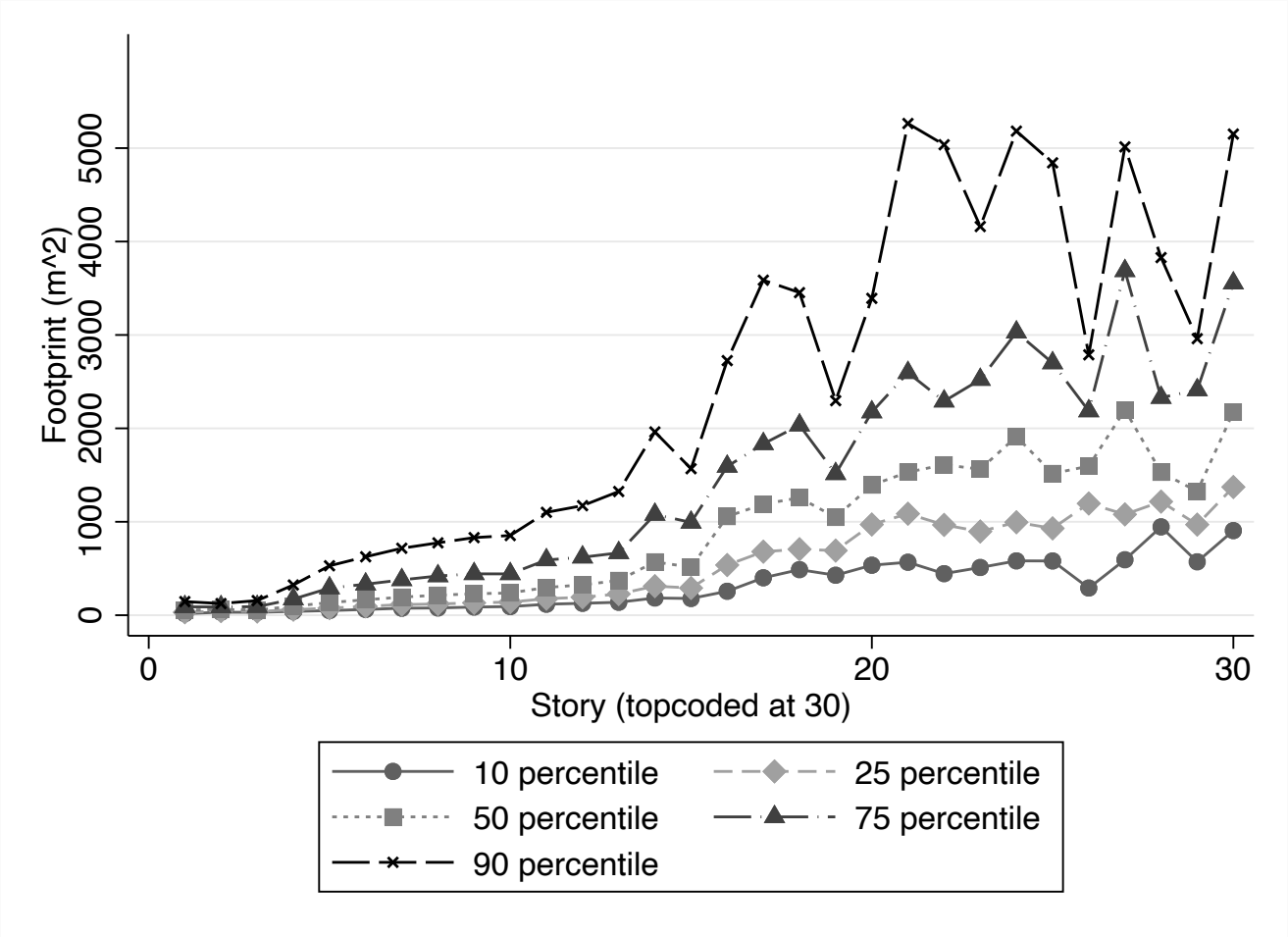
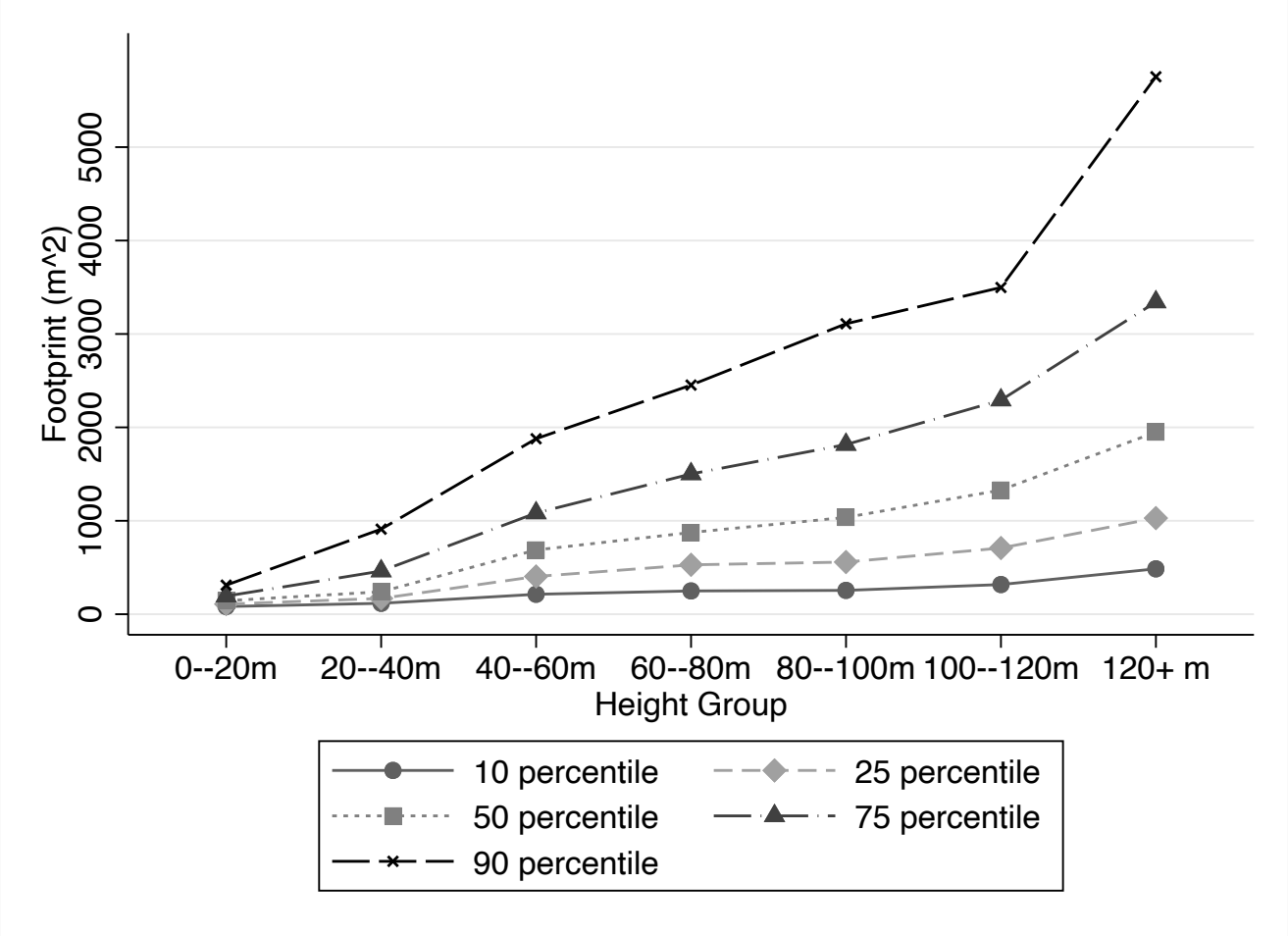
Taller Buildings Have Larger Footprint



The Same Pattern in NYC



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Our study: History of Tokyo as a laboratory

- This study examines how the initial lot fragmentation affects urban development in the long run, in the context of central Tokyo.
- Natural experiment: **release of local lords' estates** (*daimyo yashiki*) to the private market after 1868
  - Local lords (*daimyo*) are the chiefs of about 300 regional domains in Japan. They owned estates in Tokyo.
  - Estates of local lords before 1868: their lots are much larger than other area's lots in Tokyo.
  - $\rightarrow$ They lost their estates and the private sector took over them after 1868
  - $\rightarrow$ Supply shock of larger lots to Tokyo.
  - Spread across Tokyo + a zoning episode for RD

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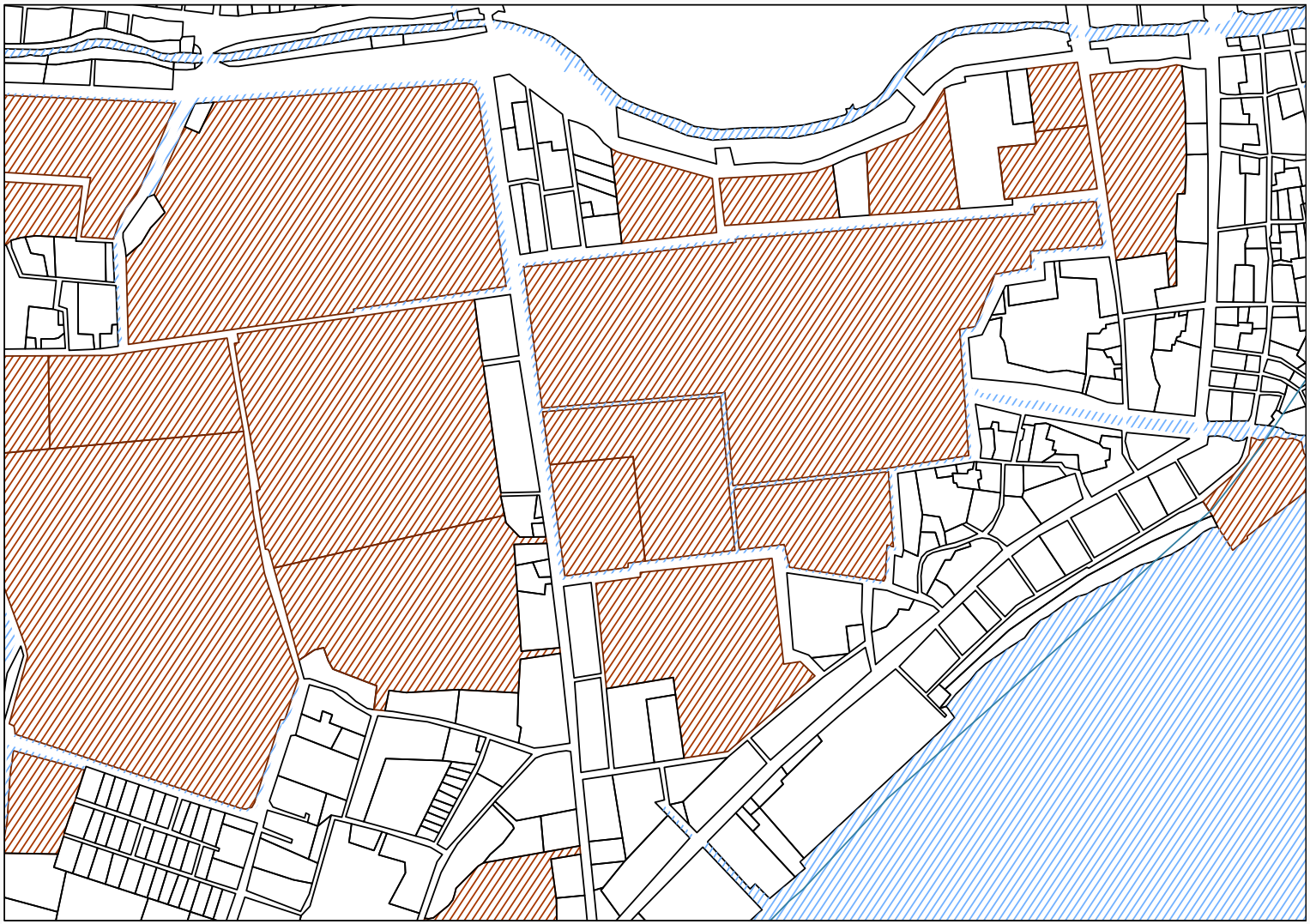
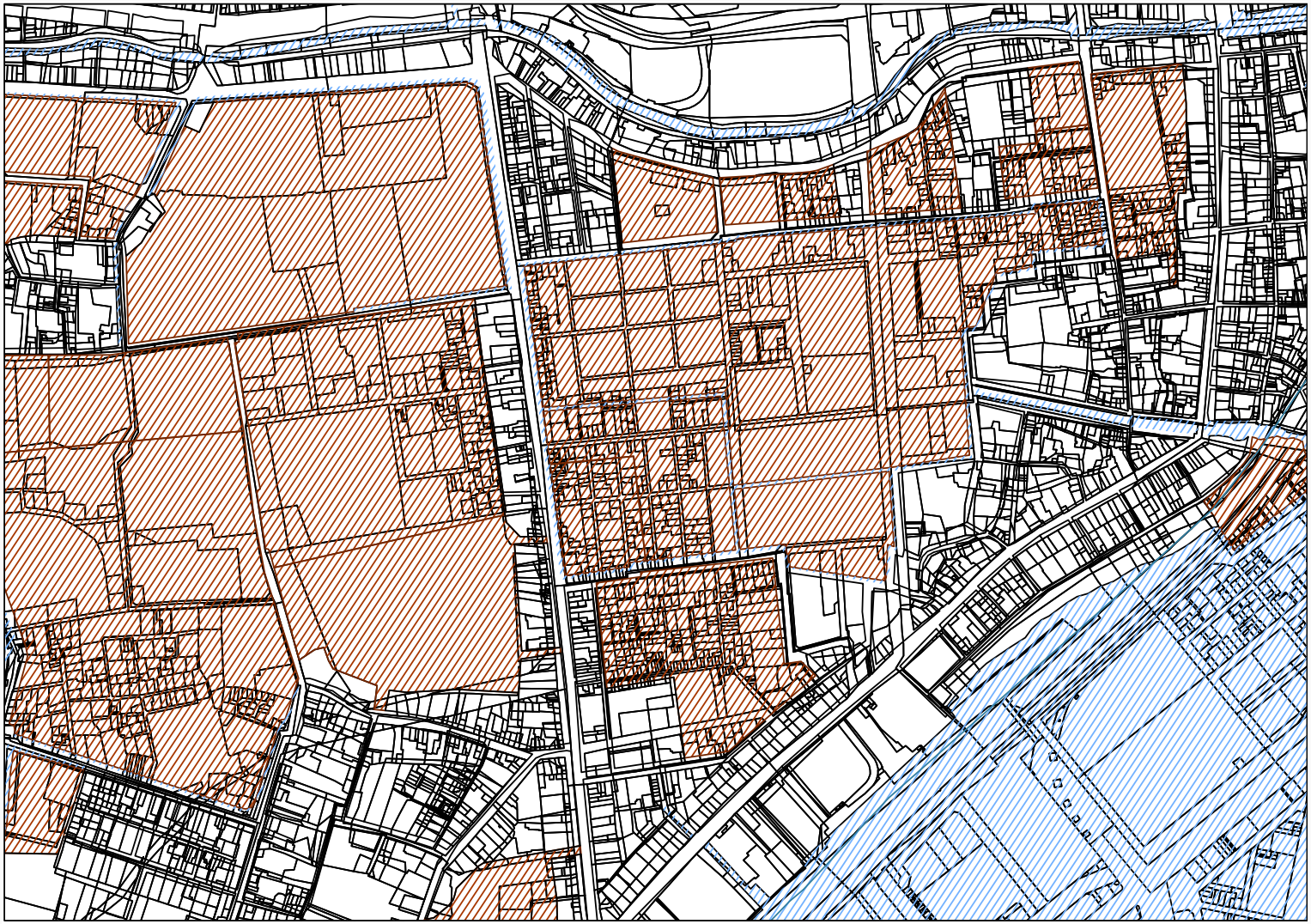
One example from a map in 1850s: Tamachi Station

