You Only Lend Twice: Corporate Borrowing and Land Values in Real Estate Cycles

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VMACS Junior Conference

Motivation

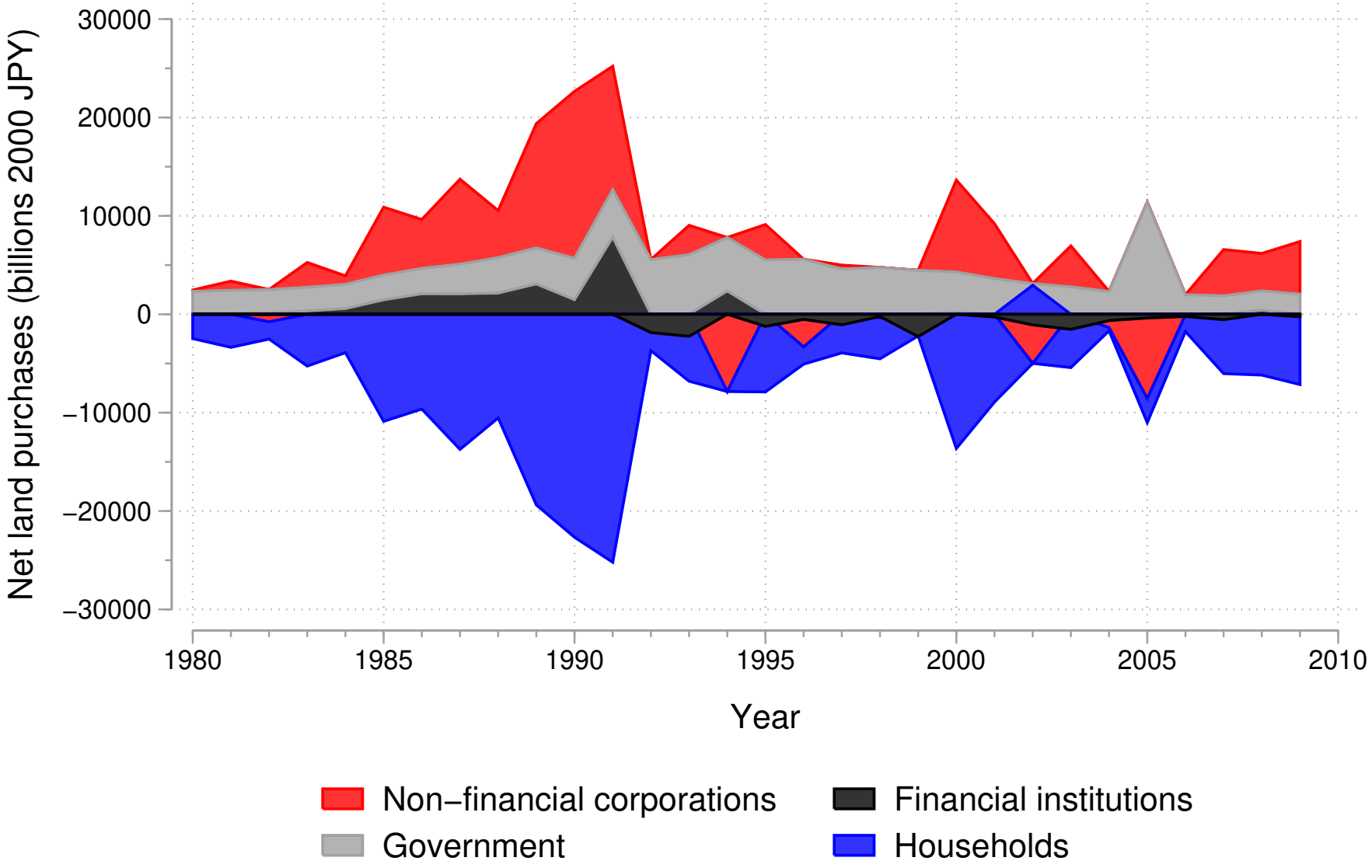
What are the effects of a shock to corporate real estate assets?

- Common focus: feedback/amplification of initial shock to asset prices
  - RE price $\uparrow \implies$ new debt $\uparrow \implies$ RE inv. $\uparrow \implies$ RE price $\uparrow$
- Existence of this loop depends on...
  1. Nature of borrowing constraints Facts Bankruptcy
  2. Reinvestment in RE collateral and/or other capital

This paper: natural experiment before 1980s Japanese Asset Price Cycle

- Land use deregulation generates boom/bust dynamics in market value of RE assets, borrowing, RE investment
- Spatial financial accelerator: variation in land use constraints + corporate borrowing limits $\implies$ large aggregate effects

Large corporate net RE purchases during booms

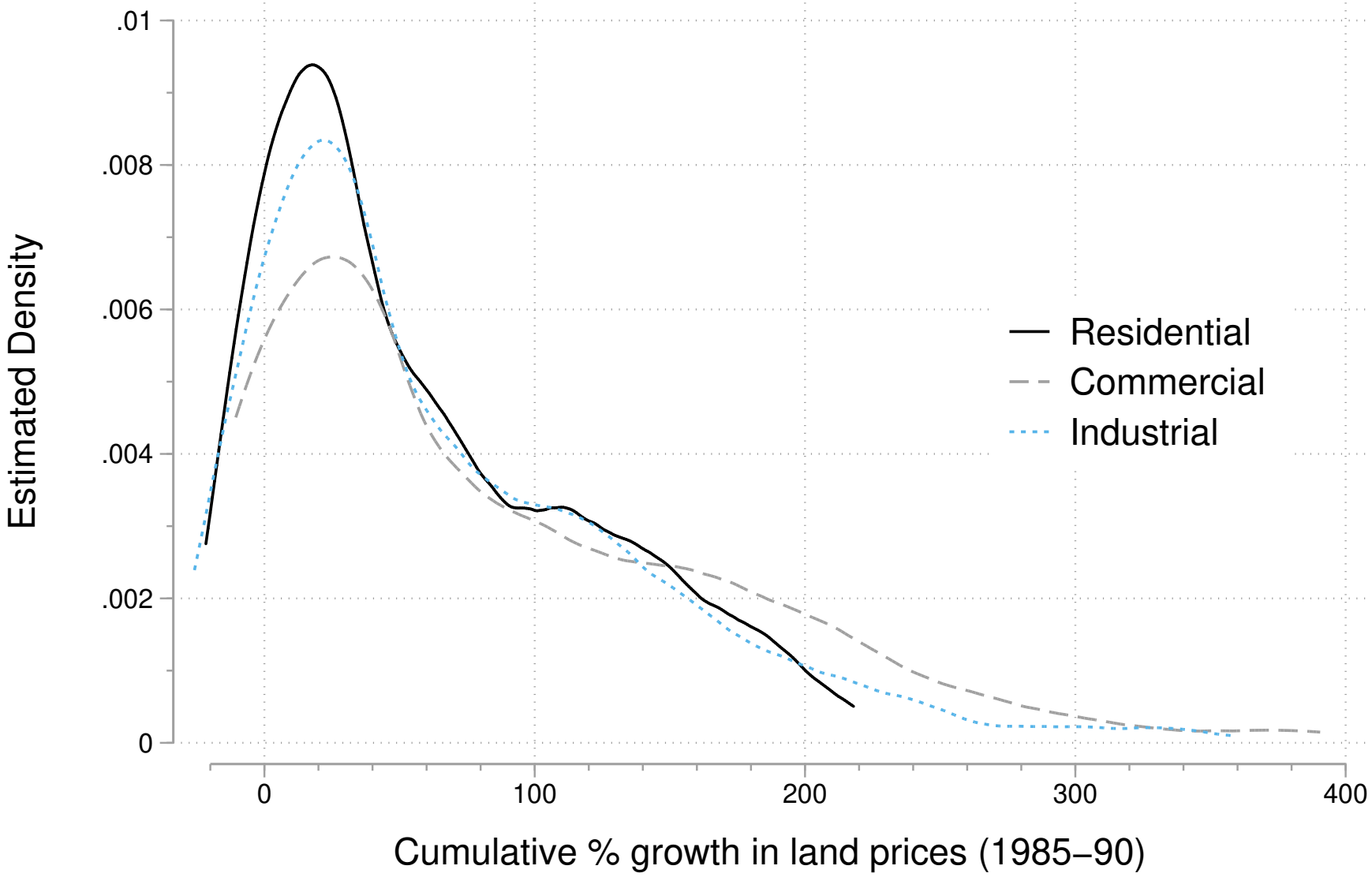


Empirical contributions

- To show this feedback loop, I construct a new dataset with...
  - 425 local price indices for commercial/industrial RE
  - Geocoded facility-level firm balance sheets
  - Matched bank-firm balance sheets
- Identify new shock to RE values based on land use deregulation
  - National reform with differential exposure to local markets
  - Prices $\uparrow$ more in areas where land use law was previously binding
  - Instruments specific to commercial/industrial RE markets
  - Exogeneity: variation originates from historical road networks

Literature Data Pricing

Heterogeneity in land price movement (1985-90)



By population

Policy background: land use deregulations in 1980s

- Isolate exogenous changes to building constraints by stacking two national-level reforms to land use code ("Urban Renaissance")