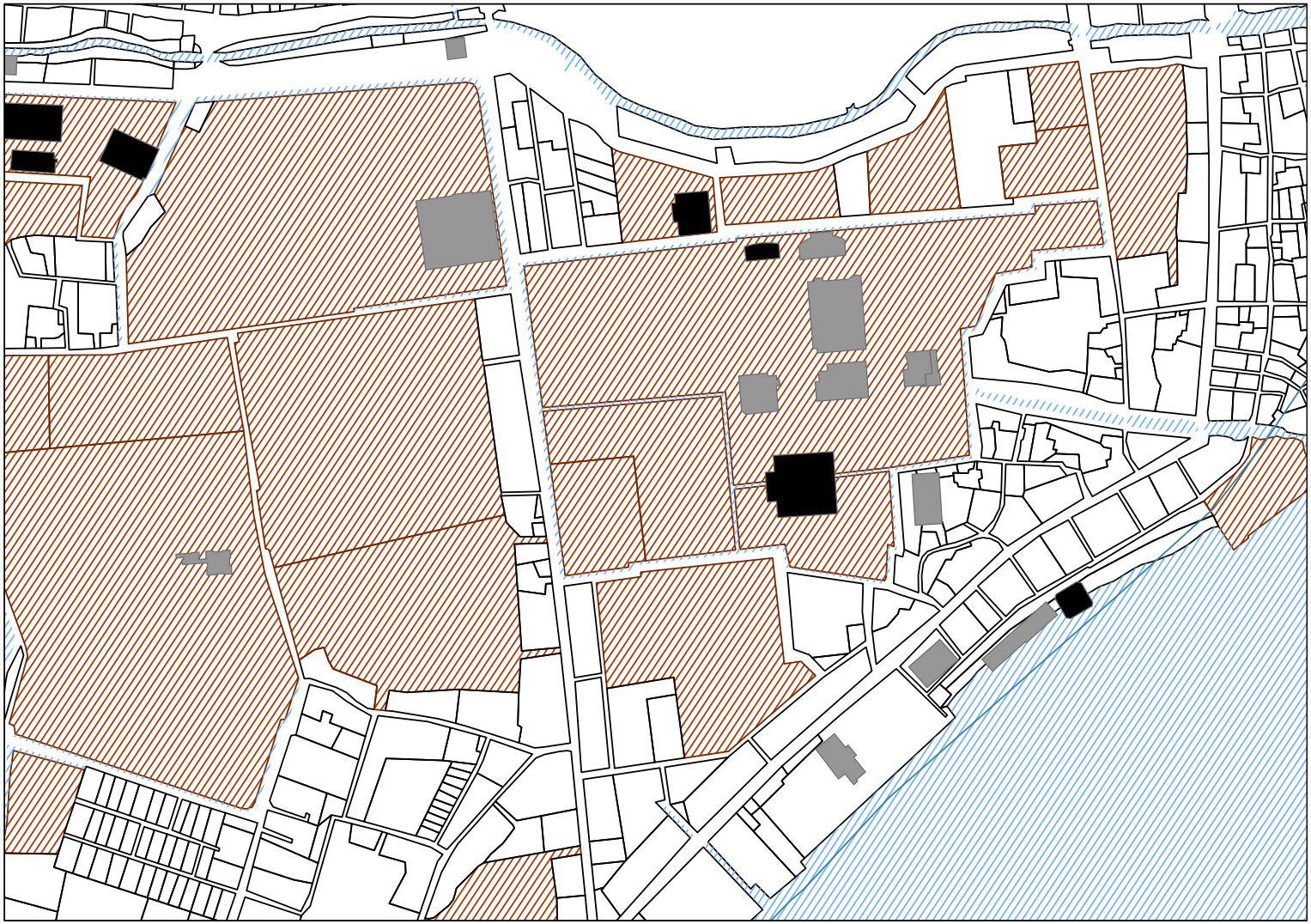
Local lords’ estates are less-fragmented (1850s)



Those lots are less fragmented even today (2010)



And tall buildings (> 15 or > 30 stories) are there (2011)



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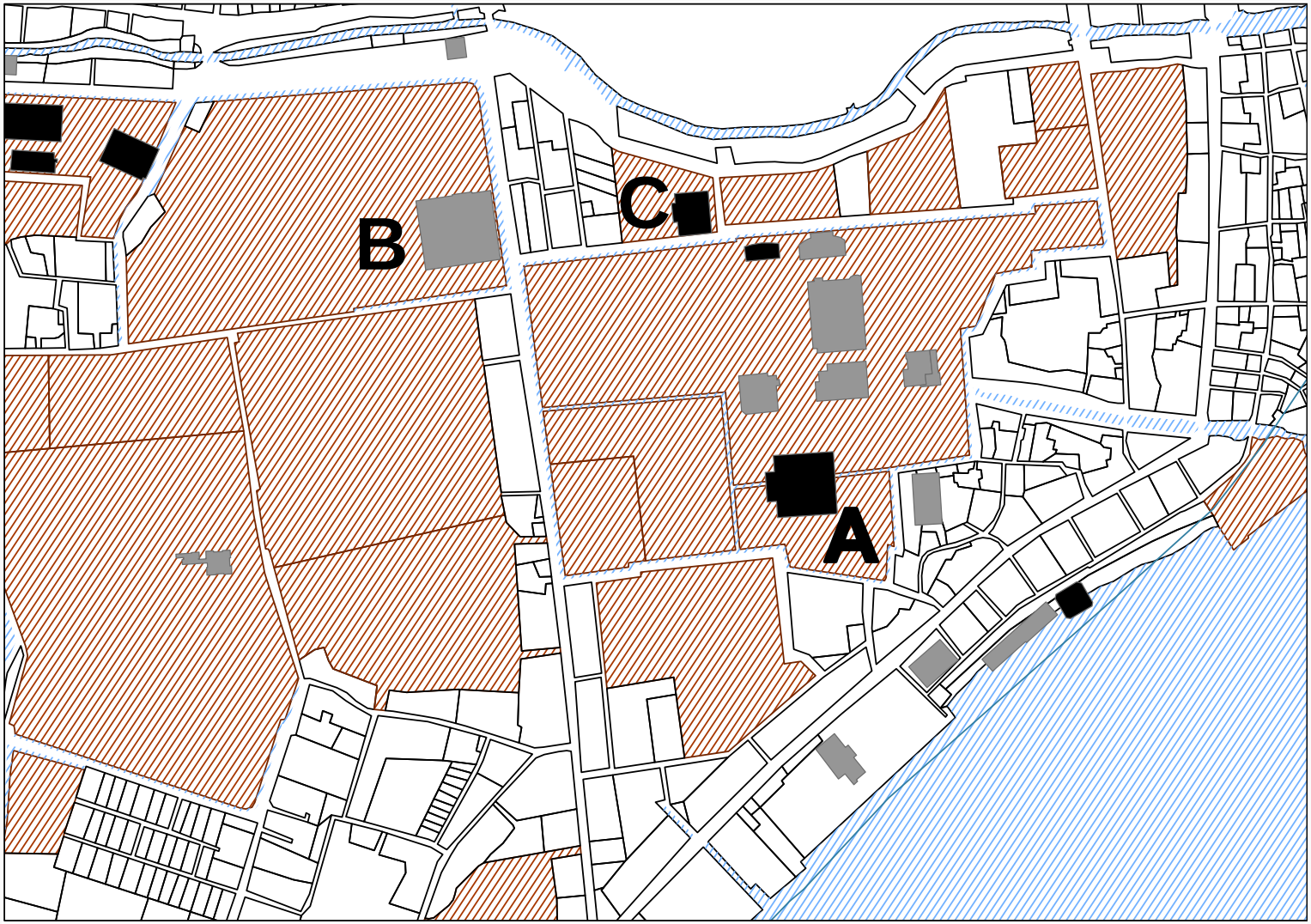
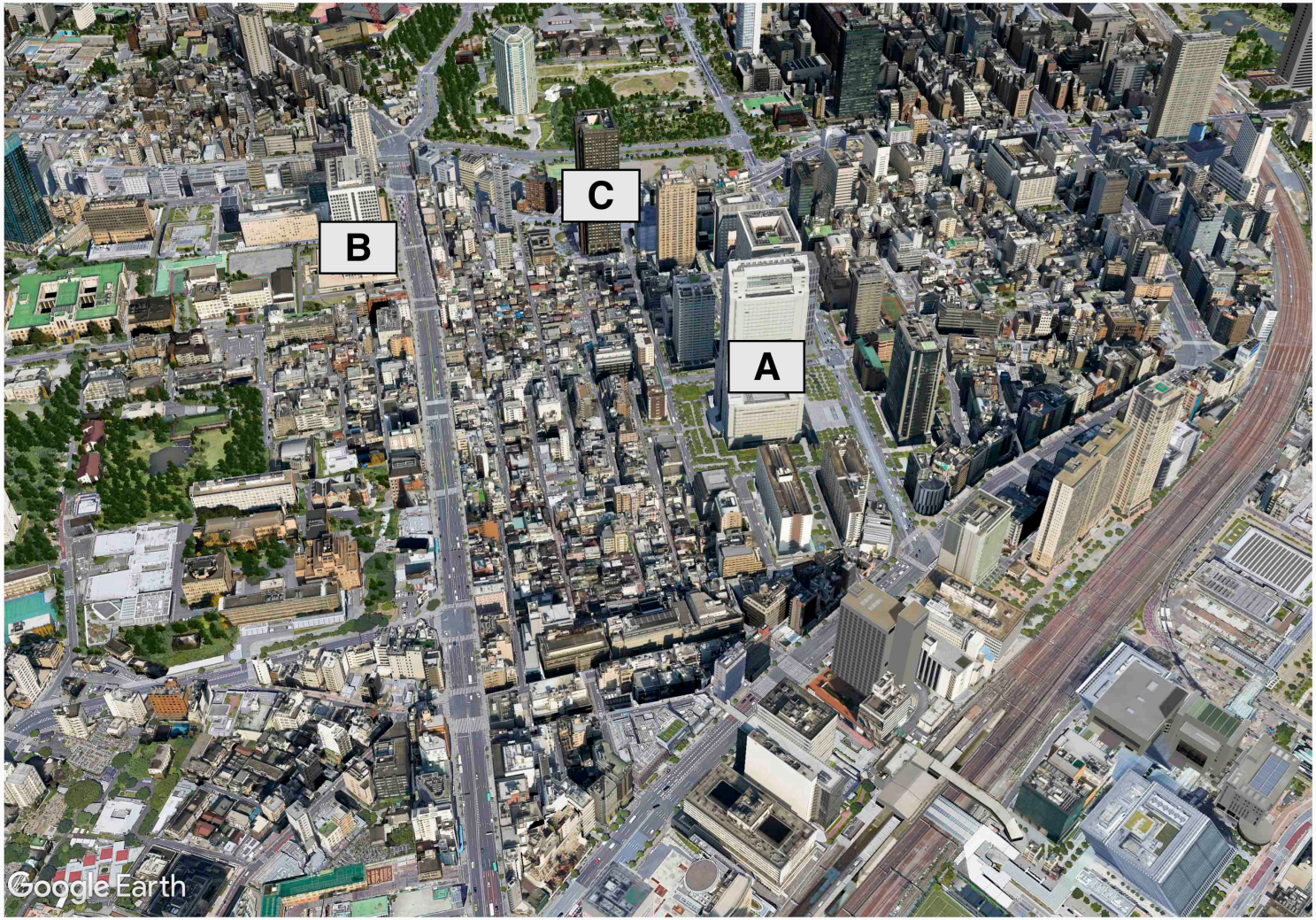


Large variation of building heights in a small area suggesting high land assembly costs



Brief preview

- Local lords' estates at the end of the 1850s → larger lots (OLS and Local randomization)
  - Lot size persistence only in the core area, suggesting that assembly frictions are more prevalent
- Local lords' estates at the end of the 1850s → taller buildings, and higher land prices today.
  - Before 1945: lots size was persistent, but had negative effect on land price (split cost)
  - Positive effect on firm productivity by tall buildings.
  - → The benefits of a larger lot size depend on the degree of the agglomeration economy.
- Land ownership at the initial stage of modern economic development affects the shape of a city today by land transaction costs.

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Literature (1) Transaction costs in urban land market

- Coordination problems in (re)development (Hornbeck and Keniston, 2017; Owens et al., 2020)
- Formalization costs in slums (Harari and Wong, 2019; Michaels et al., 2021; Henderson et al., 2021)
- Project delays owing to litigation (Gandhi et al., 2021)

Literature (1) Transaction costs in urban land market

- Lot size persistence in the rural area (Bleakley and Ferrie, 2014; Smith, 2020; Finley et al., 2021).
- The existing studies examine mostly rural/agricultural settings and find persistence disappears gradually (150 years, in the case of farms in Georgia)
- In contrast with these rural settings, we find strong lot size persistence in the urban setting, in particular the core area.
- Transaction costs are greater in the core urban areas, dominating the greater benefit of optimal land use.
    - A potential reason for higher transaction costs: holdout (Eckart, 1985; Miceli and Sirmans, 2007; Winn and McCarter, 2018).
- We also show the impact on firm productivity.

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Literature (2)

- Historical dataset + Urban (Hanlon and Heblich, 2020)
  - Intra-cities: Davis and Weinstein (2002), Bleakley and Lin (2012), Hanlon (2017)
  - Negative temporal shocks: Redding and Sturm (2016), Hornbeck and Keniston (2017), Dericks and Koster (2018), Ambrus et al. (2020)
  - Geographical origin: Saiz (2010), Harari (2020), Heblich et al. (2020)
  - Institutional origin: O'Grady (2014), Baruah et al. (2017), Brooks and Lutz (2019)
- Our paper: **historical lot fragmentation as an institutional origin of urban development**.
- We offer a new channel of how history matters: lot size differences persist, but the positive effect of lot size arises only in the long run (**reverse of fortune**, cf. Nunn and Puga (2012)).

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- Land assembly and urban development
  - Theory or lab experiment: Eckart (1985), Miceli and Sirmans (2007), Winn and McCarter (2018).
  - Short-term premia/discount of land assembly in the field data: White (1988), Brownstone and Vany (1991), Tabuchi (1996), and Brooks and Lutz (2016)
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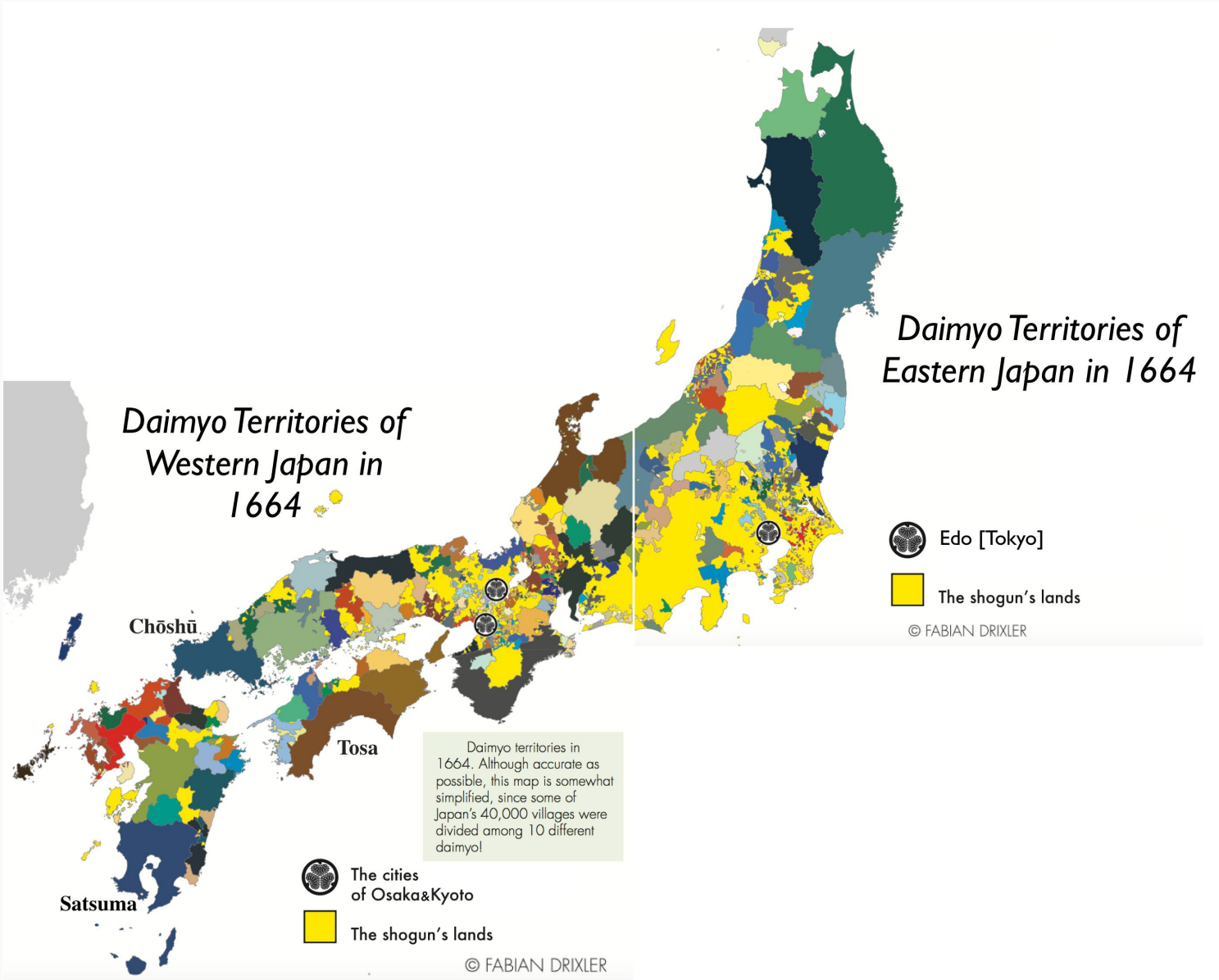
Literature (4)

- Economics of tall buildings (Liu et al., 2017; Ahlfeldt and McMillen, 2018; Ahlfeldt and Barr, 2020)
  - Agglomeration / productivity spillovers within buildings (Liu et al., 2017)
  - Floor price at the story level (Liu et al., 2018)
  - Higher land price → tall buildings (Ahlfeldt and McMillen, 2018)
  - Bedrock (Barr et al., 2011)
- Our study investigates lot fragmentation as **an obstacle to constructing high rise buildings.**

Very brief summary of history

- 1600: *Shogun* started to construct a city in a marsh.
- During the pre-modern era (1600–1868): 250-300 local feudal lords
- Local lords typically had three estates (Larger lots)
  - Wives and kids stayed in Tokyo as hostages
  - "Alternate Attendance System": Lords had to come to Tokyo once a two years and stay for a year
  - Vassals stayed in Tokyo as well
- 1868: Two estates were expropriated → mostly released to the private market
- After WWII: heavy asset tax rate so that they had to sell the remaining one

Local lords as chiefs of local domains



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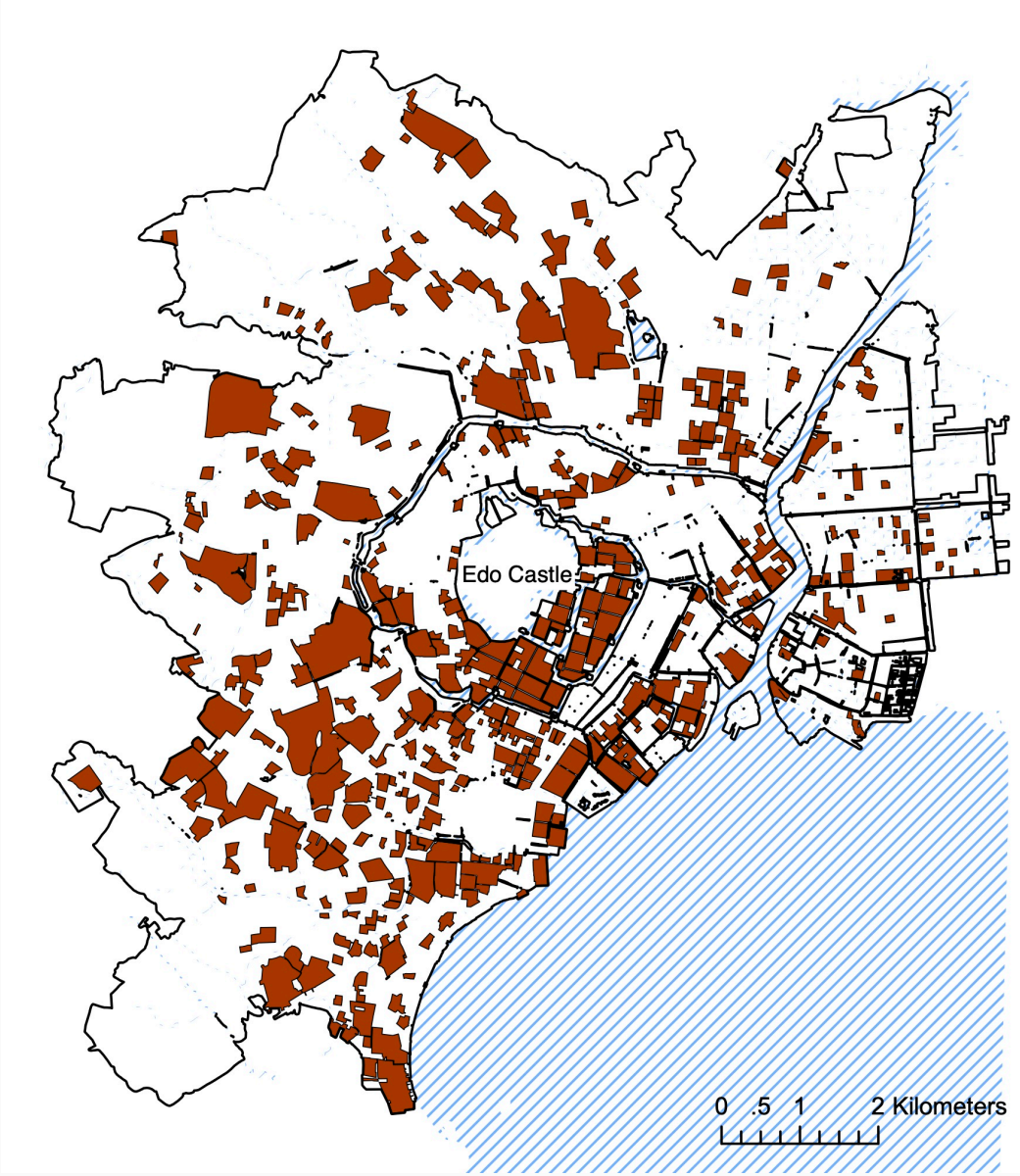
Local lords owned estates in Tokyo (Map in the 1850s)



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Urbanization of old Tokyo

- Business activities increased in old Tokyo after WWII.
- Daytime population increased from 3M to 4.7M.
  - Residential population did not increase so much.
- Tall buildings increased.
  - No skyscrapers before 1965
  - Kasumigaseki building in 1965 = 36 stories, 147 m
  - Over-30-stories buildings: 32 in 1990, 86 in 2000, 260 in 2010

Data spanning 150 years

- Various data sources including digitizing new data
  - Local lords' estates in the 1850s
  - Lot fragmentation in 1873, 1912, 1931–35, and 2008–2011.
  - Land price in 1876, 1912, 1931-1935, 1972, 1983, 2010s.
  - Buildings of today (shape, height, sector, ..)
- We aggregate all of these information at the 100 m*100 m cell level.

Various Identification Strategies

- OLS conditional on geographical controls
- Higher local lords estate's share → In 2011, larger lot size, more tall buildings, and higher land prices.
- **RD using zoning policy**

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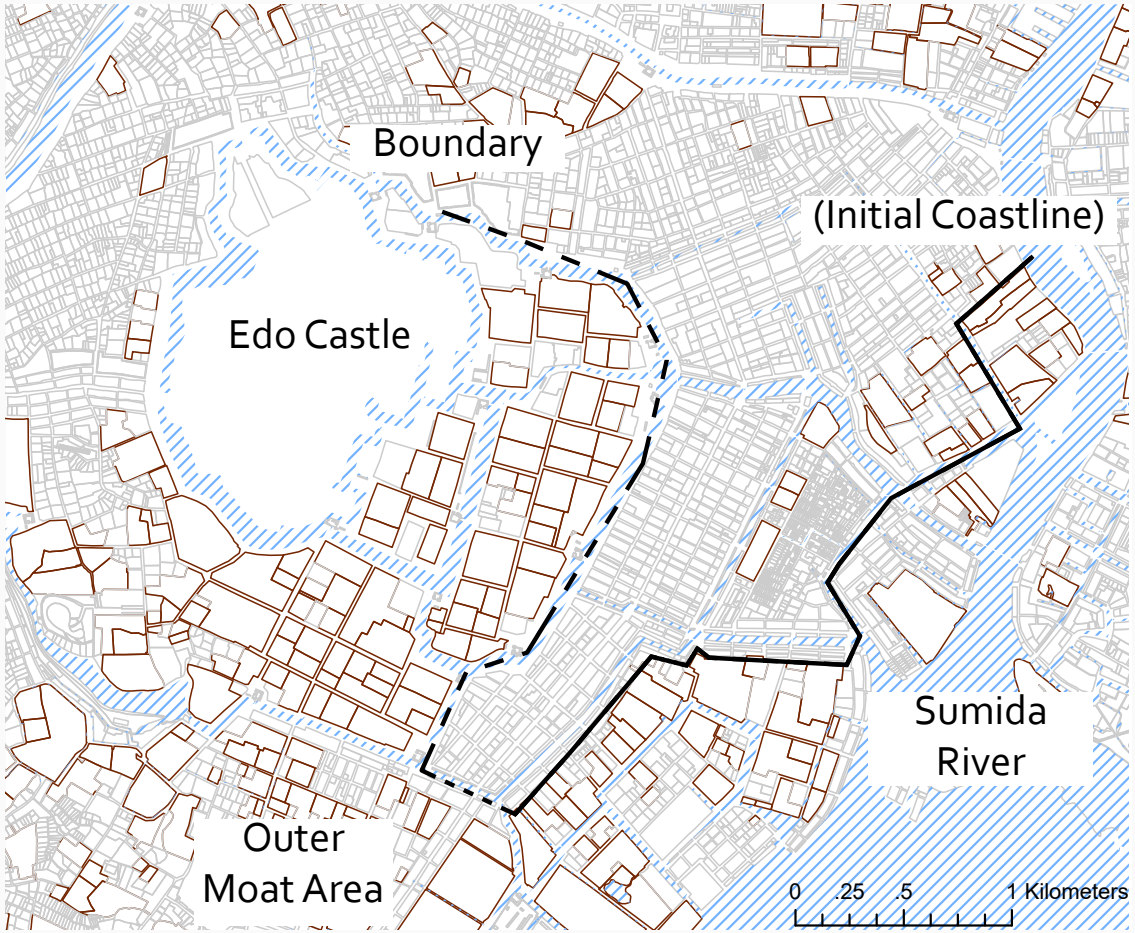
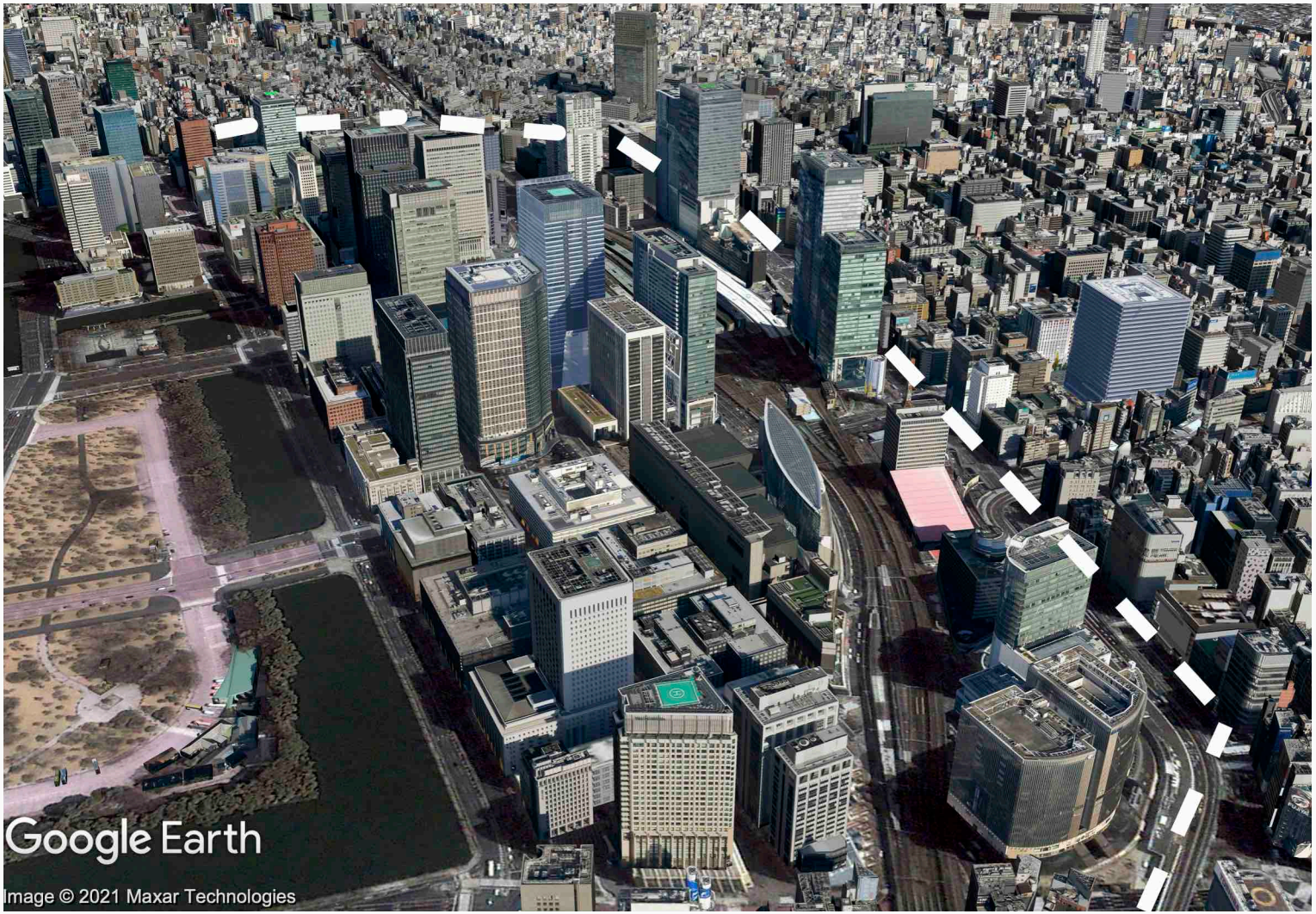
RD using the Tokugawa's Planning using the left and center zones. ▸ Result



The left and center area were initially developed. The right zone was developed later.