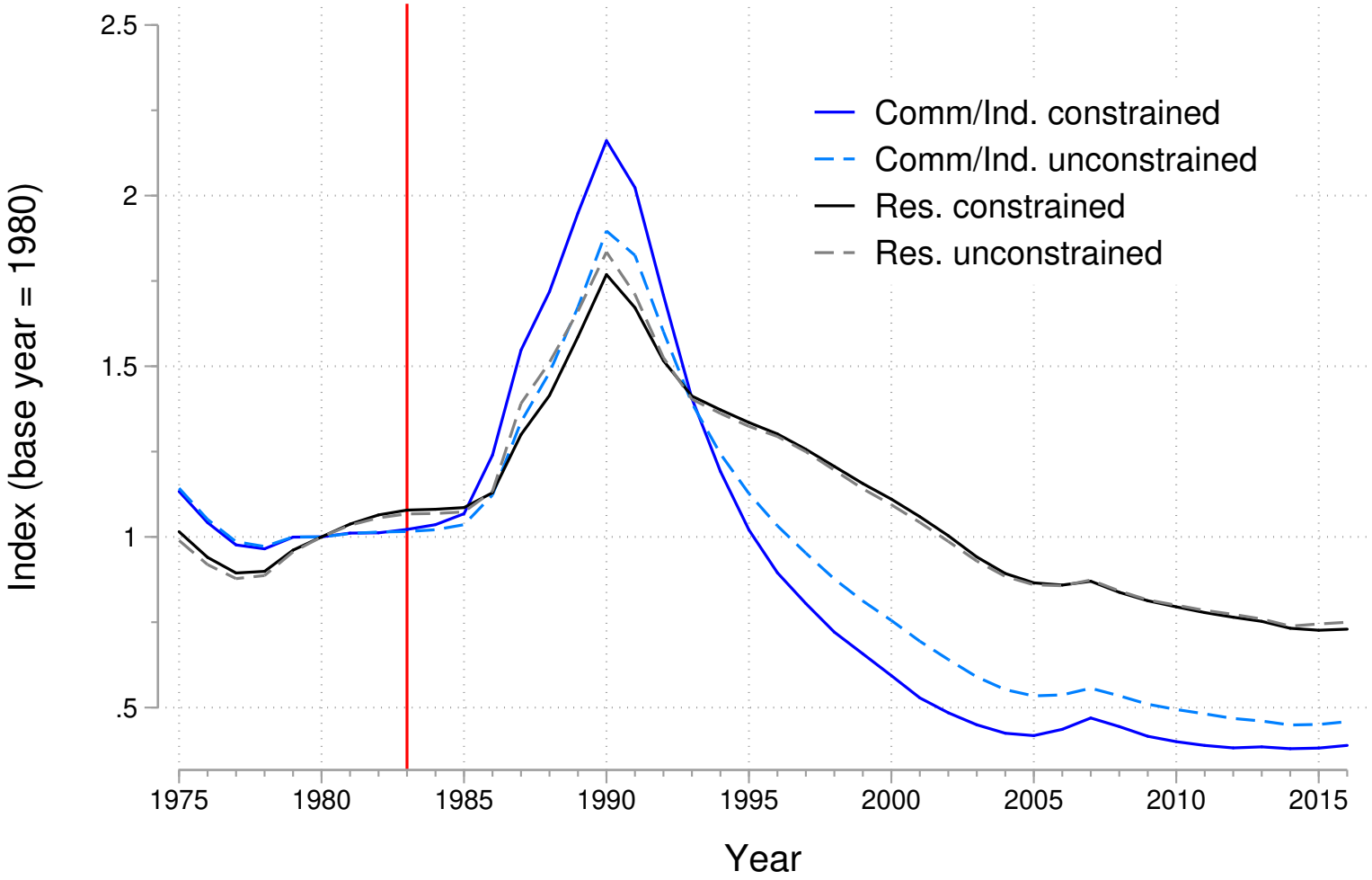
1. 1983 recommendation to Ministry of Construction
   - Increased floor-to-area ratio (FAR) allowances Example
2. 1987 reform of the Building Standards Law:
   - Increased FAR allowance for sites along wide streets
   - Relaxed slant plane restriction determining height limits

- Basic idea: height/area limits are inc. function of width of front-facing road $\implies$ small buildings on narrow roads

- Local govt. unable to pass land use ordinances prior to 1999

Policy details Shock details Construction

Shock to FAR limits specific to comm/ind RE



- For 1980-90, 30 p.p. higher growth for FAR-constrained plots in commercial areas (13 p.p. larger drop in 1990-00)

Empirical strategy

- Problems with OLS regressions of debt/investment on RE values:
  - Reverse causality: investment/borrowing might push up local RE prices
  - Unobserved local demand shocks driving land prices *and* firm decisions
  - Measurement error in firm market RE values

- IV strategy: instrument for firm market RE with reform exposure

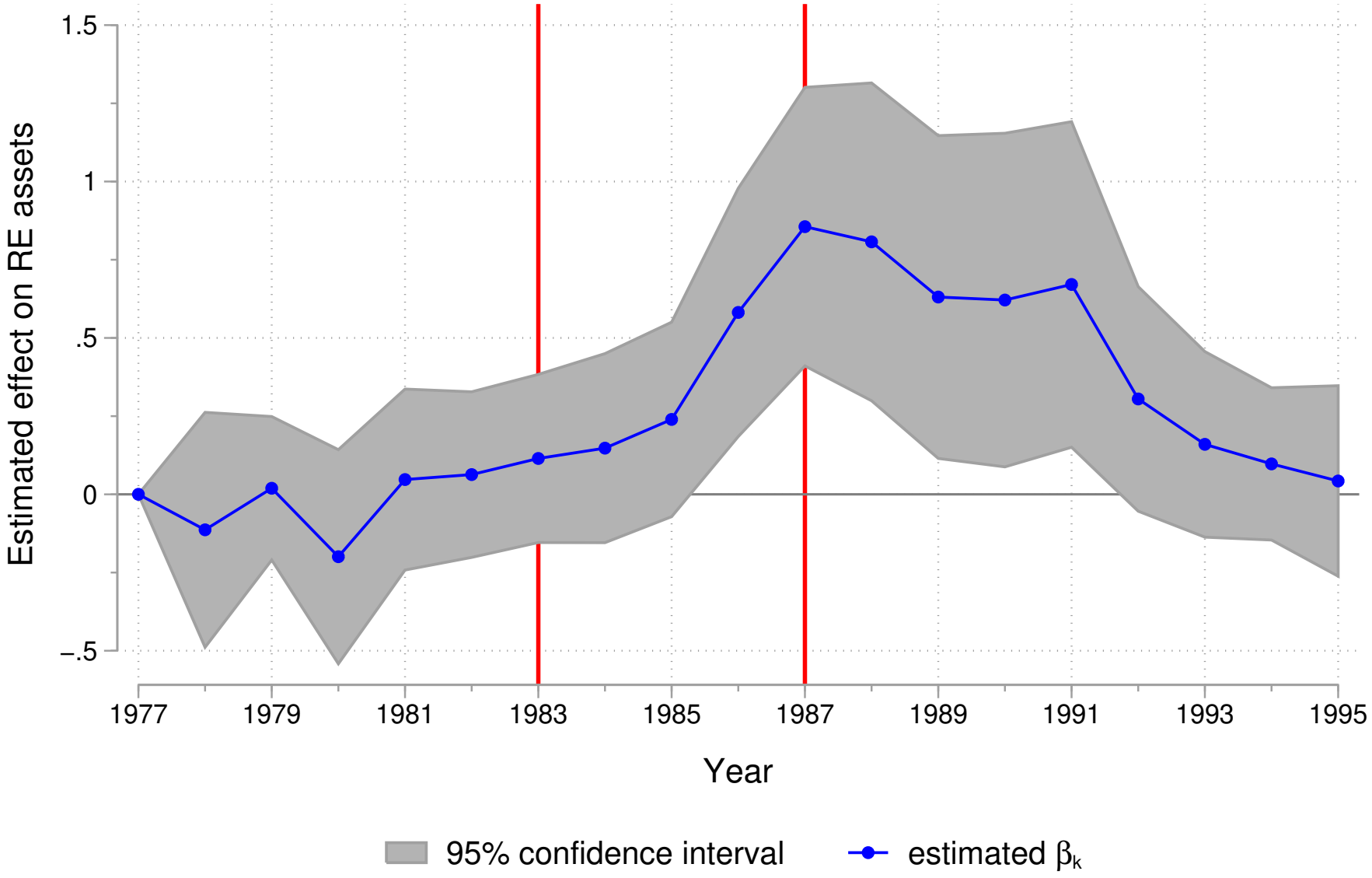
$$Y^j_{i,t} = \alpha_i + \delta_t + \beta RE^j_{i,t} + \epsilon^j_{i,t}$$

$$RE^j_{i,t} = \theta_i + \xi_t + \psi' \cdot (\mathbf{T}^{\mathbf{Pre}}_{\mathbf{j}} \times Post_t) + \eta^j_{i,t}$$

  - $\mathbf{T}^{\mathbf{Pre}}$ (FAR limit share, road width) extracts exogenous RE supply shock using post-reform dummy as common demand shock
  - Baseline: assign shock and RE price index based on HQ city j