In 1970

In 2011



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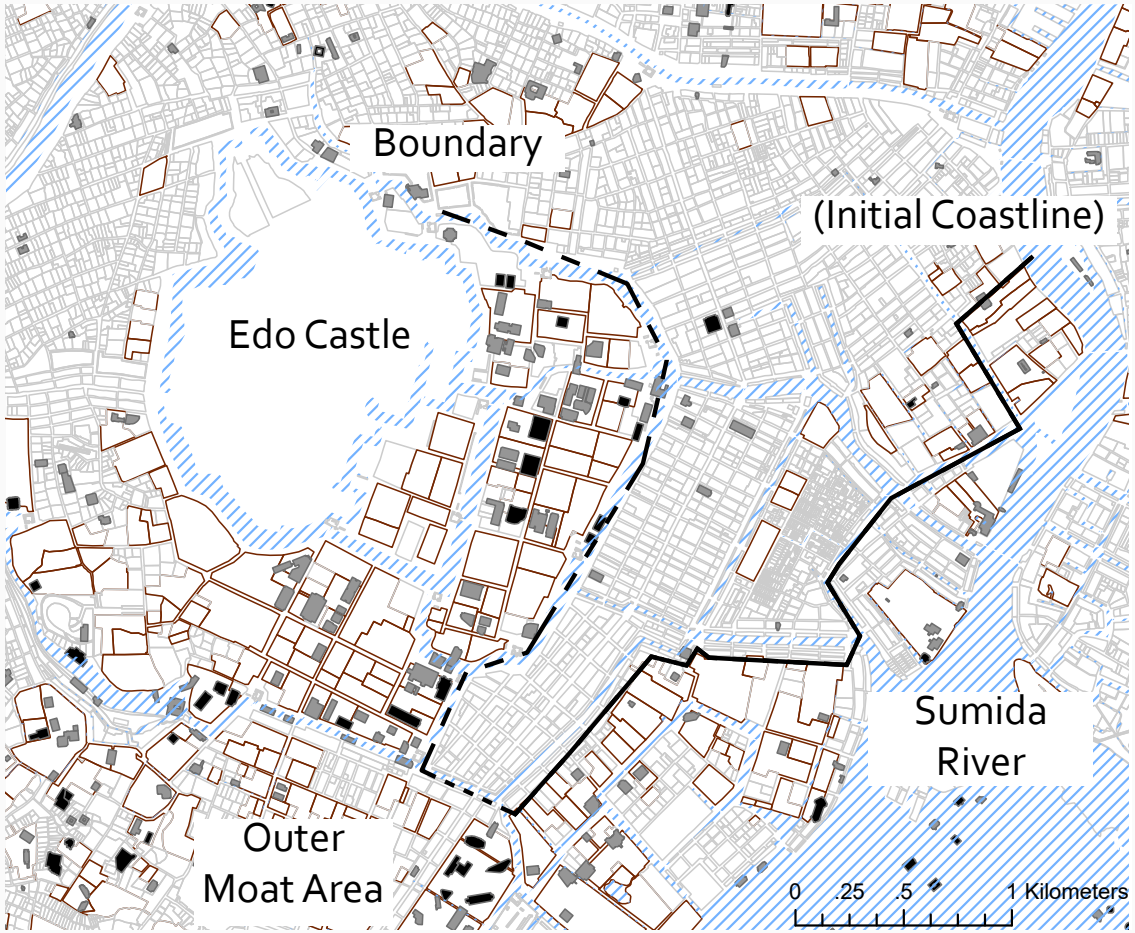

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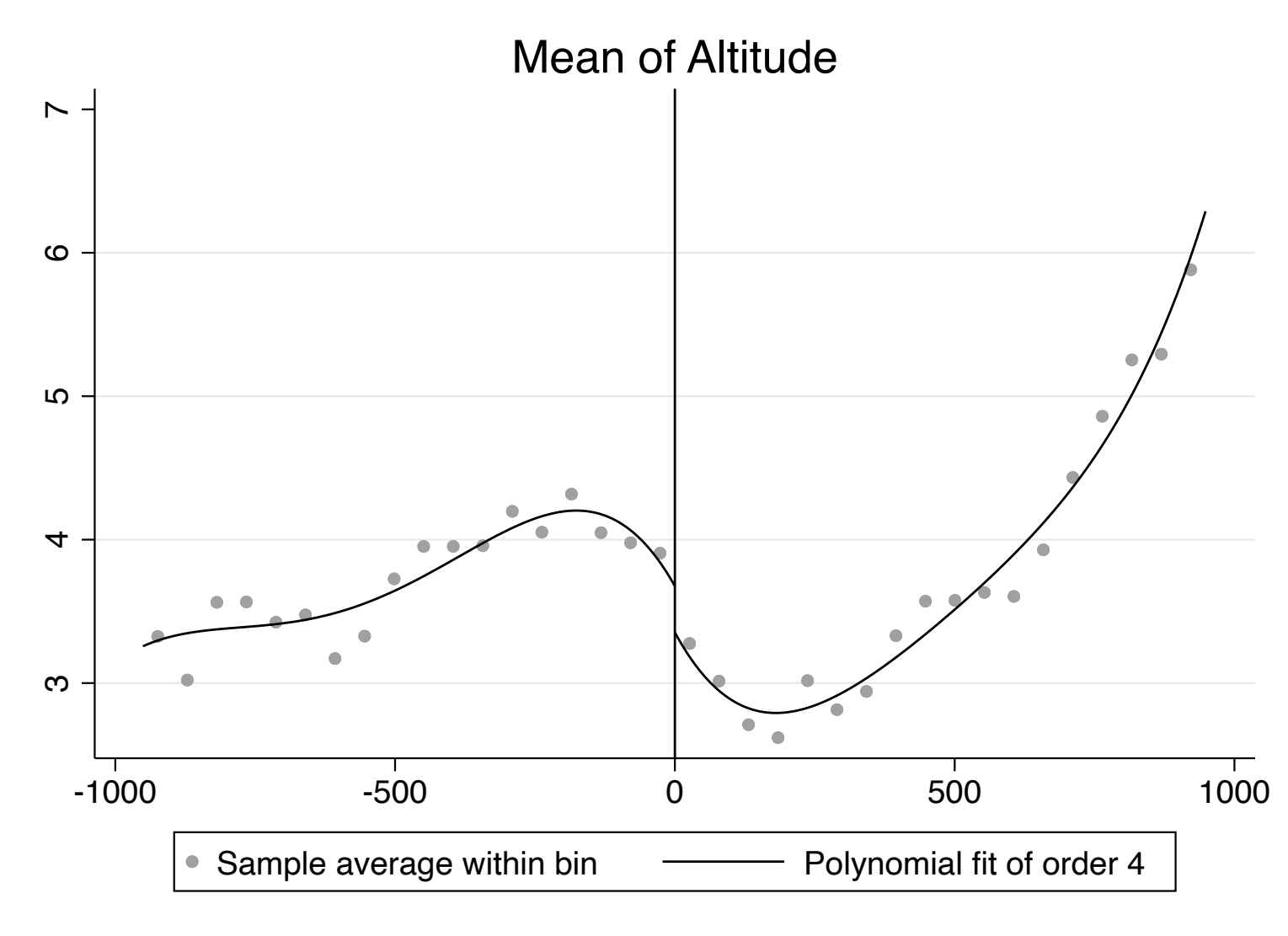
RD results (Balancing Test)

go back



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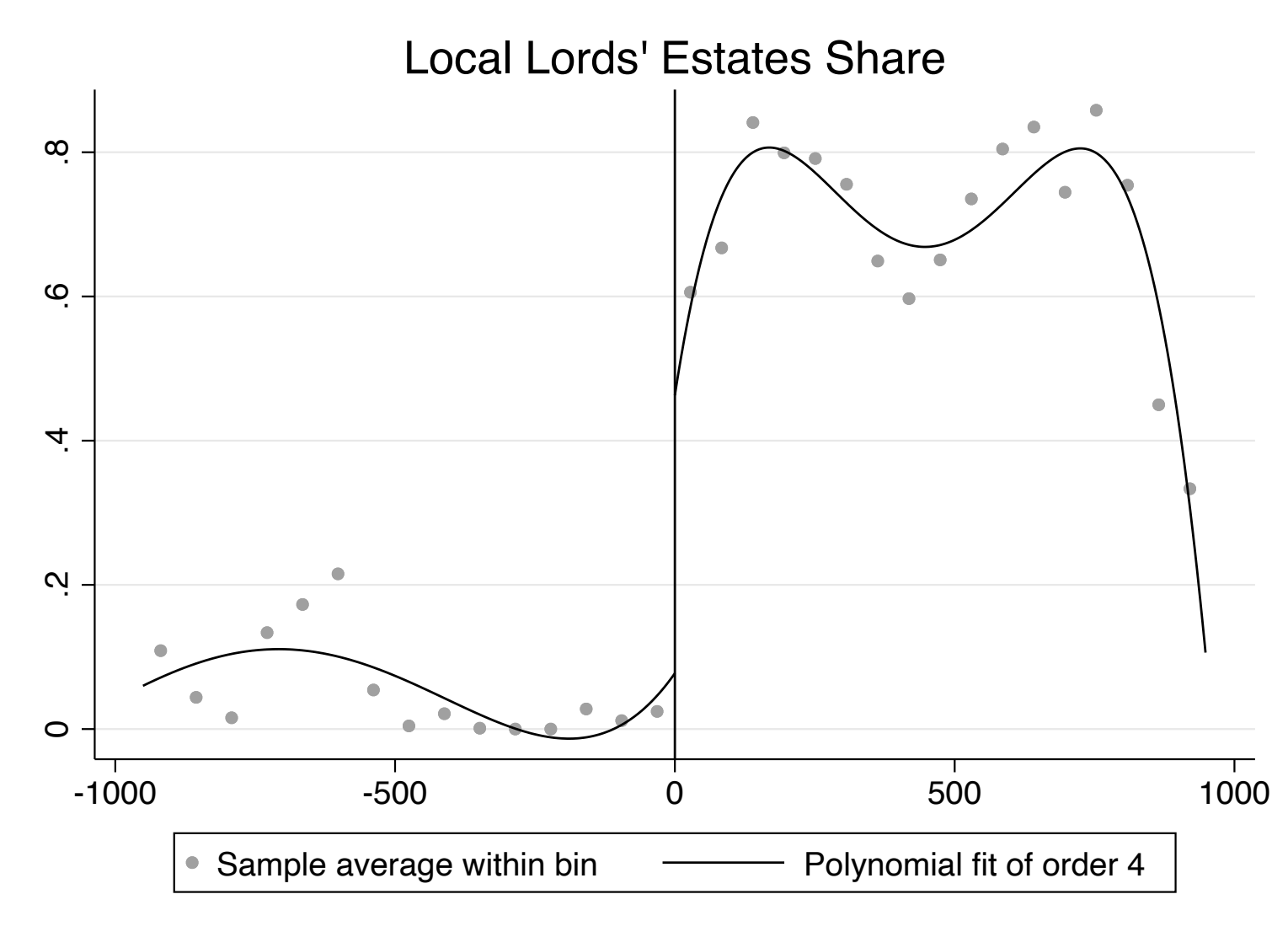
Local Lords' Estates Share
0
.2
.4
.6
.8
-1000
-500
0
500
1000
Sample average within bin
Polynomial fit of order 4

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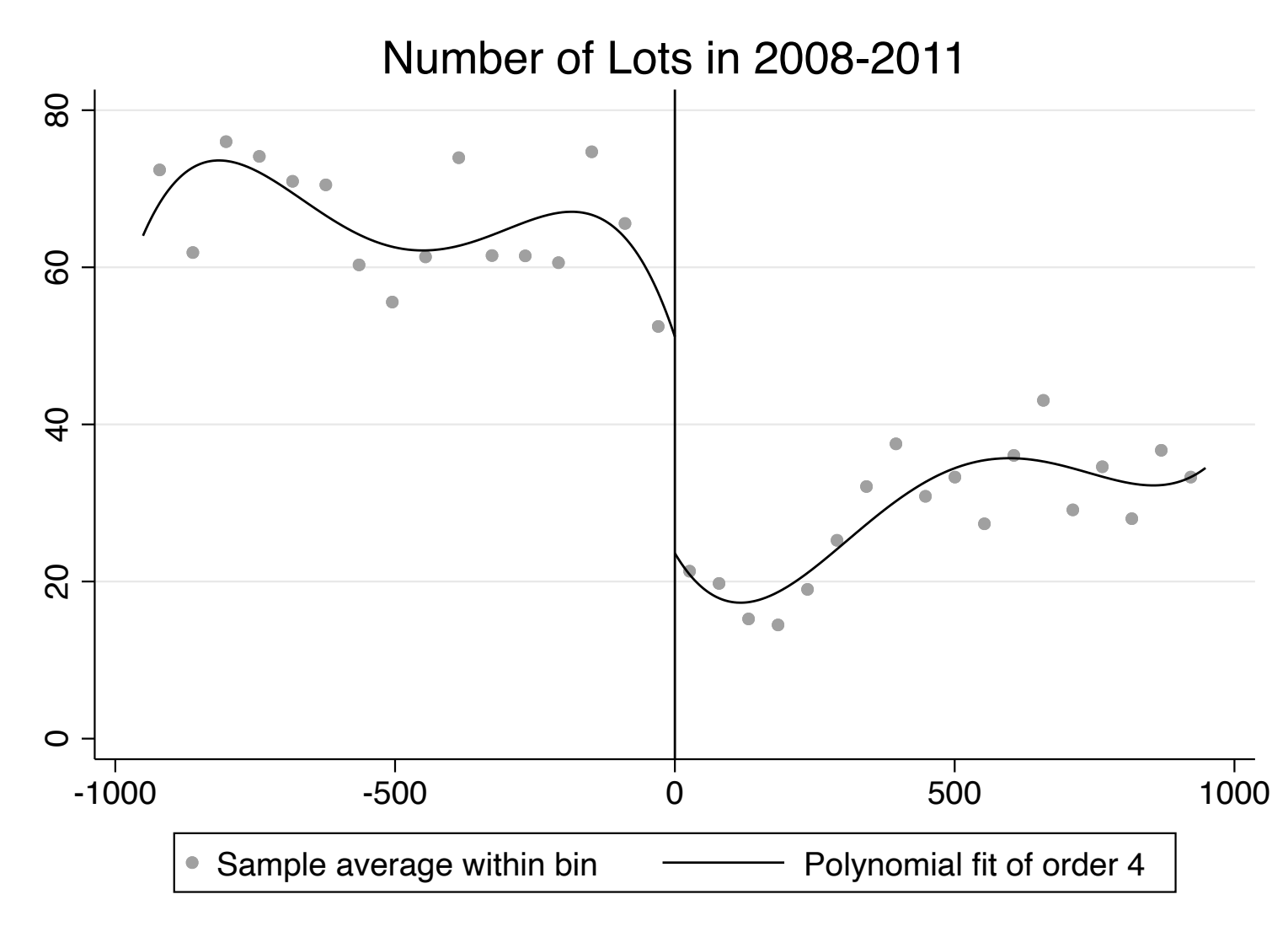
Number of Lots in 2008-2011
0
20
40
60
80
-1000
-500
0
500
1000
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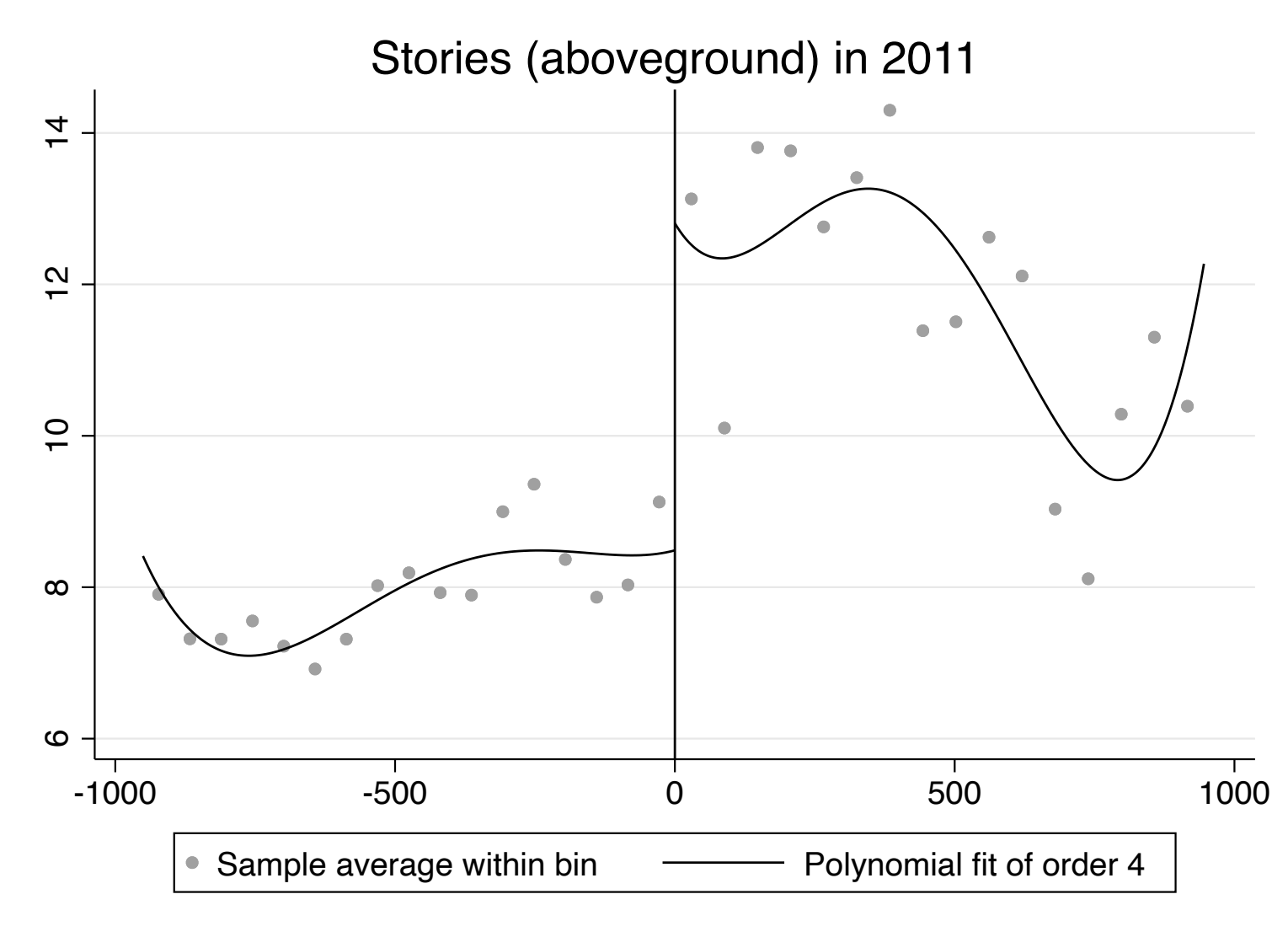
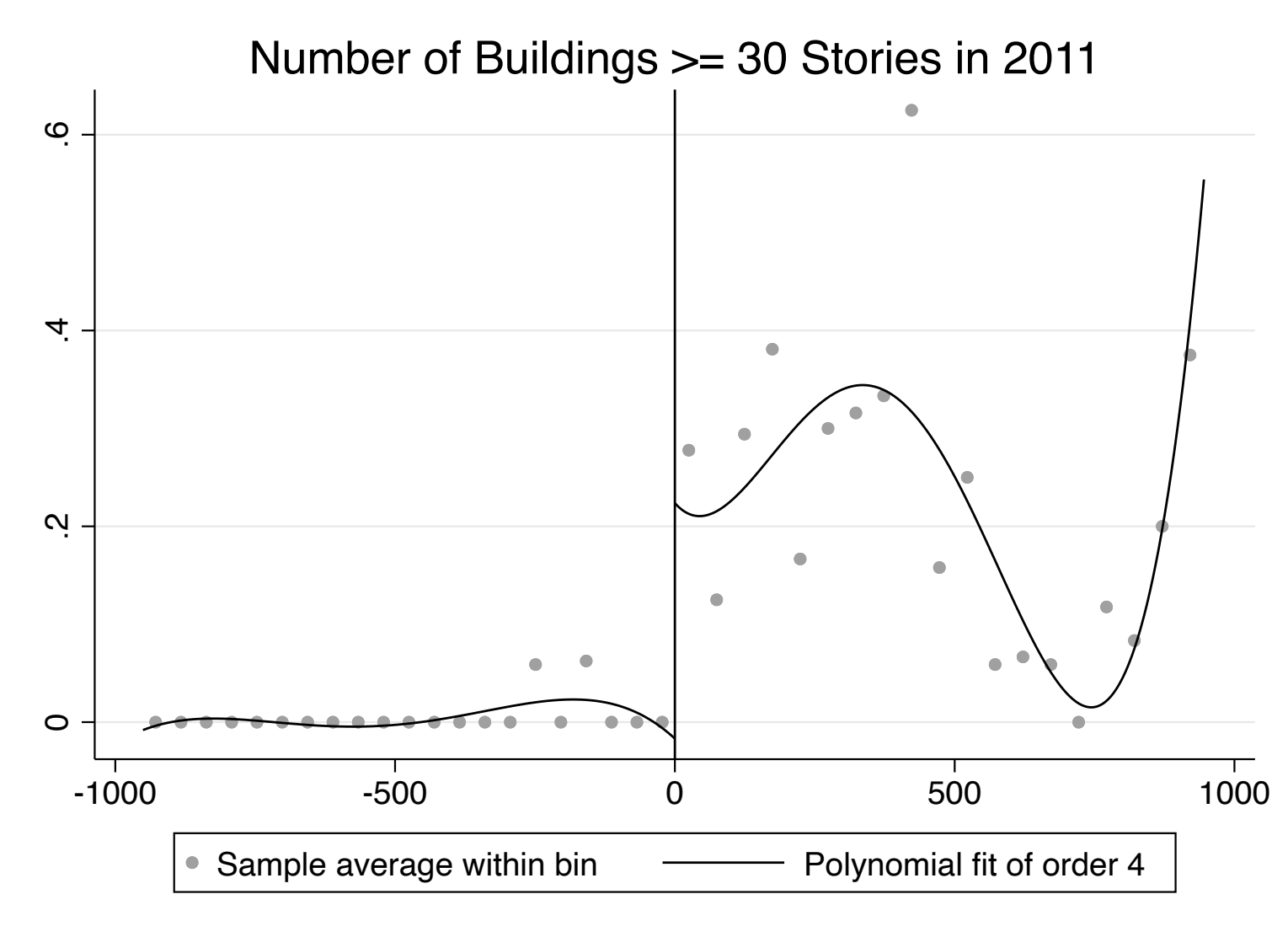
Polynomial fit of order 4