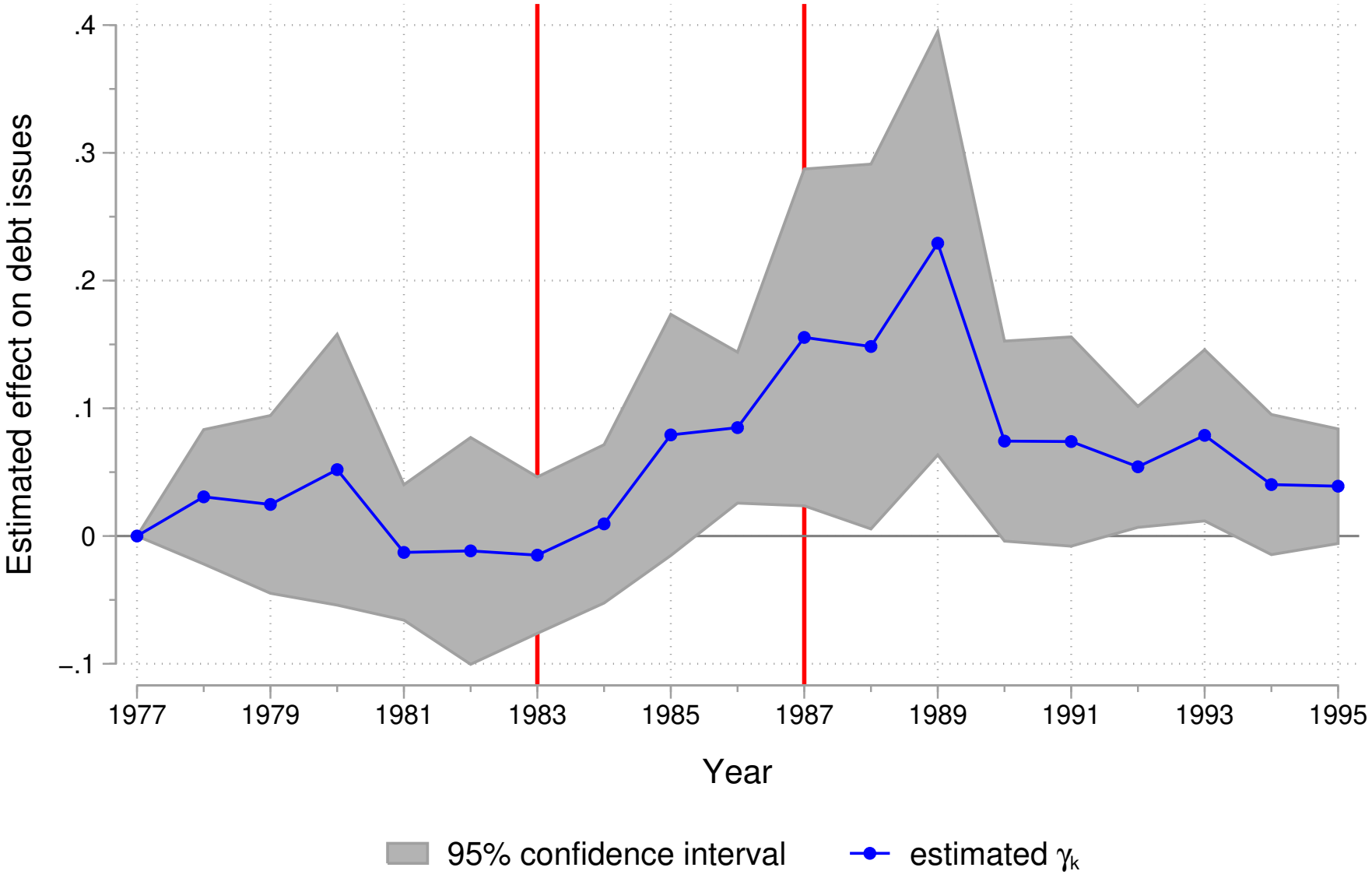
Valuation Ownership Usage

Result #1: land use shock generates boom-bust in RE



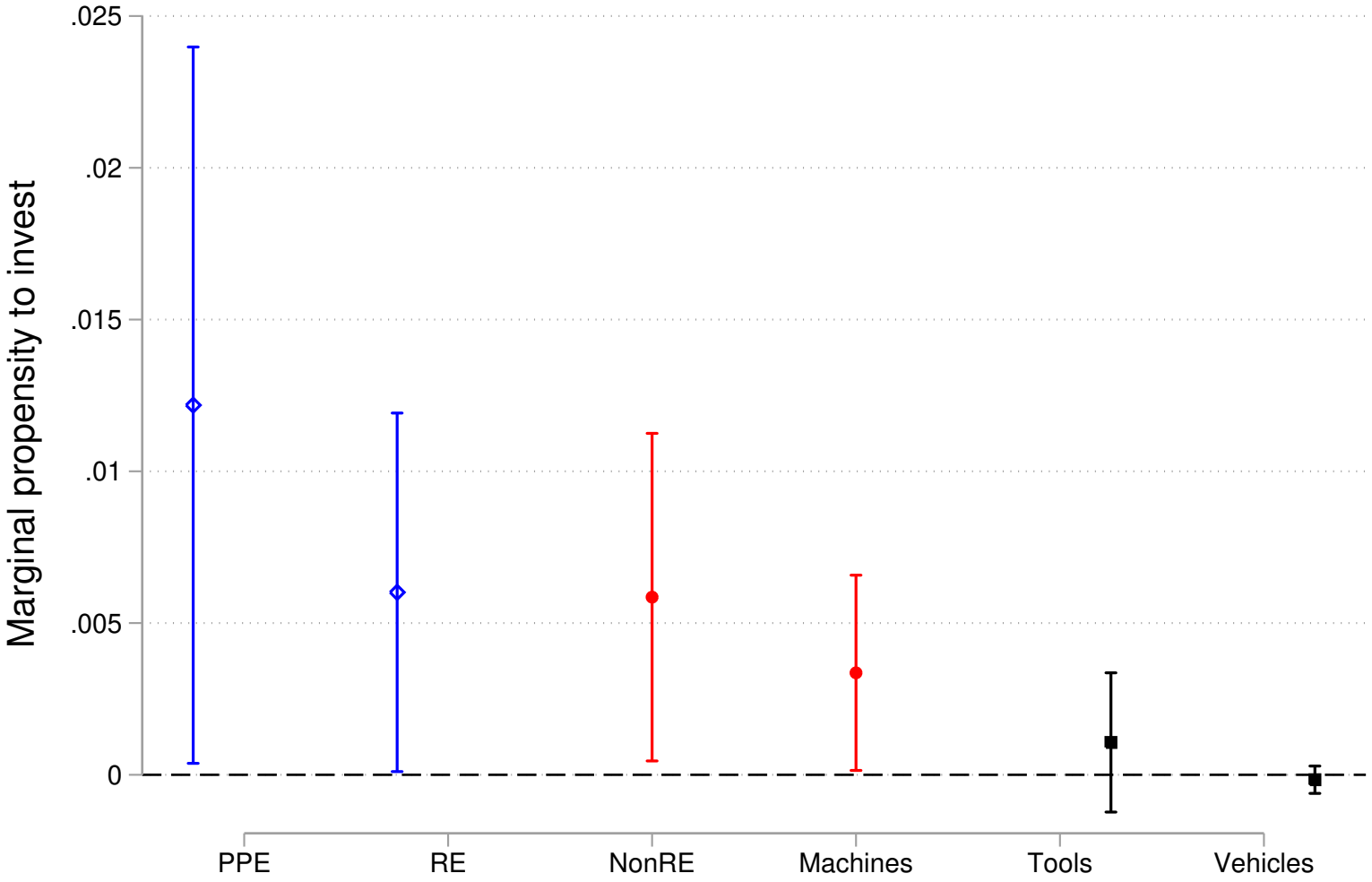
Regressions | Counterfactual | Balance | Q ratio

Result #2: reduced form effect on new debt issues



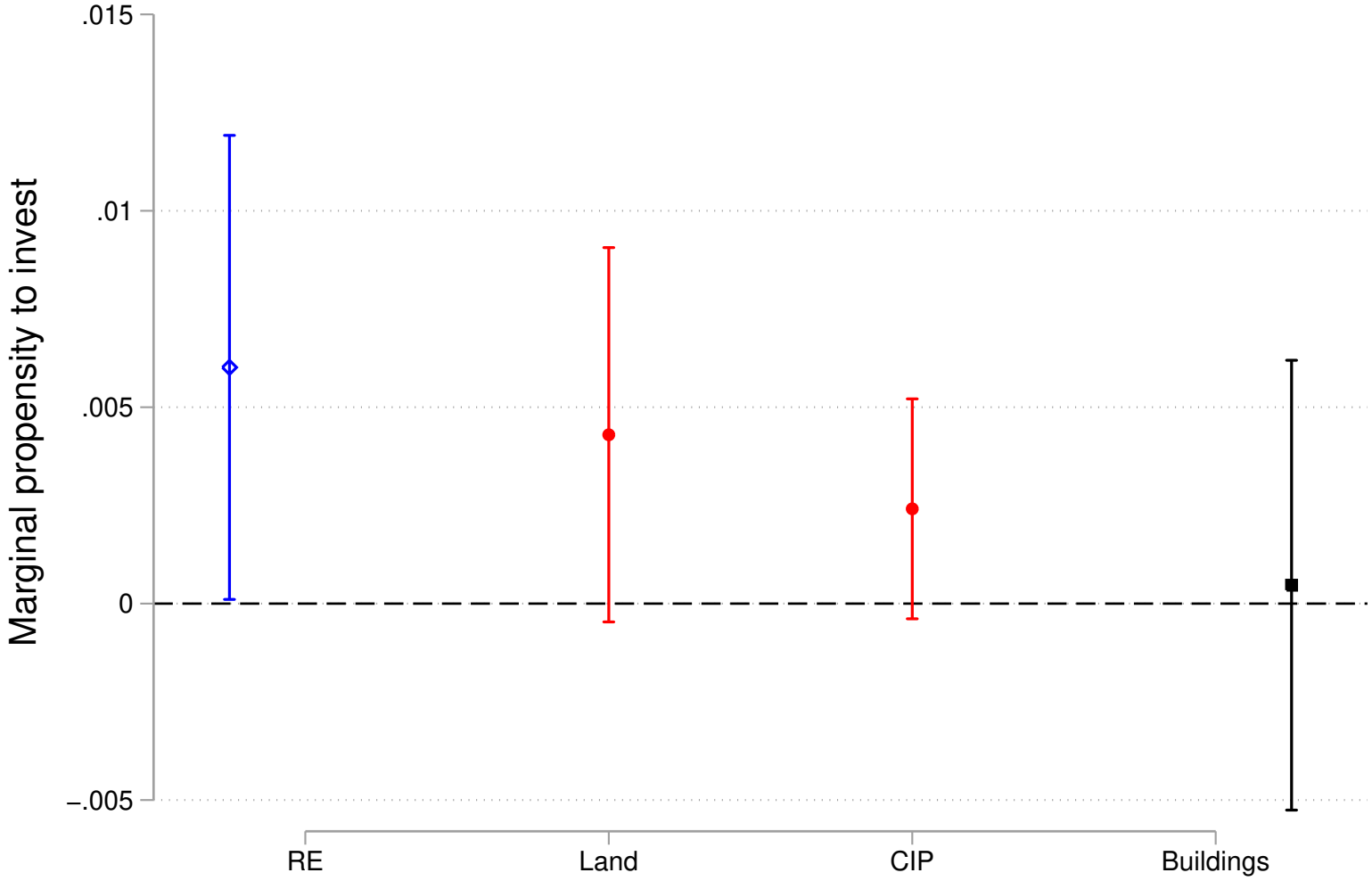
Constraints | Cash flows | Firm vs. HQ | Banks | Rescaling | By survivorship

Result #3: feedback and investment complementarity



- Feedback: inv. concentrated in RE collateral Zombies
- Complementarity: inv. in machines $\implies$ larger aggregate effects

Result #4: RE inv. concentrated in new projects



- Important because land/construction do not depreciate
- Uptick in construction further evidence of a real investment response

Going from cross-sectional to aggregate effects

- Build a multi-city structural model to...
  1. Compute aggregate effects of land use deregulation
  2. Decompose static and dynamic effects of shock to interpret why $P \uparrow$
  3. Spatial implications of corporate collateral constraints

- Main building blocks
  - Spatial sorting: workers migrate to cities with higher disposable income
  - RE supply inelasticity varies across cities due to FAR limits
  - Agglomeration: land inputs more productive with more people in a city
  - Collateral: price of RE capital determines borrowing limits

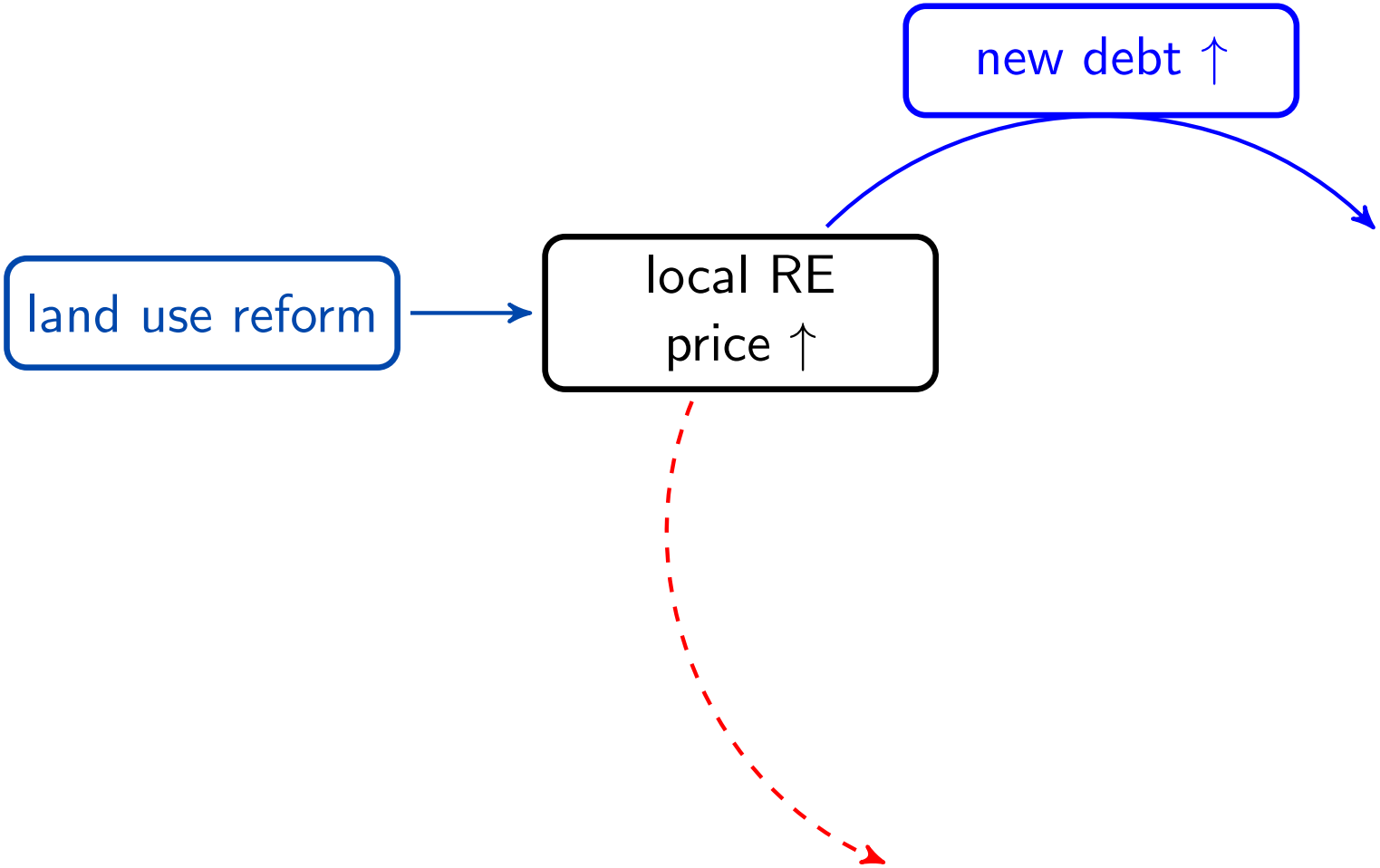
$$D_{j,t+1} \leq \psi P_{j,t} \cdot K^R_{j,t+1}$$

Evidence Exclusion Diagram Intuition

How the model works at a local level

land use reform $\longrightarrow$

How the model works at a local level



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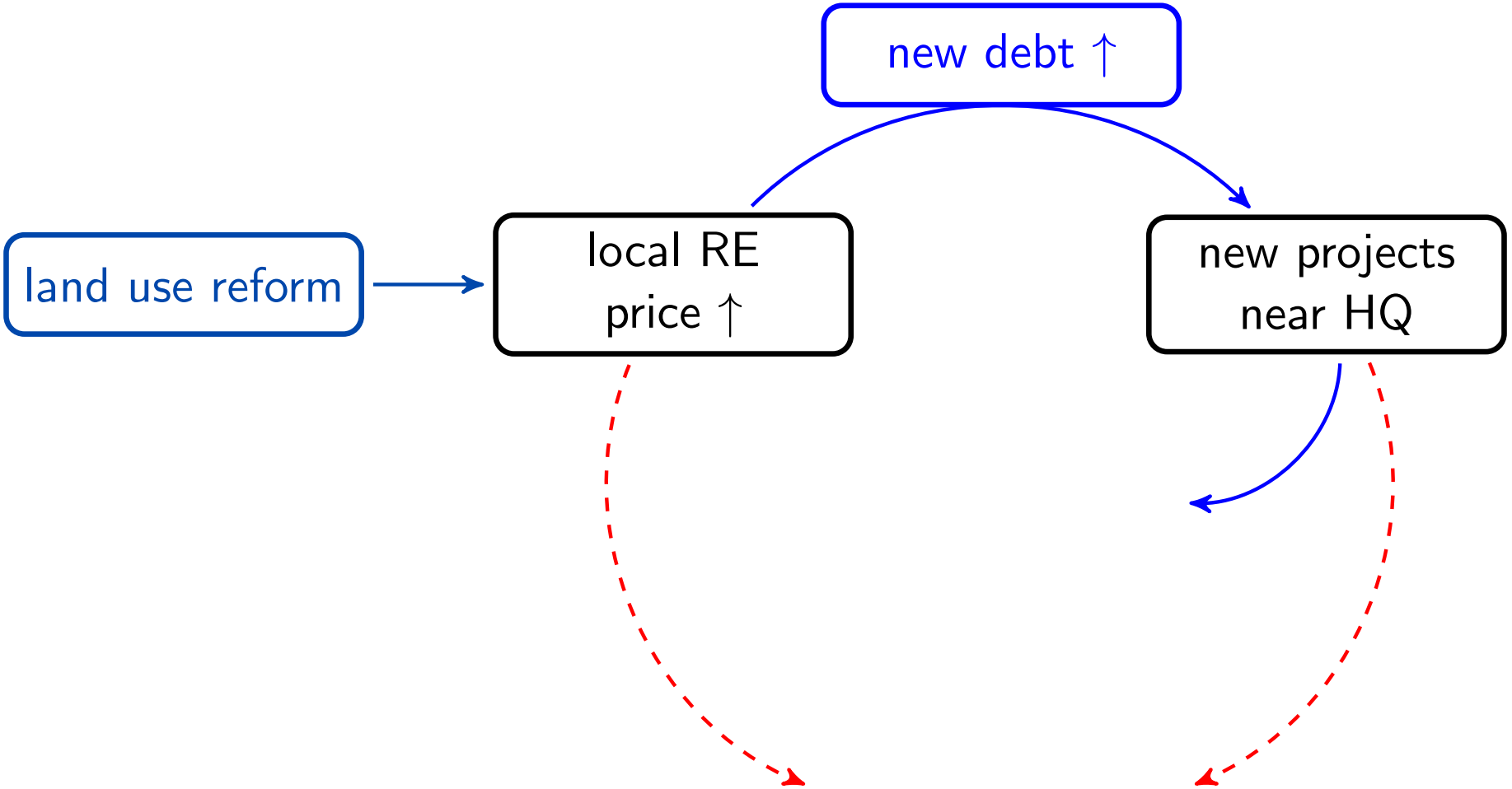

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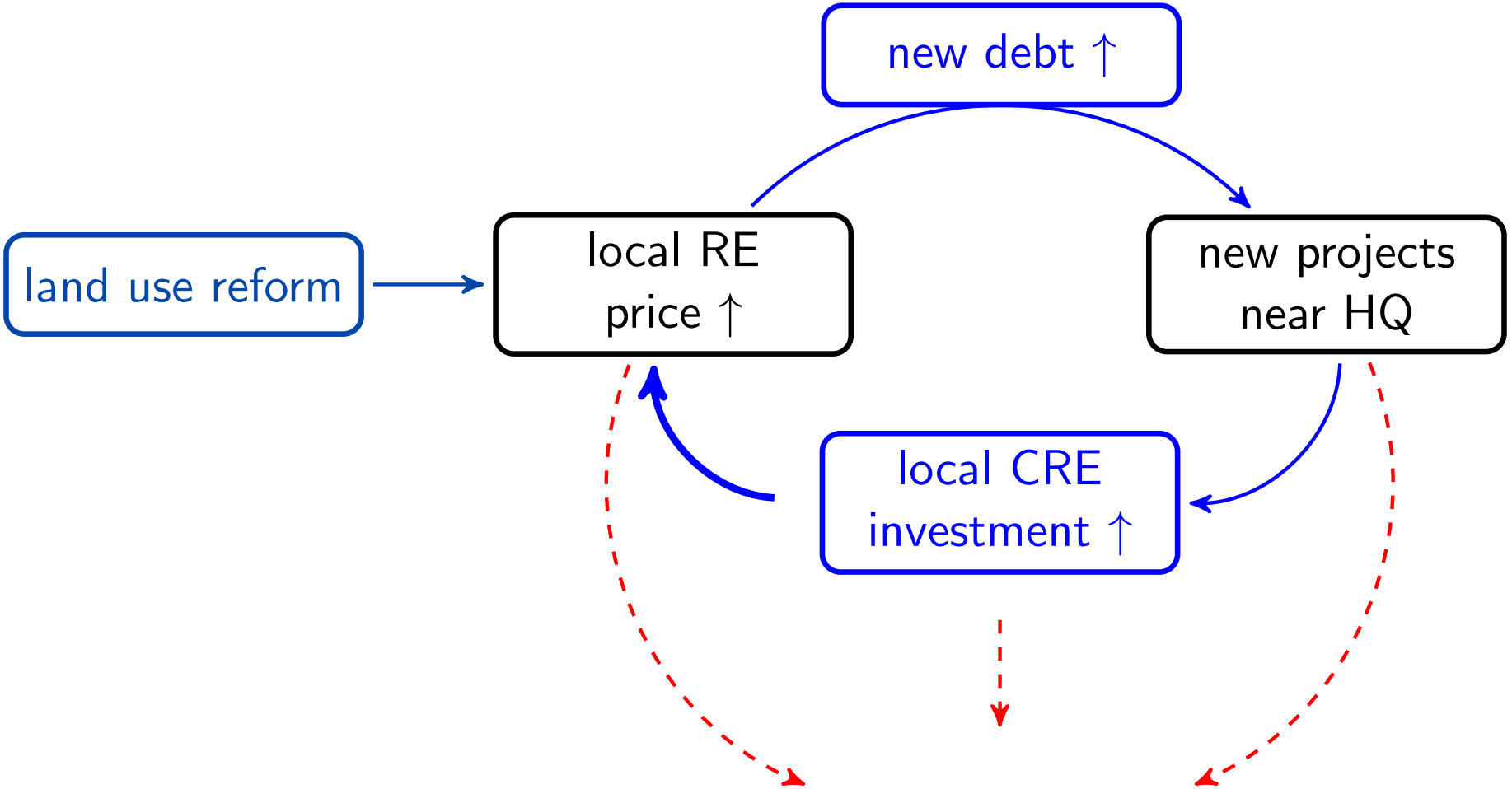