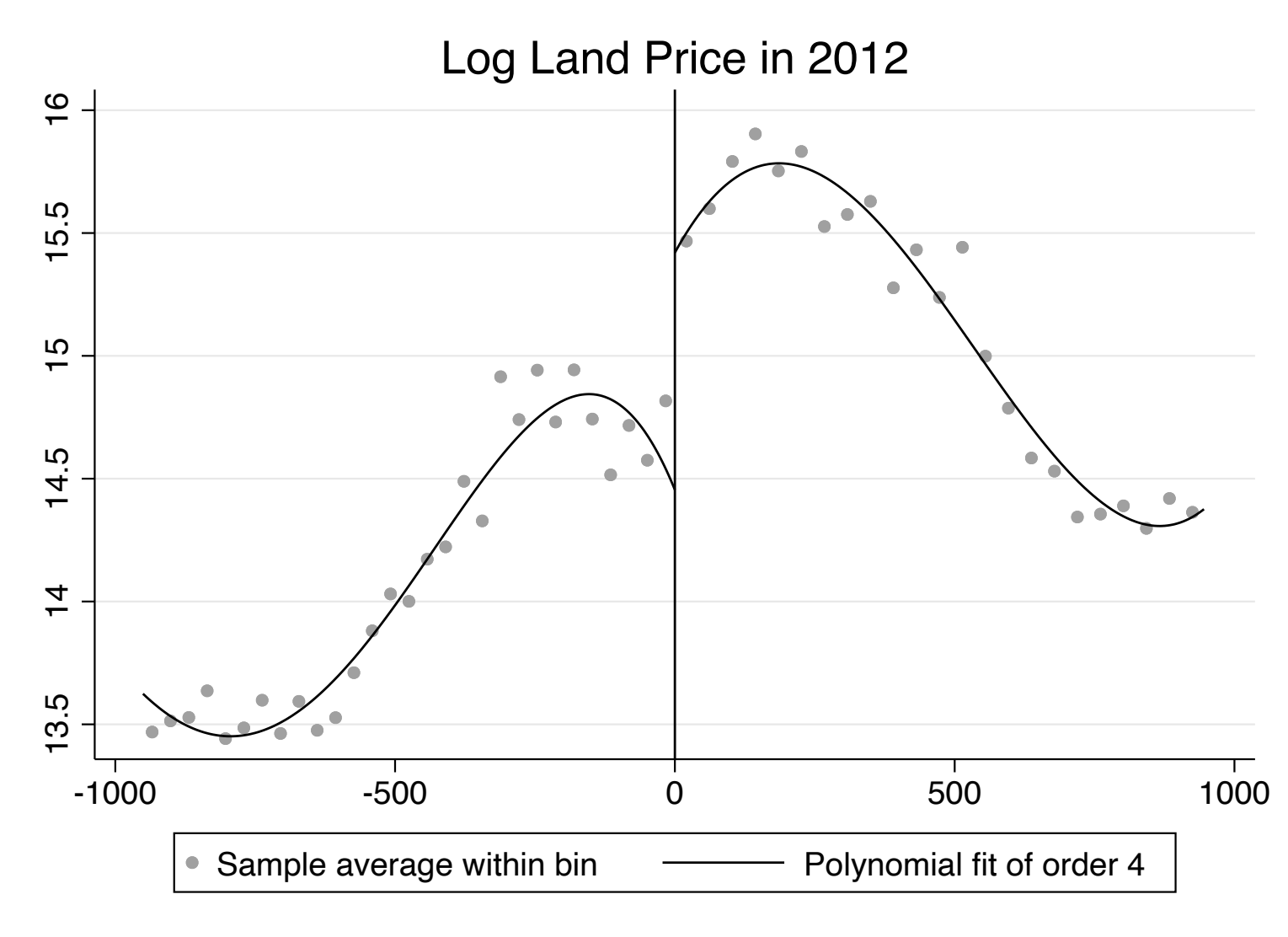
RD results


Stories (aboveground) in 2011
14
12
10
8
6
-1000
-500
0
500
1000
Sample average within bin
Polynomial fit of order 4

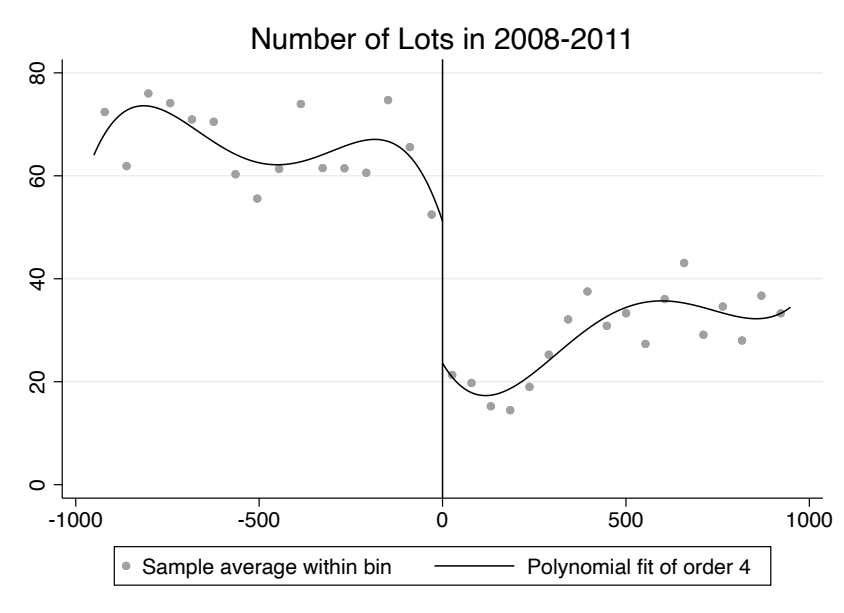
RD results

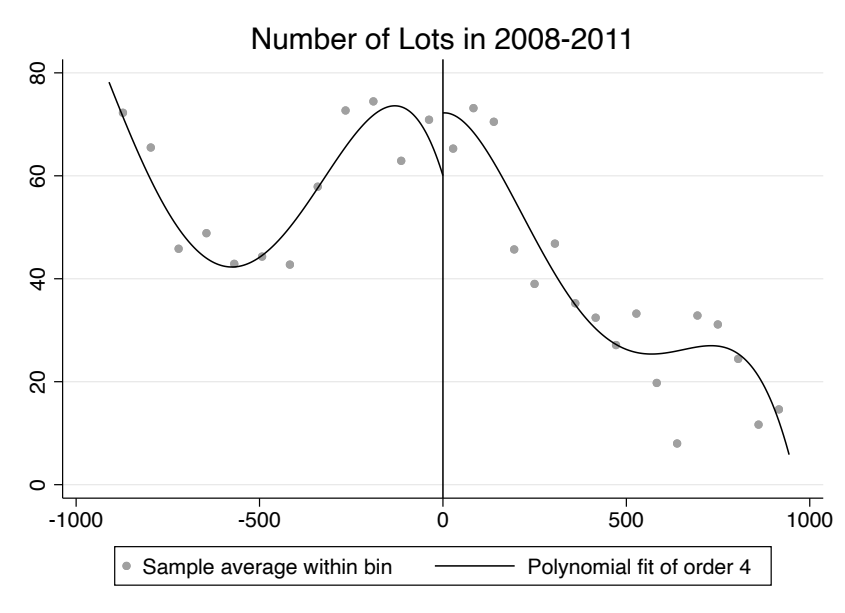

Number of Buildings >= 30 Stories in 2011
0
.2
.4
.6
-1000
-500
0
500
1000
Sample average within bin
Polynomial fit of order 4

RD results


Log Land Price in 2012
16
15.5
15
14.5
14
13.5
-1000
-500
0
500
1000
Sample average within bin
Polynomial fit of order 4

Core vs Non-core





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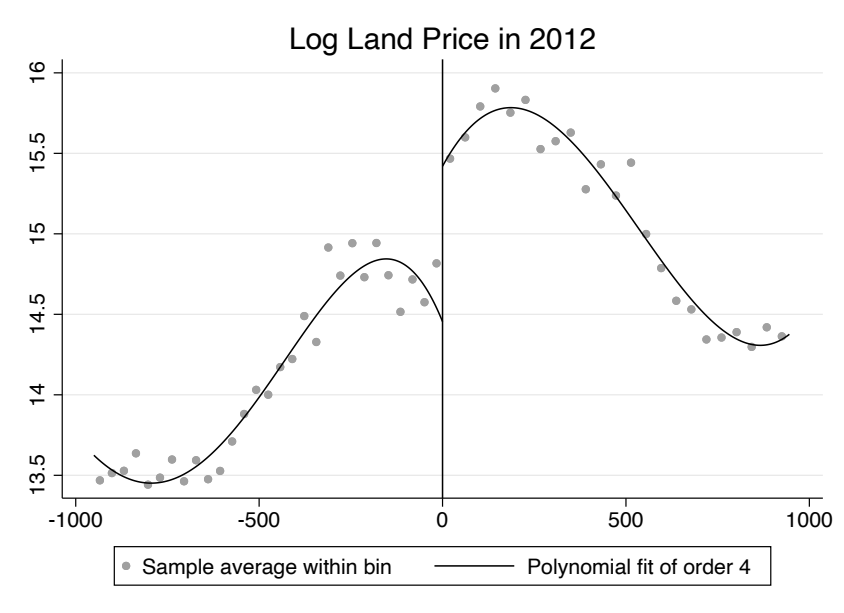
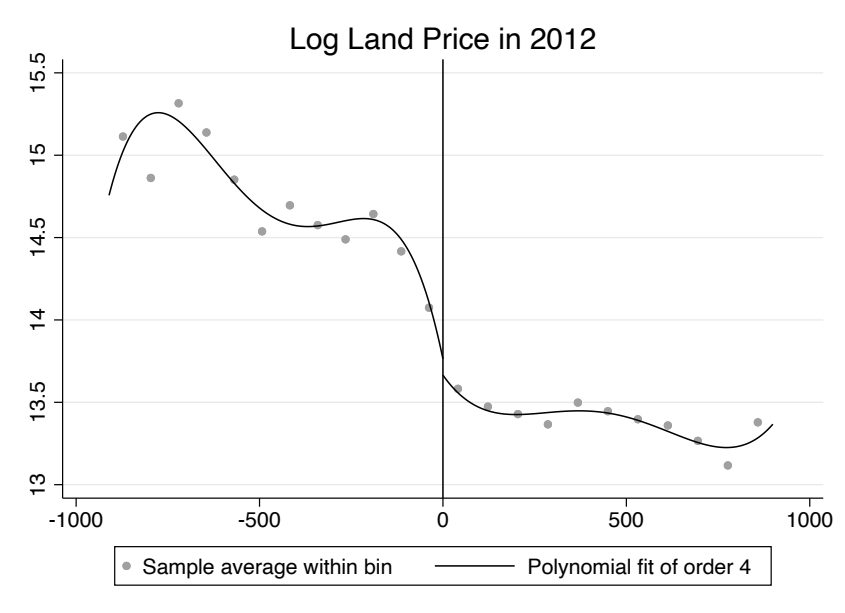
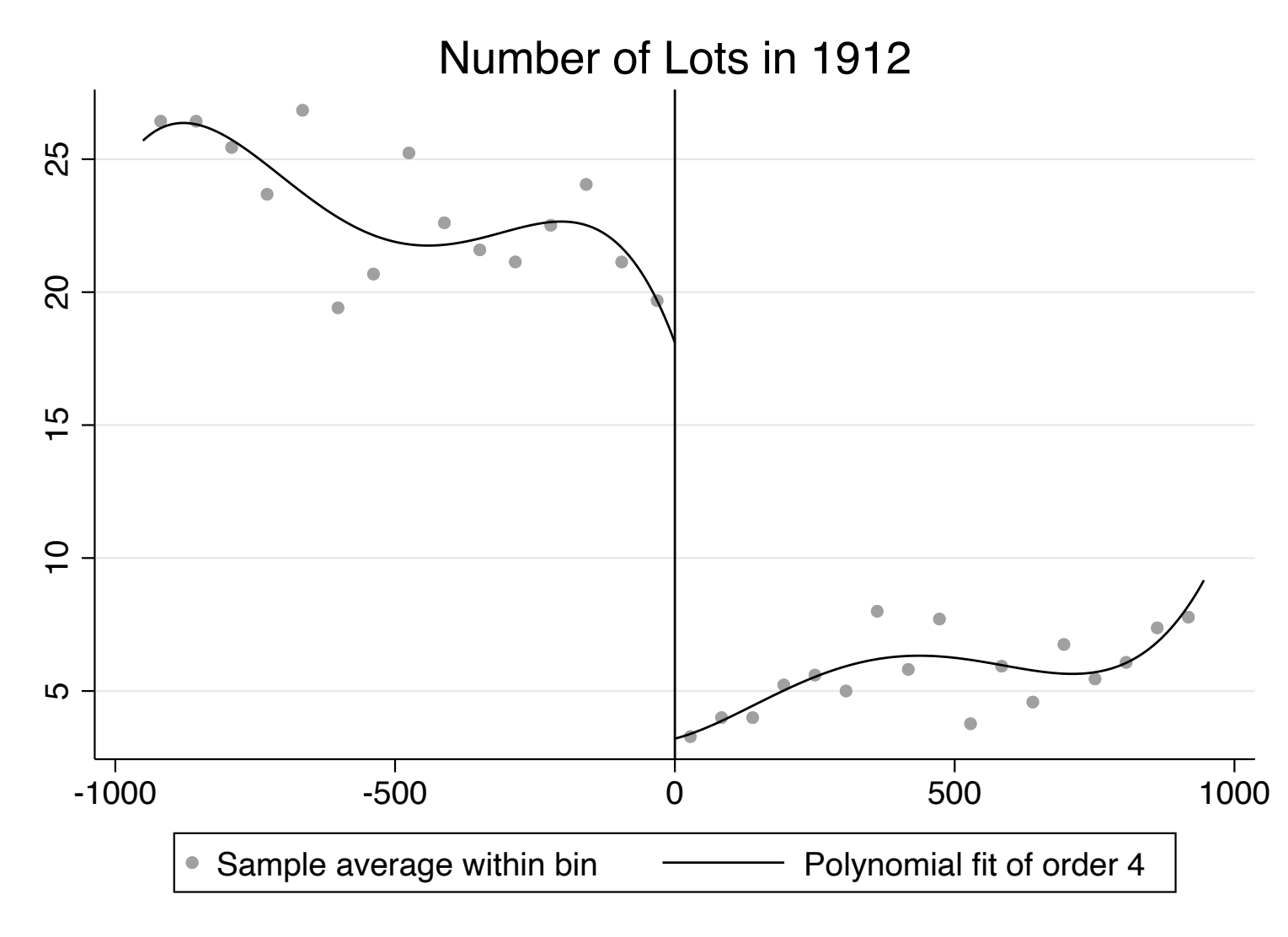
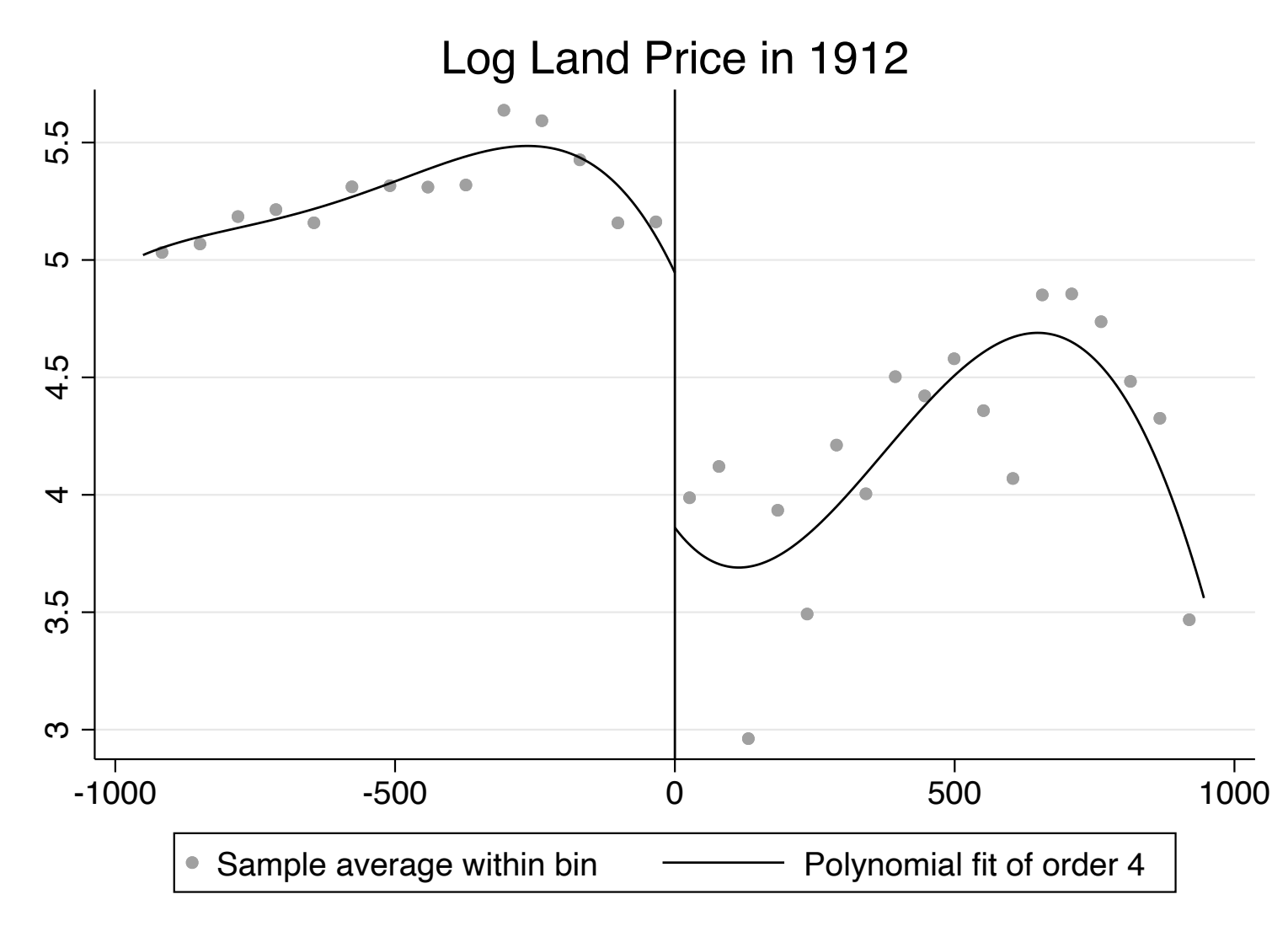




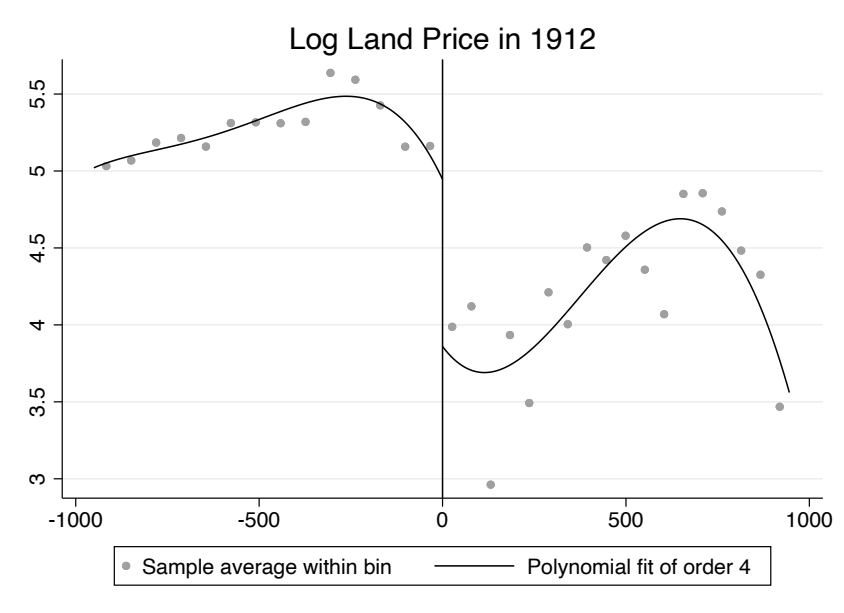
Before the age of skyscraper: Lots were larger

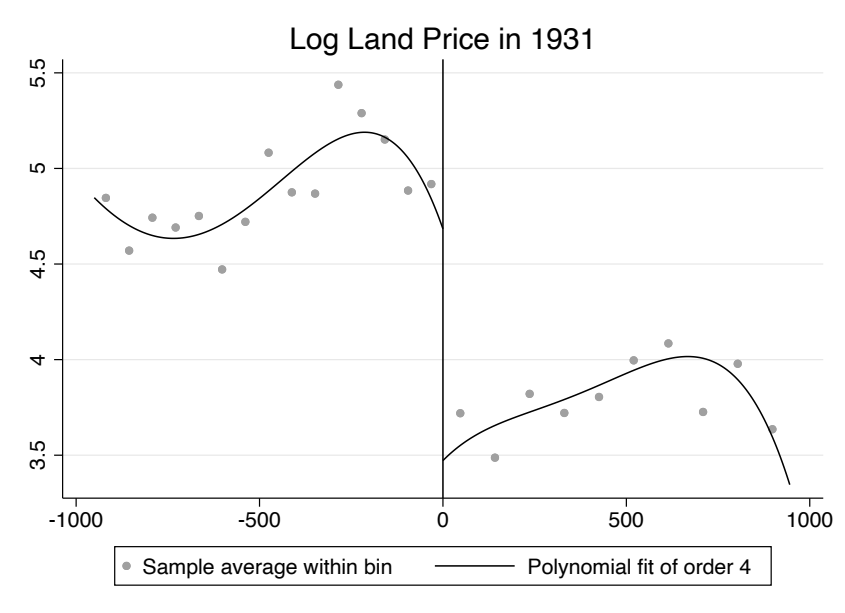


But land price was lower



Reverse of fortune





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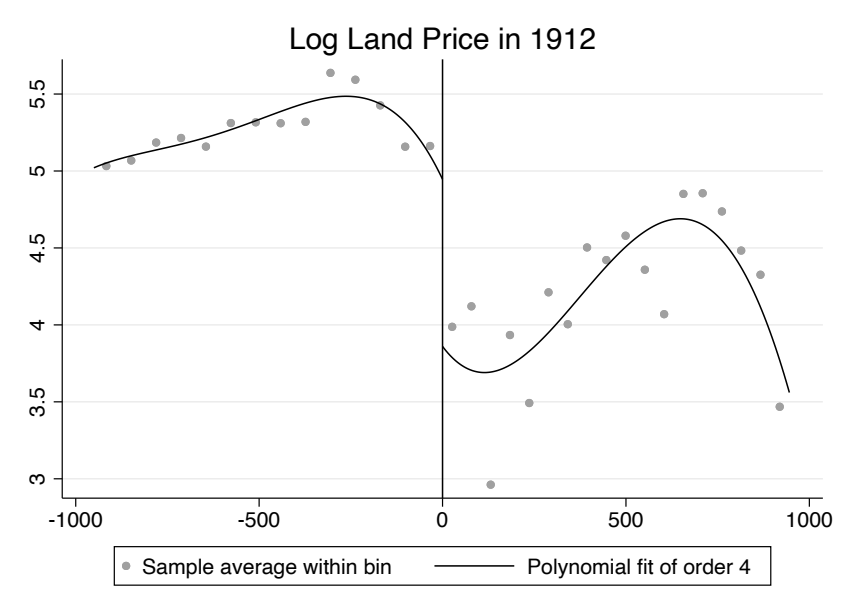

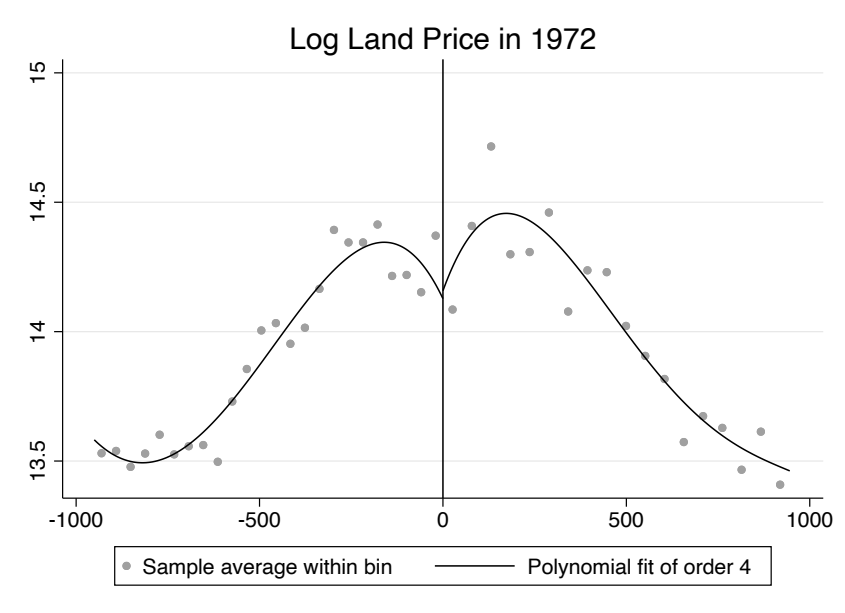

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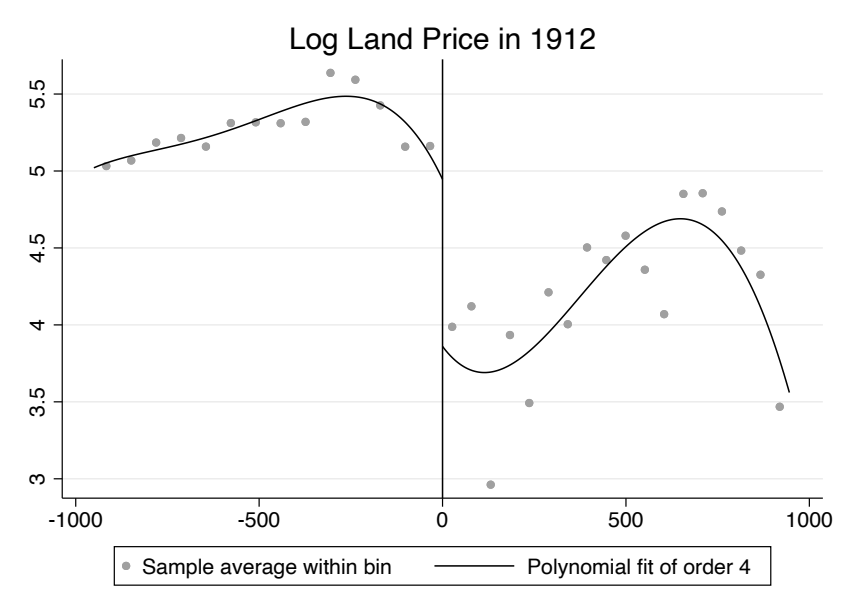