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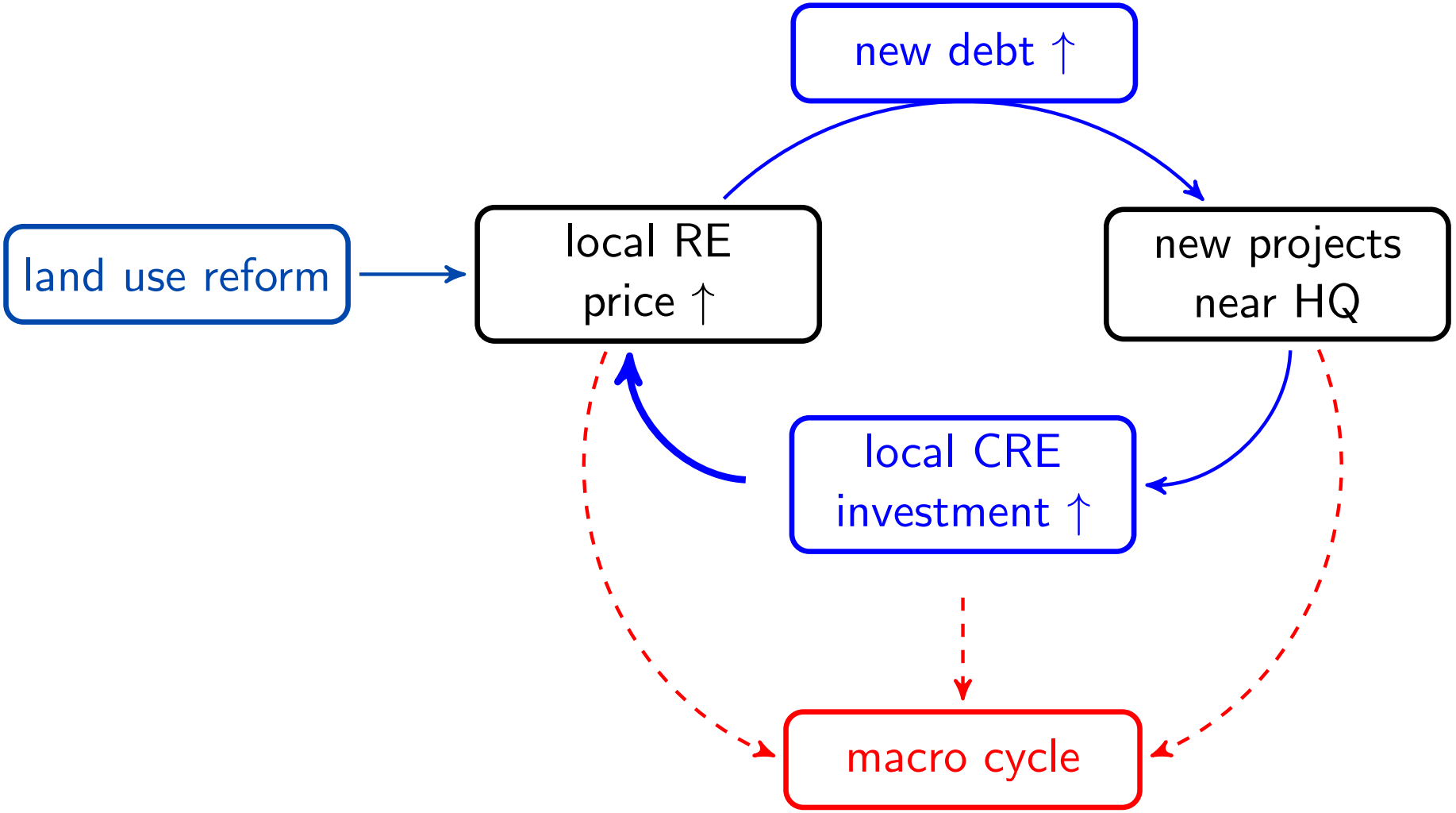
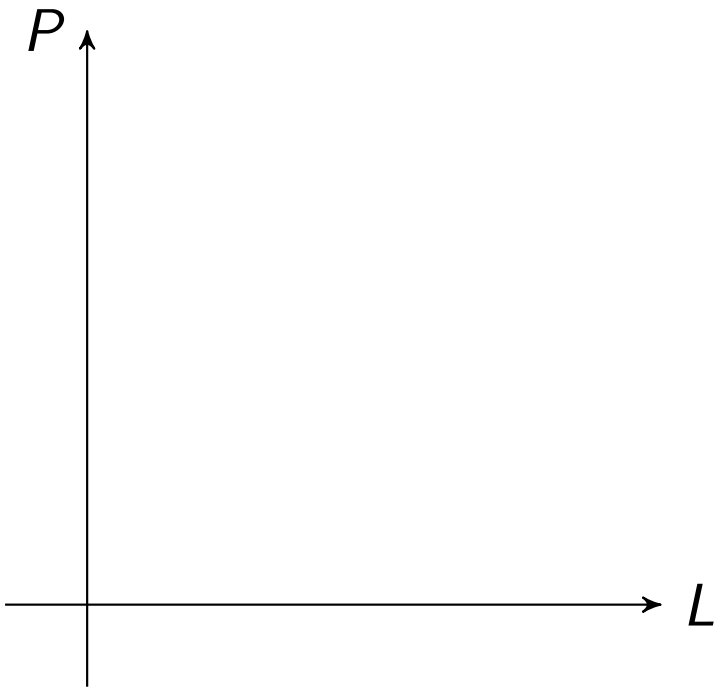


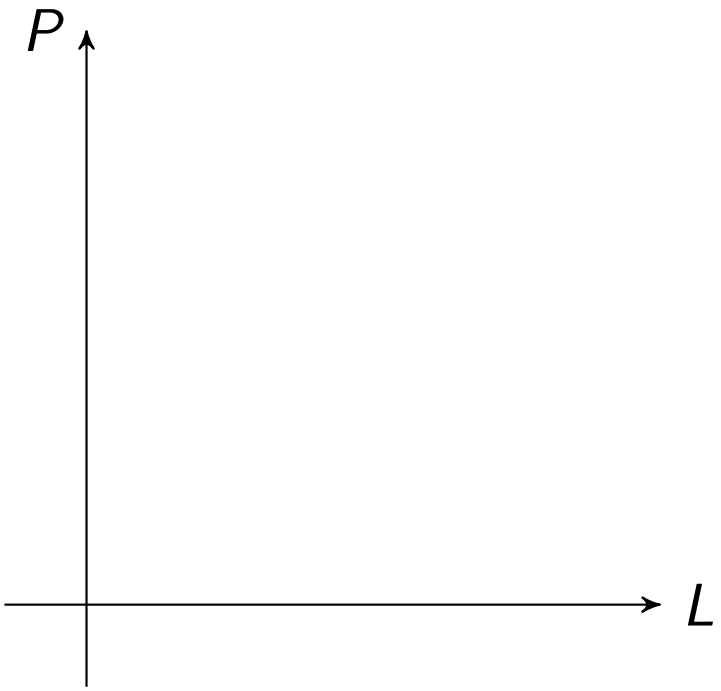
- Importantly, this loop can go in both directions – some cities lose!

GE effects of land use reform

Unconstrained city



Constrained city



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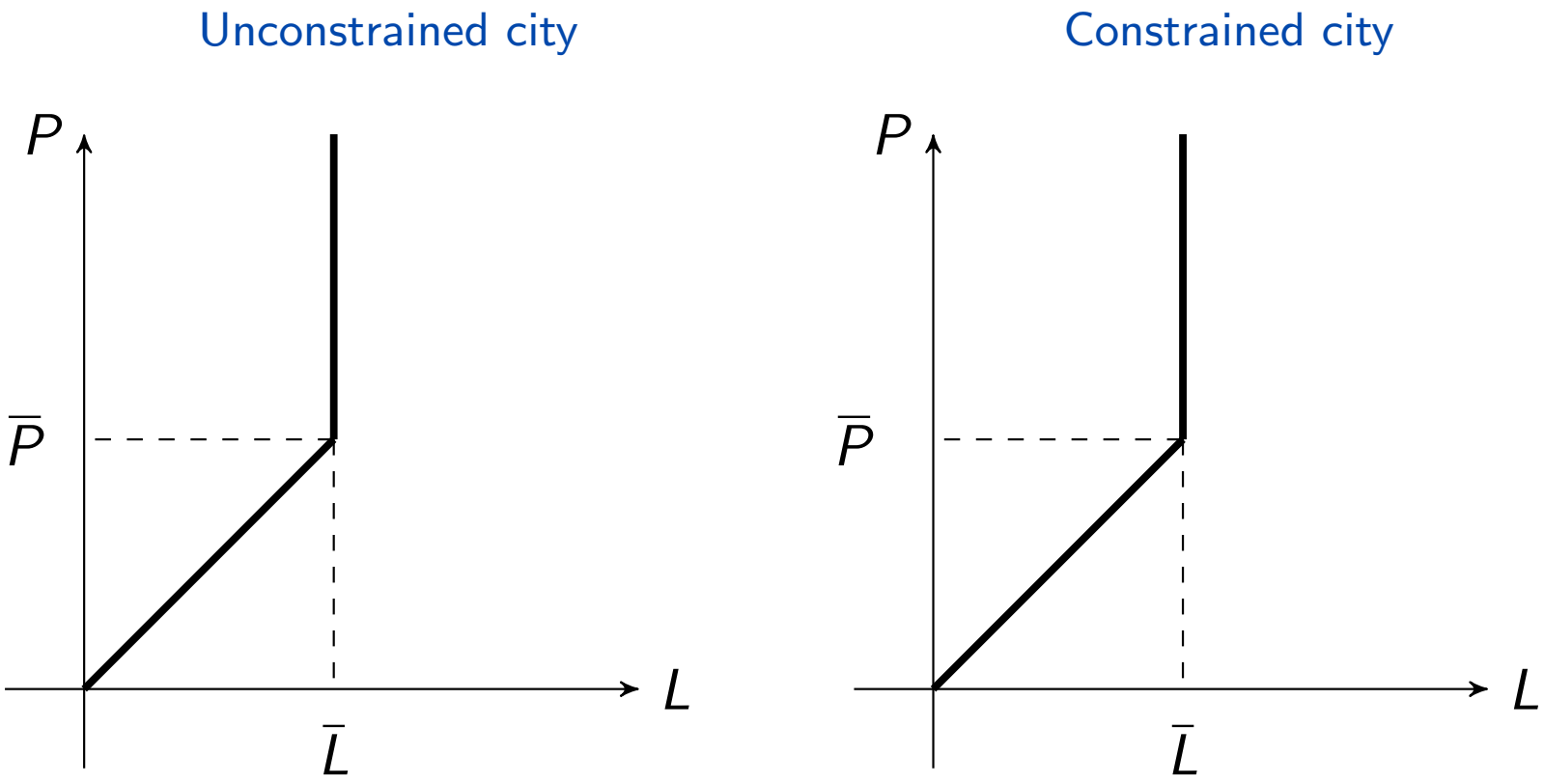
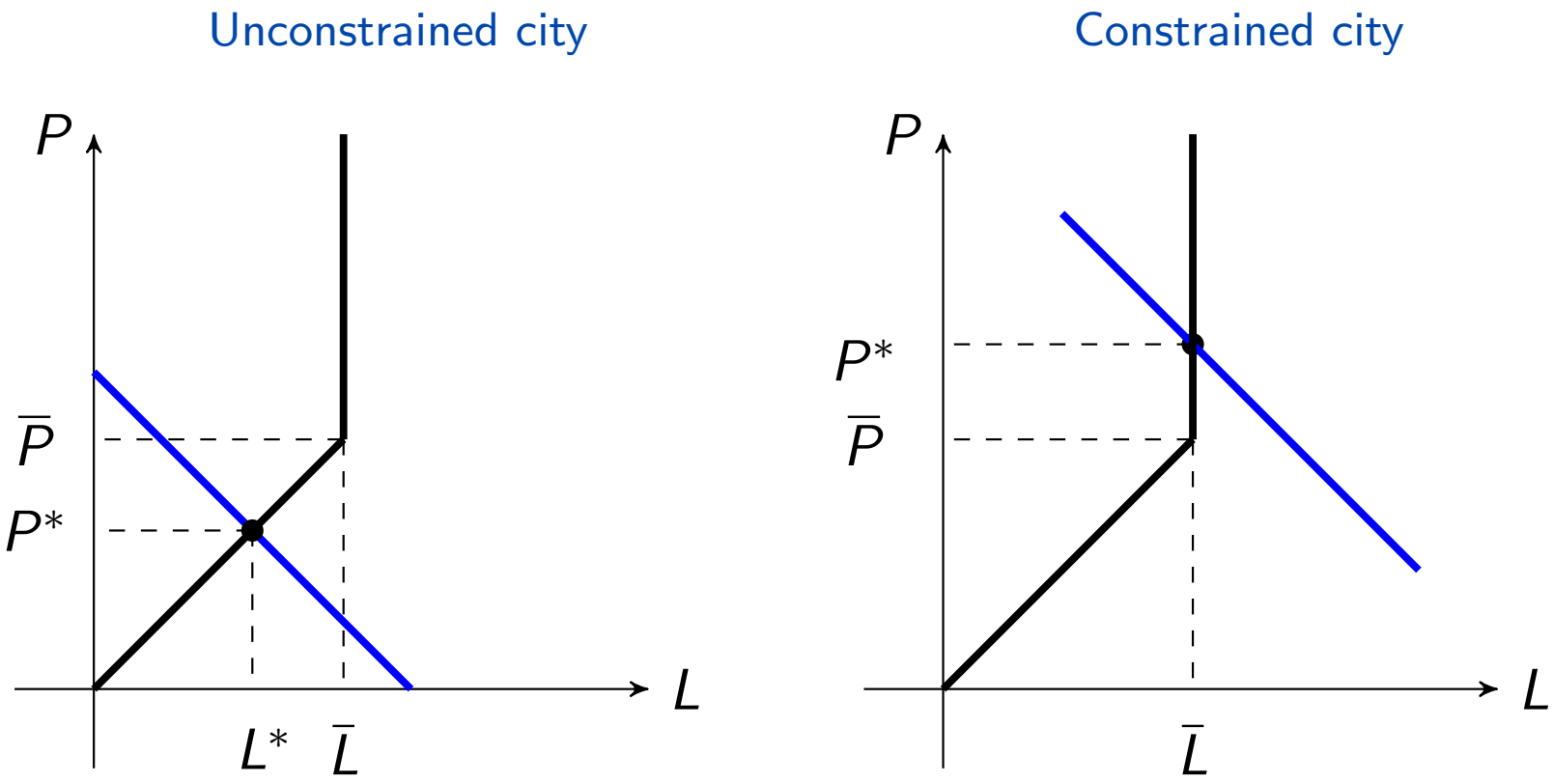


- Land use law: threshold $\bar{L}$ at which supply becomes perfectly inelastic

GE effects of land use reform



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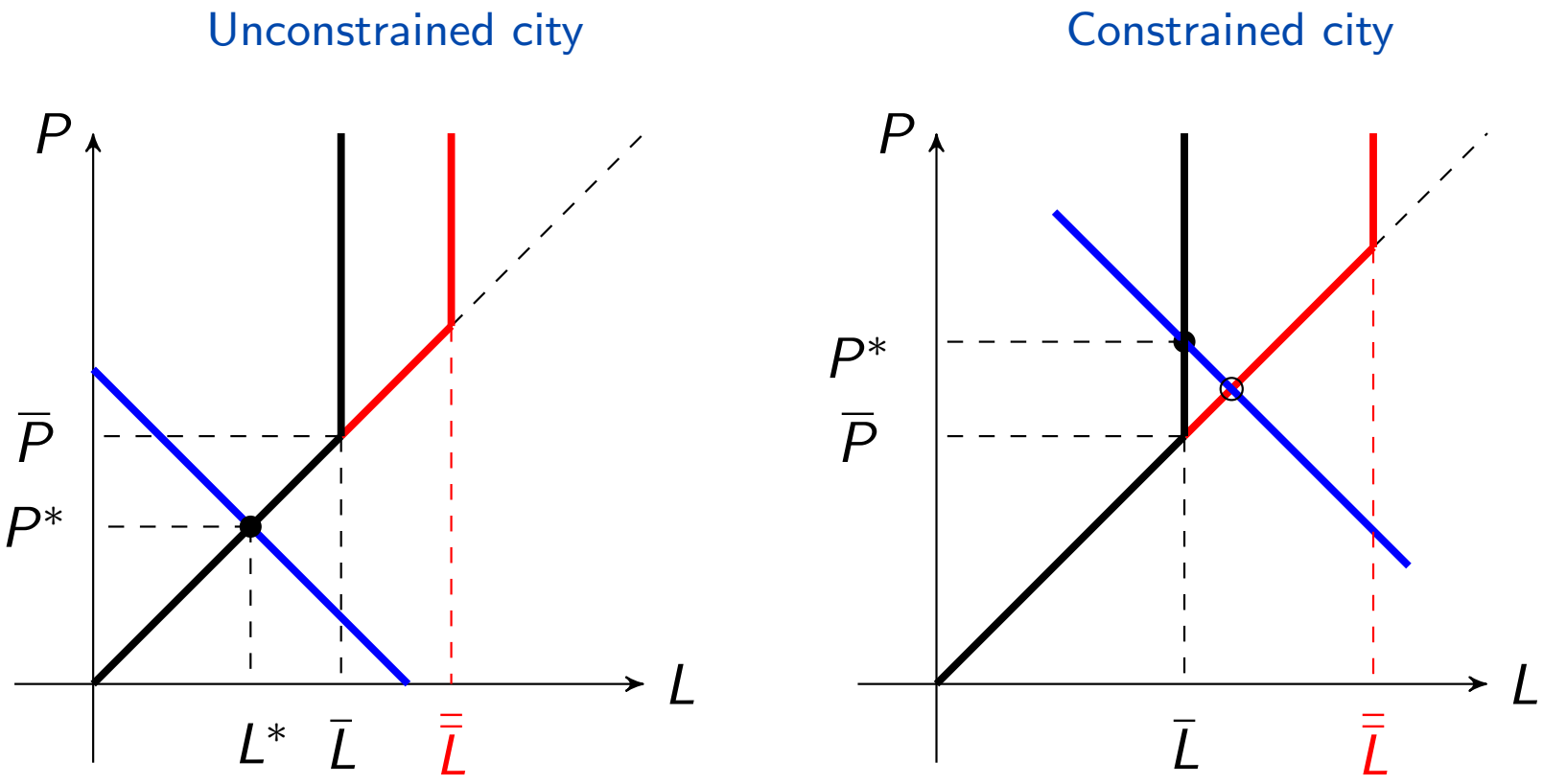

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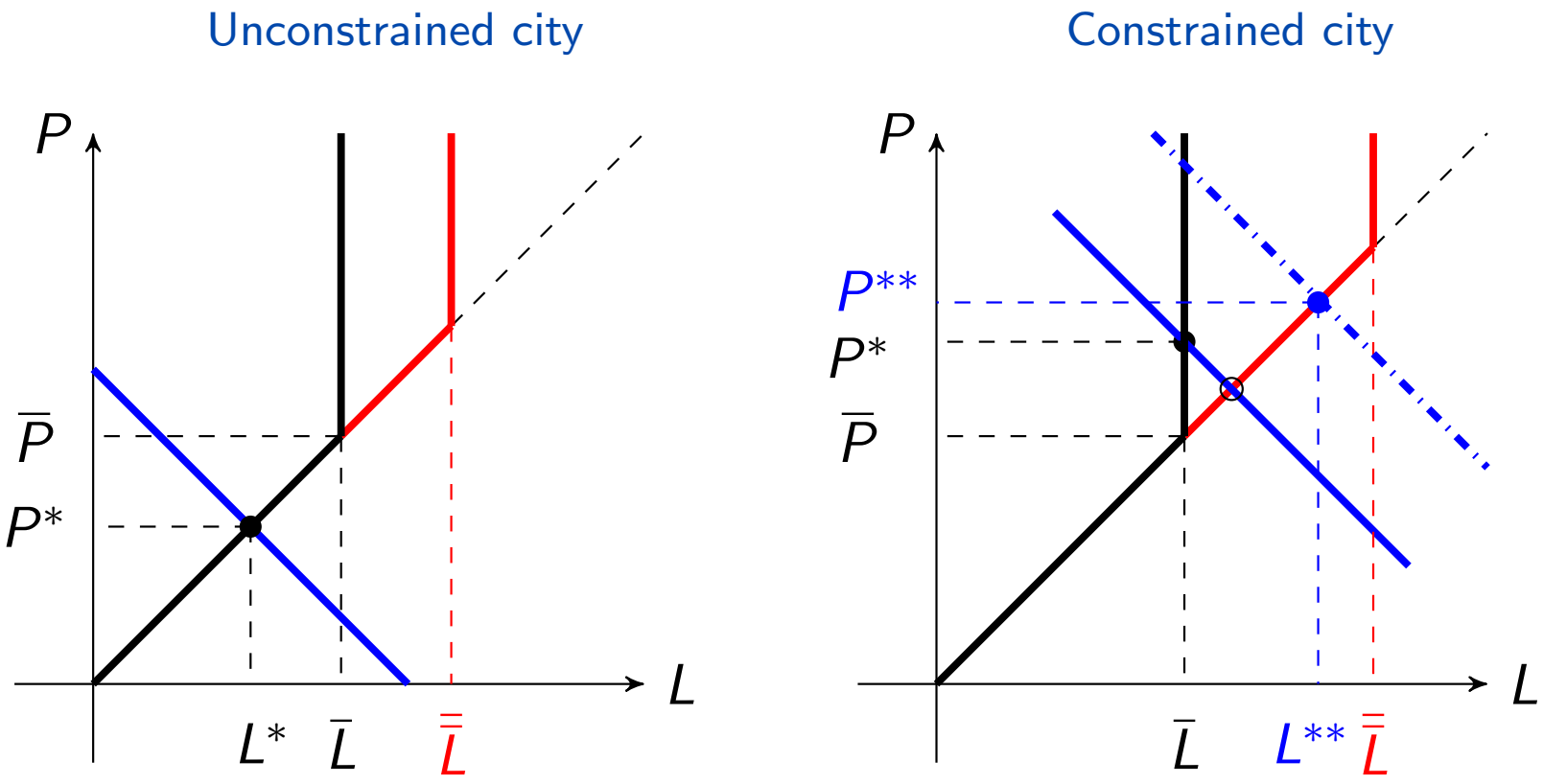