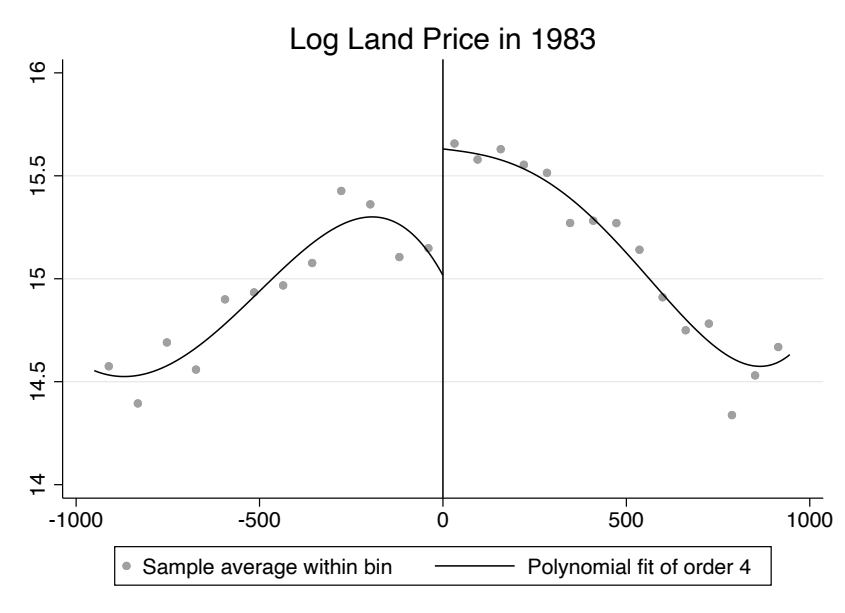

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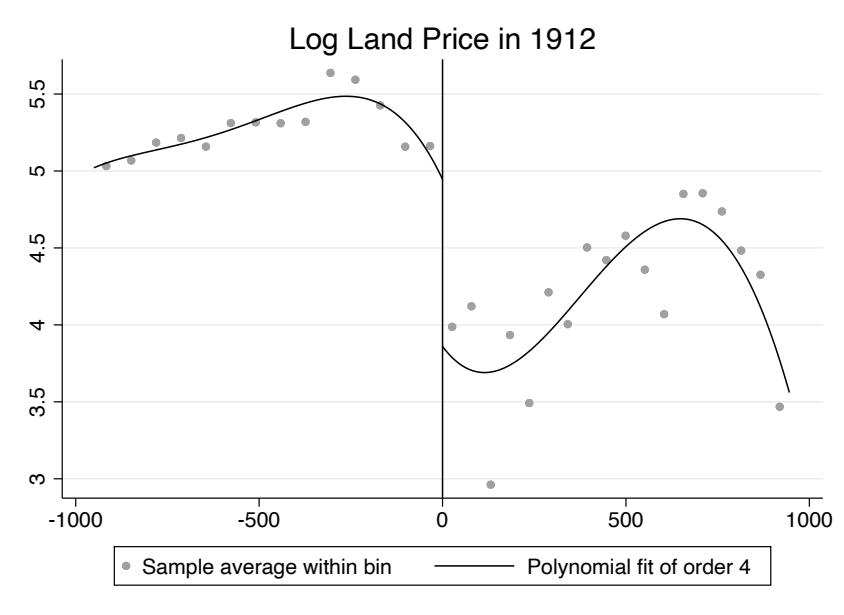

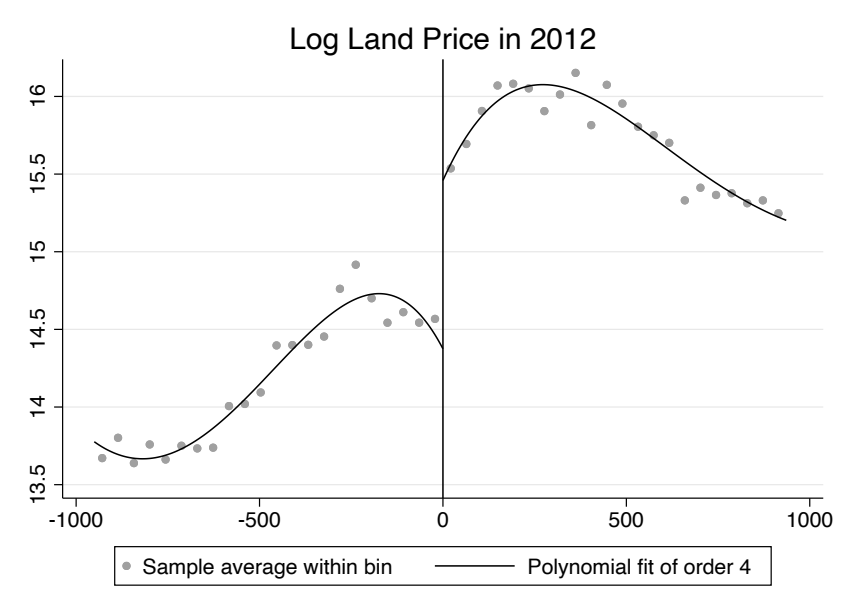

Summary so far

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- Mechanism
  - Lot size persistence only in the core area where assembly frictions are more prevalent
  - Before 1945: lots size was persistent, but had negative effect on land price (split cost)
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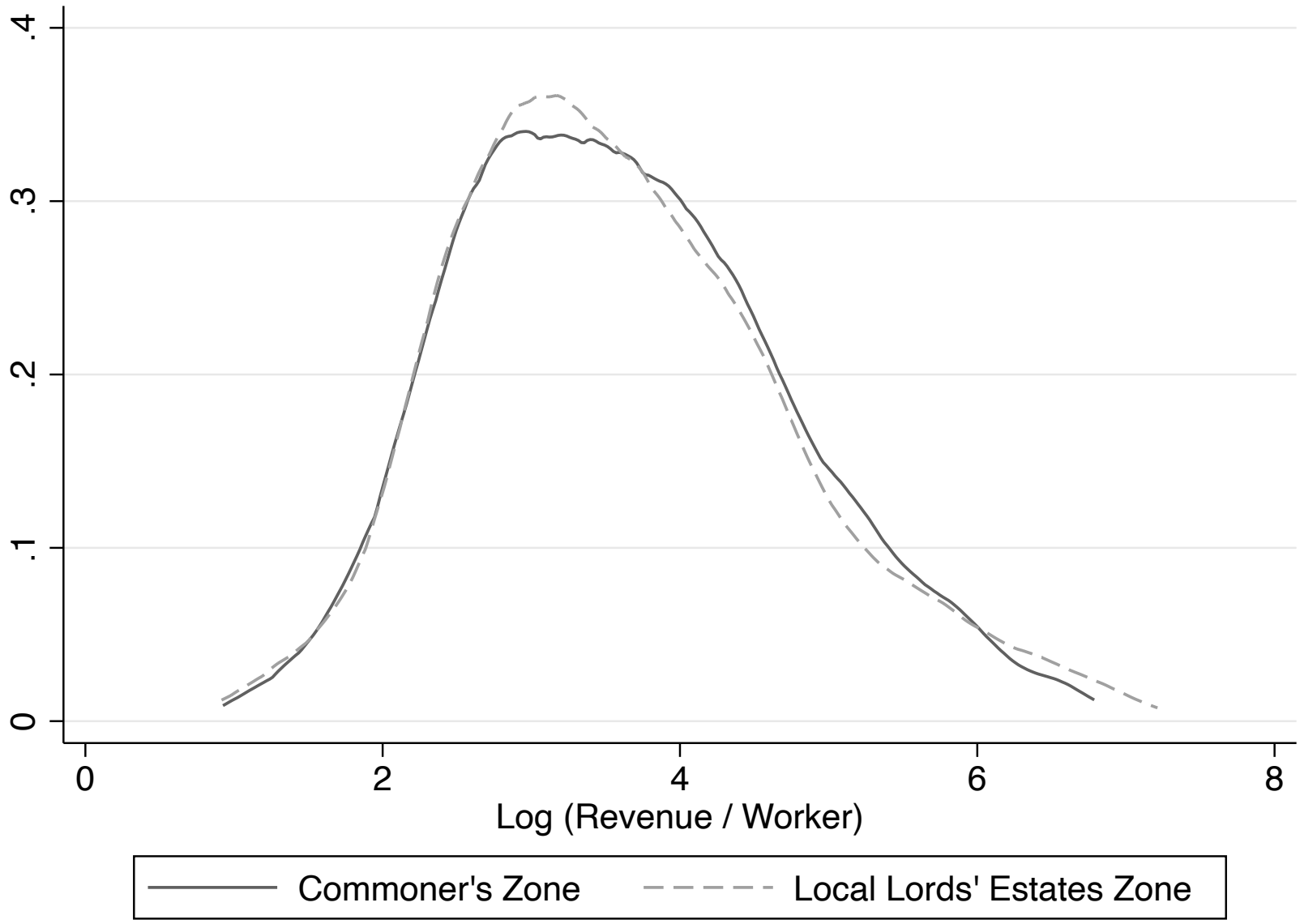
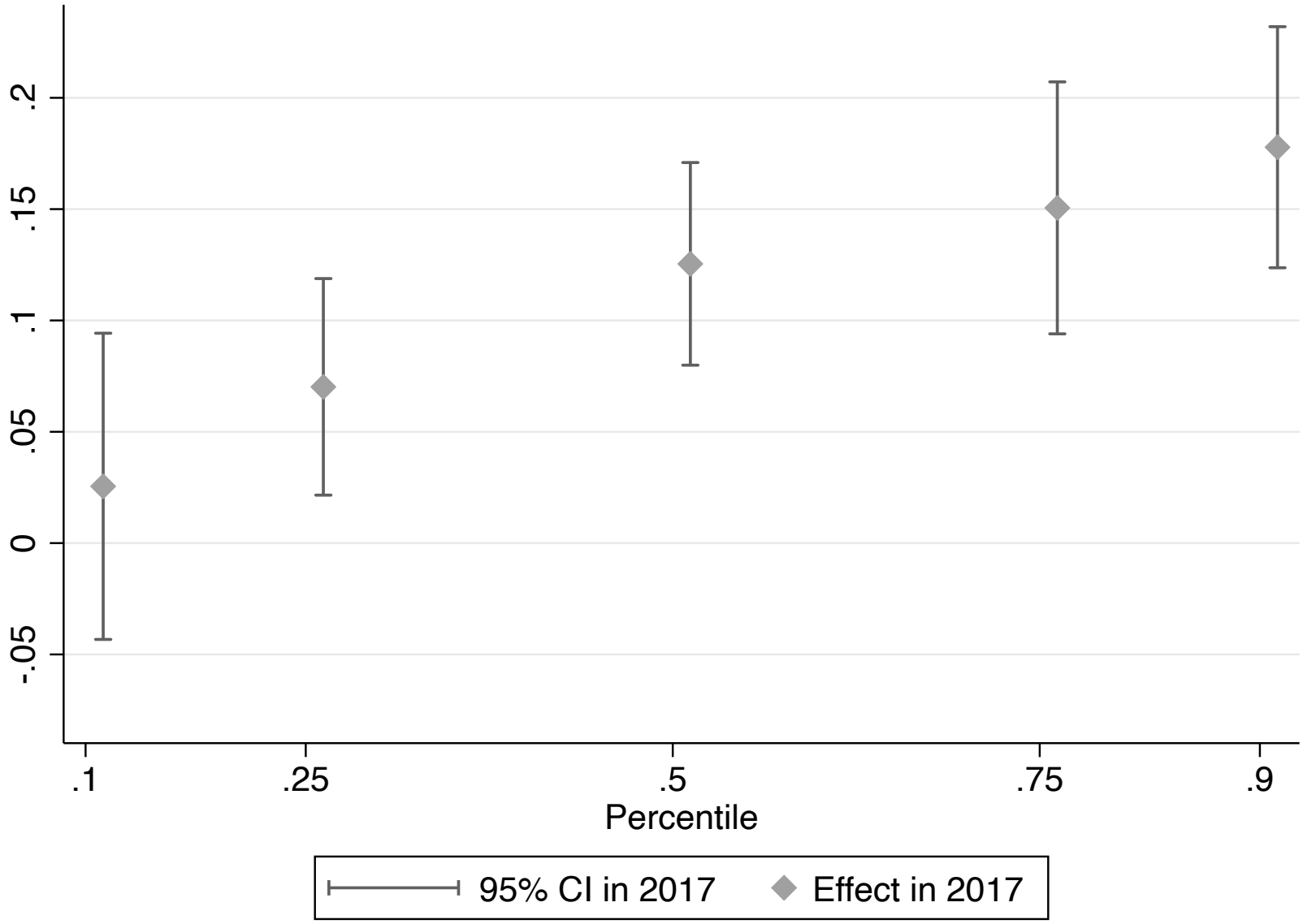
Firm-level micro data to investigate agglomeration benefits

- TFP will increase in two ways (Combes et al., 2012).
  - Firm selection (competition -> less productive firms will exit)
    - cutoff in the lower tail
  - Productivity gain by agglomeration (knowledge spillover, thicker labor markets, etc)
    - shift to the right and/or thicker upper tail
- We use firm-level data collected by a major Japanese credit research company (Teikoku Databank).
  - Cover the most of the Japanese firms
  - Revenue per worker (proxy of TFP)
  - Location of HQ

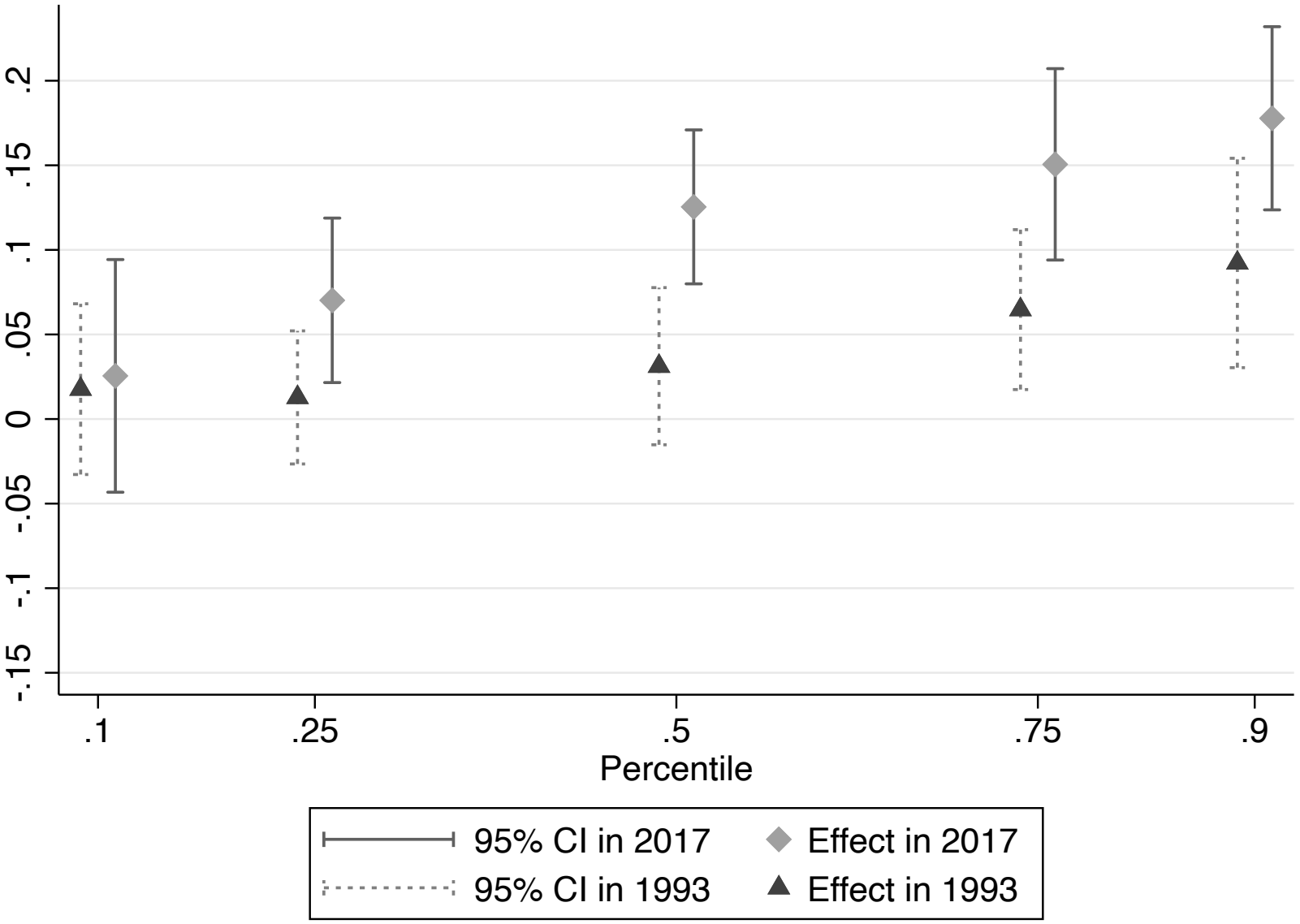
The upper tail is thicker and the lower tail does not show clear cutoff