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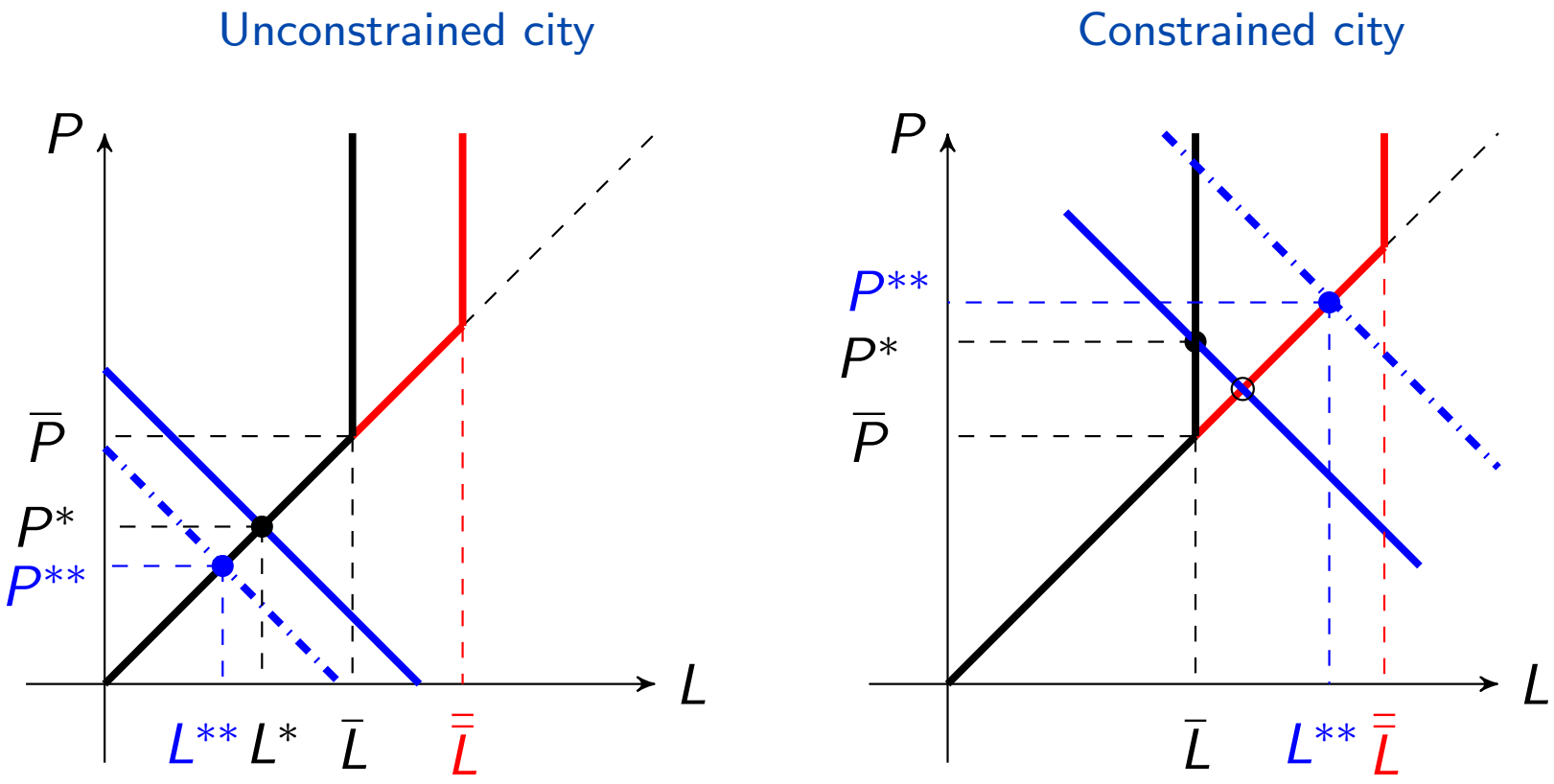


- Land use law: threshold $\bar{L}$ at which supply becomes perfectly inelastic
- Deregulation makes local RE supply more elastic ($P \downarrow$) but induces more people to sort into constrained city $\implies P \uparrow$

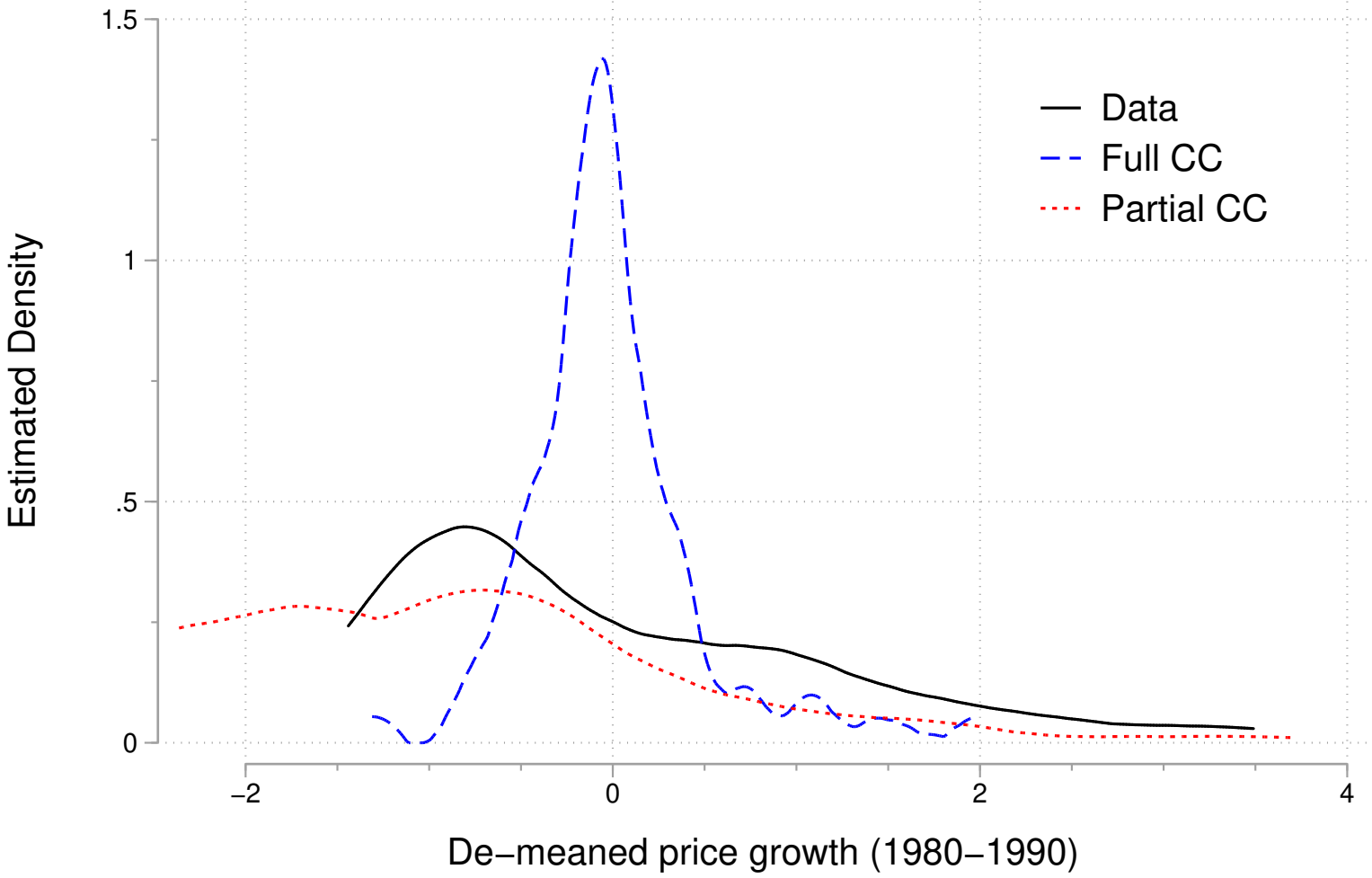
Aggregate effects of the reform (1980-90)

	Full CC	Partial CC	No CC	Data
ΔP_{80-90}	19%	20%	26%	67%
ΔY_{80-90}	197%	399%	-34%	82%
ΔK^R_{80-90}	84%	55%	44%	87%
ΔK^N_{80-90}	422%	198%	6%	98%
ΔK_{80-90}	185%	55%	29%	87%
ΔD_{80-90}	2%	19%	0%	150%

- GE spatial sorting dampens the aggregate effect on prices and debt issues – one city's gain in population is another's loss
- Large effects on output due to productivity gains/losses from sorting

Calibration Zipf's law

Spatial distribution of price growth: model vs. data



- Partial CC version of model generates large local booms as in data

Intuition: model yields four types of firms

Land use constraint \ RE collateral constraint	*Non-binding*	*Binding*
Non-binding	17%	40%
Binding	12%	31%

- Both types of binding constraints $\implies$ feedback loop + amplification
- Heterogeneity in borrowing capacity important for RE price dispersion!

Conclusion

- New empirical evidence for closed feedback loop between RE prices, corporate borrowing, and investment
- Land use deregulation $\implies P \uparrow$ from productivity shock to land + borrowing constraints and further RE inv.
- New spatial version of financial accelerator: local feedback loops important driver of aggregate fluctuations during booms
  - Land use constraints + corporate borrowing limits $\implies$ amplification and superstar city effects
- New stylized facts about 1980s Japan RE cycle
  - Transaction volume, price growth concentrated in non-residential RE
  - Need variation in both supply constraints and corporate borrowing limits to explain geographic dispersion in ΔP

THANKS!