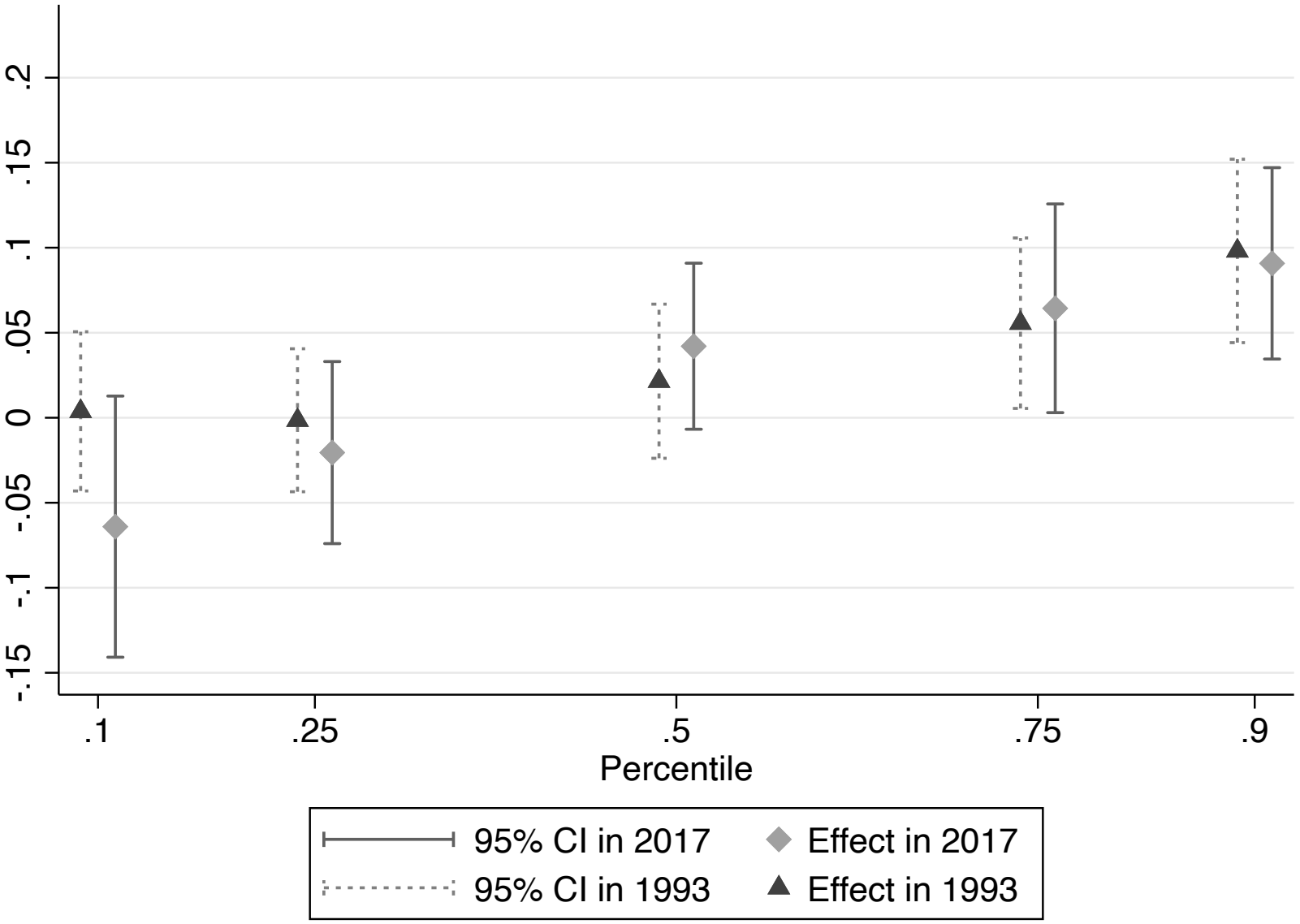
Larger impacts in the upper tail using 2017



Impacts are smaller in 1993 when buildings were shorter



Impacts becomes similar when controlling for stories



Robustness Checks

- Main results: Local loads estates → Larger lot size → Skyscrapers → Higher land price
  - Public infrastructure, not skyscrapers? → Table A.11 and A.12 in the paper
  - Block size, not lot size? → Table A.13 and A.14
  - Initial land price, not lot size? → Table A.15 and A.16
  - Coefficient stability analysis → Table A.5 and A.7
- Construction technology and office economy after WWII → Larger lots are more valued
  - Destruction by bombing in WWII? (This might affect results about inside vs outside the core area as well) → Table A.16–A.19.
  - Transform of military land use to non-military land use? → Table A.20 and A.21
  - Loss of their political privilege & tax base increase? → Table A.22 and Table A.23

Summary

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Holdout seems a common problem for big cities

RD results

	(1)	(2)	(3)
Panel I: Local Lords' Estates Share (N: 351)			
Local Lords' Estates Zone	0.542***	0.538***	0.468***
	(0.0803)	(0.0755)	(0.0822)
Panel A: Number of Lots in 1872 (N: 350)			
Local Lords' Estates Zone	-12.14***	-11.97***	-10.79***
	(1.896)	(1.777)	(2.059)
Panel B: Number of Lots in 2008-2011 (N: 352)			
Local Lords' Estates Zone	-23.74***	-24.29***	-22.22***
	(7.128)	(5.781)	(6.297)
Panel C: Number of Buildings in 2011 (N: 351)			
Local Lords' Estates Zone	-10.06**	-11.16***	-10.60***
	(4.446)	(3.866)	(3.656)
Panel D: Stories (aboveground) in 2011 (N: 351)			
Local Lords' Estates Zone	2.159***	2.317***	2.020**
	(0.746)	(0.715)	(0.873)
Panel E: Number of Buildings >= 30 Stories in 2011 (N: 351)			
Local Lords' Estates Zone	0.114**	0.126**	0.124***
	(0.0452)	(0.0512)	(0.0469)
Panel F: Log Land Price in 2012 (N: 341)			
Local Lords' Estates Zone	0.179	0.443*	0.343*
	(0.333)	(0.244)	(0.202)
Distance from the Center (Castle)	No	Yes	Yes
West of the Yamanote line	No	Yes	Yes
Mean of Altitude	No	No	Yes
S.D. of Altitude	No	No	Yes
Earthquake Risk	No	No	Yes

Standard errors allowing within-300 m correlation are in parentheses. $^{+}$ p<0.10, * p<0.05, ** p<0.01, *** p<0.001. N shows the maximum sample size. Sample size varies across the outcome variables.

FAR / Block Size / Road Width (Local Randomization)

	(1)	(2)	(3)	(4)	(5)
Panel I: Local Lords' Estates					
Local Lords' Estates Zone	0.443***	0.389***	0.454***	0.420***	0.381***
	(0.0868)	(0.0848)	(0.0853)	(0.0828)	(0.0803)
Panel A: Number of Lots in 1872					
Local Lords' Estates Zone	-10.45***	-10.08***	-10.56***	-9.598***	-9.391***
	(2.081)	(1.914)	(2.116)	(2.006)	(1.956)
Panel B: Number of Lots in 2008-2011					
Local Lords' Estates Zone	-21.16***	-18.85***	-20.49***	-15.31***	-13.20**
	(6.481)	(5.886)	(6.435)	(5.766)	(5.284)
Panel C: Number of Buildings in 2011					
Local Lords' Estates Zone	-10.04***	-7.780**	-9.878**	-6.486**	-4.662
	(3.834)	(3.328)	(3.846)	(3.143)	(2.935)
Panel D: Stories (aboveground) in 2011					
Local Lords' Estates Zone	2.578***	2.302***	2.660***	2.169***	2.143***
	(0.872)	(0.757)	(0.848)	(0.746)	(0.653)
Panel E: Number of Buildings >= 30 Stories in 2011					
Local Lords' Estates Zone	0.129**	0.117**	0.124**	0.121**	0.106**
	(0.0538)	(0.0497)	(0.0527)	(0.0486)	(0.0446)
Panel F: Log Land Price in 2012					
Local Lords' Estates Zone	0.350	0.128	0.331	0.158	-0.0104
	(0.218)	(0.160)	(0.221)	(0.170)	(0.148)
Distance from the Center (Castle)	Yes	Yes	Yes	Yes	Yes
West of the Yamanote line	Yes	Yes	Yes	Yes	Yes
Mean of Altitude	Yes	Yes	Yes	Yes	Yes
S.D. of Altitude	Yes	Yes	Yes	Yes	Yes
Earthquake Risk	Yes	Yes	Yes	Yes	Yes
FAR Regulation	No	Yes	No	No	Yes
Block Size	No	No	Yes	No	Yes
Road Width	No	No	No	Yes	Yes

Standard errors are in parentheses. We allow a within-300 m correlation in error terms. $^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. *Block Size* is the average area of blocks (land surrounded by roads). *Road Width* consists of the average road width and the proportion of roads more than 12 m wide.

Controlling for Public Infrastructure (Local Randomization)

	(1)	(2)	(3)	(4)	(5)
Panel I: Local Lords' Estates Share					
Local Lords' Estates Zone	0.468***	0.432***	0.472***	0.466***	0.430***
	(0.0822)	(0.0786)	(0.0807)	(0.0777)	(0.0744)
Panel A: Number of Lots in 1872					
Local Lords' Estates Zone	-10.79***	-9.935***	-10.76***	-10.69***	-9.602***
	(2.059)	(2.042)	(2.040)	(2.164)	(2.099)
Panel B: Number of Lots in 2008-2011					
Local Lords' Estates Zone	-22.22***	-16.16***	-22.03***	-22.47***	-15.79***
	(6.297)	(5.523)	(6.256)	(5.648)	(5.021)
Panel C: Number of Buildings in 2011					
Local Lords' Estates Zone	-10.60***	-7.362**	-10.52***	-11.10***	-7.557***
	(3.656)	(3.154)	(3.622)	(3.246)	(2.824)
Panel D: Stories (aboveground) in 2011					
Local Lords' Estates Zone	2.020**	1.897**	2.048**	1.975**	1.796**
	(0.873)	(0.766)	(0.890)	(0.851)	(0.727)
Panel E: Number of Buildings >= 30 Stories in 2011					
Local Lords' Estates Zone	0.124***	0.120***	0.126***	0.117**	0.112**
	(0.0469)	(0.0462)	(0.0473)	(0.0478)	(0.0454)
Panel F: Log Land Price in 2012					
Local Lords' Estates Zone	0.343*	0.173	0.354*	0.366*	0.199
	(0.202)	(0.168)	(0.201)	(0.193)	(0.166)
Panel G: Log Land Price in 2012					
Local Lords' Estates Zone (Core)	0.827***	0.544**	0.836***	0.699***	0.427**
	(0.228)	(0.212)	(0.233)	(0.215)	(0.194)
Local Lords' Estates Zone (Non-core)	-0.237	-0.227	-0.225	-0.0475	-0.0603
	(0.275)	(0.264)	(0.268)	(0.274)	(0.250)
Road Width	No	Yes	No	No	Yes
Hospital, University, and Parks	No	No	Yes	No	Yes
Distance to Nearest Station in 2018 and 1950	No	No	No	Yes	Yes
Distance from the Center (Castle)	Yes	Yes	Yes	Yes	Yes
West of the Yamanote line	Yes	Yes	Yes	Yes	Yes
Mean of Altitude	Yes	Yes	Yes	Yes	Yes
S.D. of Altitude	Yes	Yes	Yes	Yes	Yes
Earthquake Risk	Yes	Yes	Yes	Yes	Yes

Standard errors are in parentheses. We allow a within-300 m correlation in the error terms. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

U.S. Army Air Force bombing in WWII

Physical Capital Plays Little Role (Local Randomization)

	(1)	(2)	(3)	(4)
Panel I: Local Lords' Estates Share (N: 351)				
Local Lords' Estates Zone	0.512***	0.502***	0.443***	0.440***
	(0.0808)	(0.0846)	(0.0868)	(0.0882)
Panel A: Number of Lots in 1872 (N: 350)				
Local Lords' Estates Zone	-11.61***	-10.02***	-10.39***	-9.002***
	(1.808)	(1.611)	(2.080)	(1.812)
Panel B: Number of Lots in 2008-2011 (N: 352)				
Local Lords' Estates Zone	-23.32***	-21.49***	-21.16***	-19.72***
	(5.965)	(5.849)	(6.481)	(6.228)
Panel C: Number of Buildings in 2011 (N: 351)				
Local Lords' Estates Zone	-10.73***	-9.881***	-10.04***	-9.304***
	(4.087)	(3.530)	(3.834)	(3.367)
Panel D: Stories (aboveground) in 2011 (N: 351)				
Local Lords' Estates Zone	2.820***	2.399***	2.578***	2.285***
	(0.751)	(0.669)	(0.872)	(0.823)
Panel E: Number of Buildings >= 30 Stories in 2011 (N: 351)				
Local Lords' Estates Zone	0.127**	0.100**	0.129**	0.110**
	(0.0578)	(0.0465)	(0.0538)	(0.0458)
Panel F: Log Land Price in 2012 (N: 341)				
Local Lords' Estates Zone	0.445*	0.405*	0.350	0.342
	(0.265)	(0.244)	(0.218)	(0.221)
WWII Destruction	No	Yes	No	Yes
Distance from the Center (Castle)	No	No	Yes	Yes
West of the Yamanote line	No	No	Yes	Yes
Mean of Altitude	No	No	Yes	Yes
S.D. of Altitude	No	No	Yes	Yes
Earthquake Risk	No	No	Yes	Yes

Standard errors are in parentheses. We allow a within-300 m correlation in error terms. $^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Controlling for Block Size or FAR (OLS)

	(1)	(2)	(3)
Panel I: Local Lords' Estates Share			
Local Lords' Estates Zone	0.468***	0.478***	0.412***
	(0.0822)	(0.0811)	(0.0810)
Panel A: Number of Lots in 1872			
Local Lords' Estates Zone	-10.79***	-10.90***	-10.09***
	(2.059)	(2.083)	(2.053)
Panel B: Number of Lots in 2008-2011			
Local Lords' Estates Zone	-22.22***	-21.60***	-18.25***
	(6.297)	(6.234)	(6.333)
Panel C: Number of Buildings in 2011			
Local Lords' Estates Zone	-10.60***	-10.43***	-8.457**
	(3.656)	(3.645)	(3.488)
Panel D: Stories (aboveground) in 2011			
Local Lords' Estates Zone	2.020**	2.082**	2.019**
	(0.873)	(0.862)	(0.836)
Panel E: Number of Buildings >= 30 Stories in 2011			
Local Lords' Estates Zone	0.124***	0.120***	0.121**
	(0.0469)	(0.0456)	(0.0481)
Panel F: Log Land Price in 2012			
Local Lords' Estates Zone	0.343*	0.323	0.165
	(0.202)	(0.203)	(0.140)
Panel G: Log Land Price in 2012			
Local Lords' Estates Zone (Core)	0.827***	0.806***	0.454**
	(0.228)	(0.236)	(0.188)
Local Lords' Estates Zone (Non-core)	-0.237	-0.241	-0.153
	(0.275)	(0.278)	(0.181)
Block Size	No	Yes	No
FAR Regulation	No	No	Yes
Distance from the Center (Castle)	Yes	Yes	Yes
West of the Yamanote line	Yes	Yes	Yes
Mean of Altitude	Yes	Yes	Yes
S.D. of Altitude	Yes	Yes	Yes
Earthquake Risk	Yes	Yes	Yes

Standard errors are in parentheses. We allow a within-300 m correlation in the error terms. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

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