Appendix

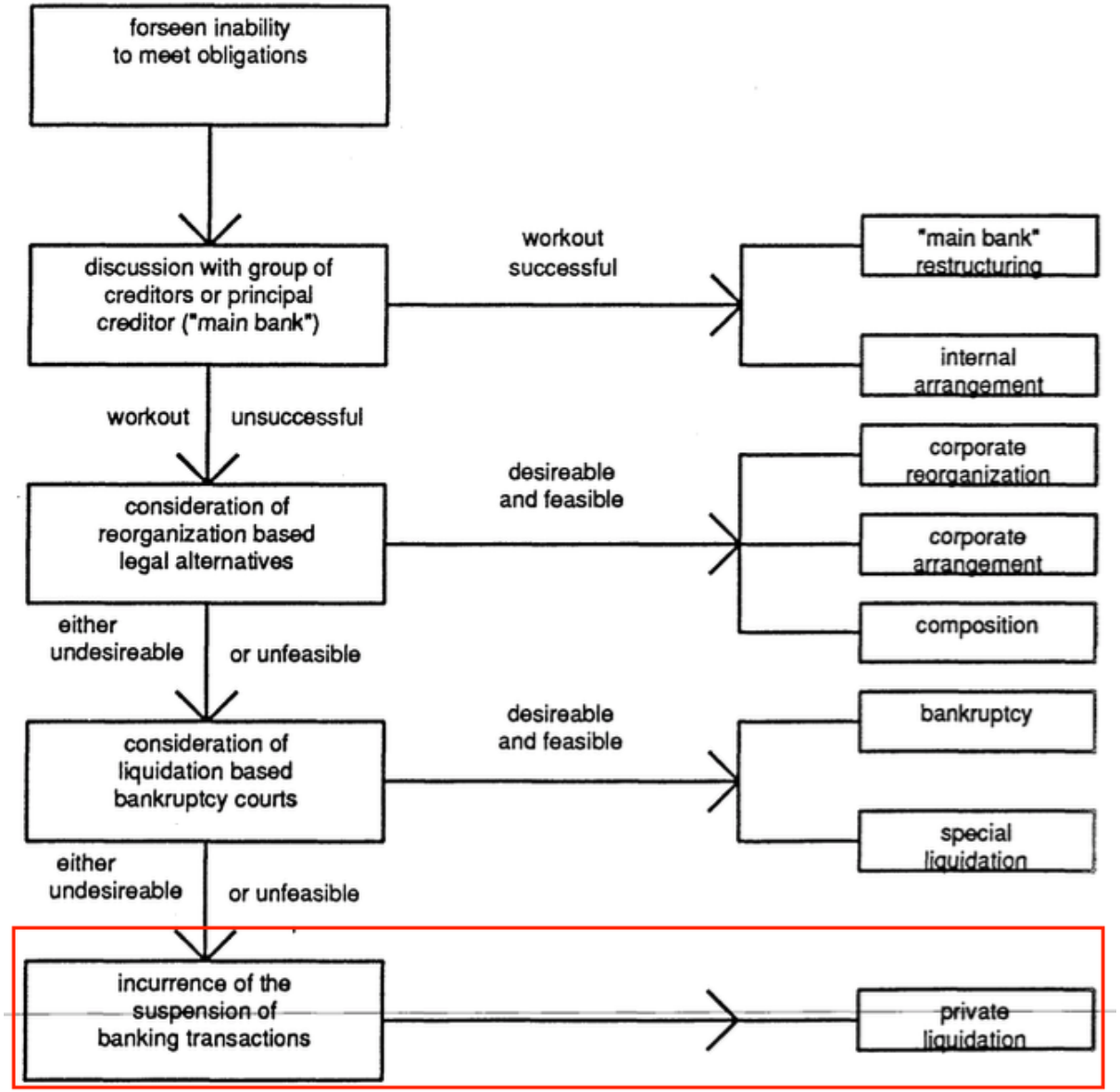
Related work

- Corporate collateral channel Main deck
  - Kashyap et al. (1990), Almeida & Campello (2007), Gan (2007), Mora (2008), Benmelech & Bergman (2009,11), Campello et al. (2010), Chaney et al. (2012), Campello & Giambona (2013), Cvijanović (2014), Lin (2015), Chen et al. (2017), Catherine et al. (2018), Bahaj et al. (2018,19), Lian & Ma (2019), Aretz et al. (2019), Welch (2020)
- Effects of supply regulation on real estate markets
  - Glaeser & Gyourko (2003), Quigley & Rosenthal (2005), Gyourko et al. (2008), Glaeser (2013), Autor et al. (2014,17), Hilber & Vermeulen (2016), Brueckner et al. (2017), Herkenhoff et al. (2018), Hsieh & Moretti (2019), Favilukis et al. (2019), Gyourko et al. (2019), Lin & Wachter (2019), Brueckner & Singh (2020)
- Spatial dimensions of firm financing and factor allocation
  - Holmes (1998), Benmelech et al. (2005), Sufi (2007), Greenstone et al. (2010), Almazan et al. (2010), Giroud (2013), Giroud & Rauh (2015), Suárez Serrato & Zidar (2016), Benmelech et al. (2018), Bernstein et al. (2018), Giroud & Mueller (2015,17,19), Fajgelbaum et al. (2019)

Corporate borrowing in Japan

- Corporate borrowing emphasizes physical assets such as real estate
  - Creditor payoffs in bankruptcy tied to liquidation value of phys. assets
  - Lenders can liquidate assets w/o appealing to bankruptcy court
  - $>$ 99% of firms in my sample hold RE in 1980
  - Non-residential RE averages 15% of total asset book value
- How do firms issue debt?
  - Largest source new debt issues is long-term bank debt
  - For median firm only 8% of new debt issues in form of bonds
  - No new short-term debt issues in 23% of firm-years
  - Action on intensive margin: zero net debt issuance in 9% of firm-years

Main deck



Source: Packer & Ryser (1992), "An Anatomy of Corporate Bankruptcy in Japan"

Main deck

Court-based arbitration is very time-consuming

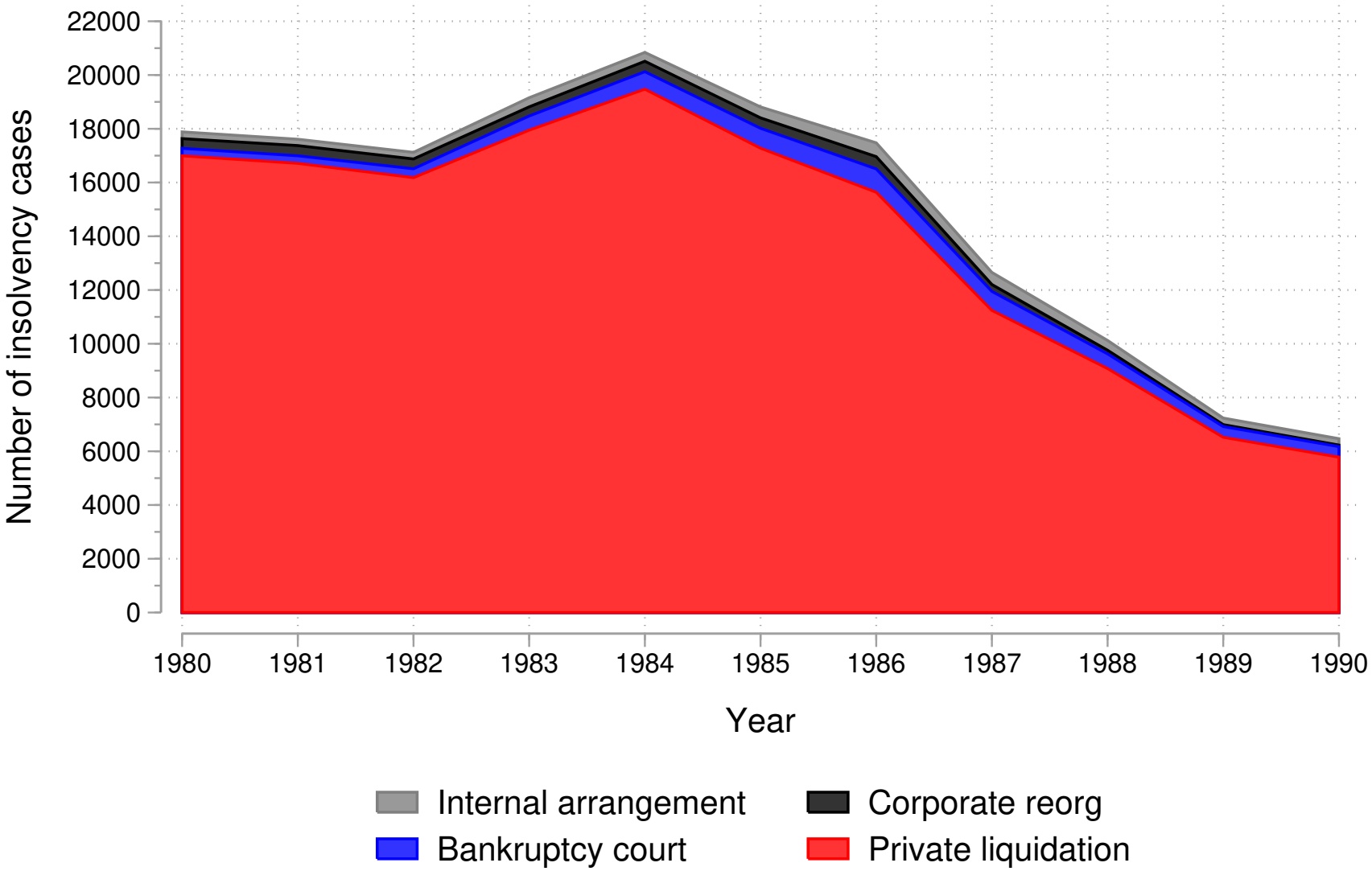
Length of Court Proceedings for Insolvency (1989)

	Bankruptcy	Corporate reorg.
$<$ 1 year	151 (5.8%)	1 (1.6%)
1-2 years	598 (22.9%)	1 (1.6%)
2-3 years	551 (21.1%)	11 (18.0%)
3-5 years	685 (26.2%)	3 (4.9%)
$>$ 5 years	632 (24.0%)	45 (73.8%)
Concluded cases	2,617	61

Source: Annual Report of Judicial Statistics (1989)

Main deck

Vast majority of insolvencies handled privately



Source: Tabulations based on Packer & Ryser (1992) for firms with > 10 million JPY in liabilities

Main deck

Data overview

1. Originally-constructed local price indices for non-residential RE
   - Aggregate publicly available property tax appraisal records
   - Panel dimension: same properties surveyed each year
2. Land use deregulation shock
   - Aggregate plot-level information on zoning, neighborhood layout
   - Sources: public city planning maps, appraisal records
3. Geocoded bank-firm balance sheets
   - Hand collect facility-level locations from Form 10-K equivalents
   - Firm balance sheet data from Development Bank of Japan (DBJ)
   - Bank financial statements from Nikkei NEEDS database

Main deck

Measuring Land Prices

- Estimate an index by running regression for each city c:

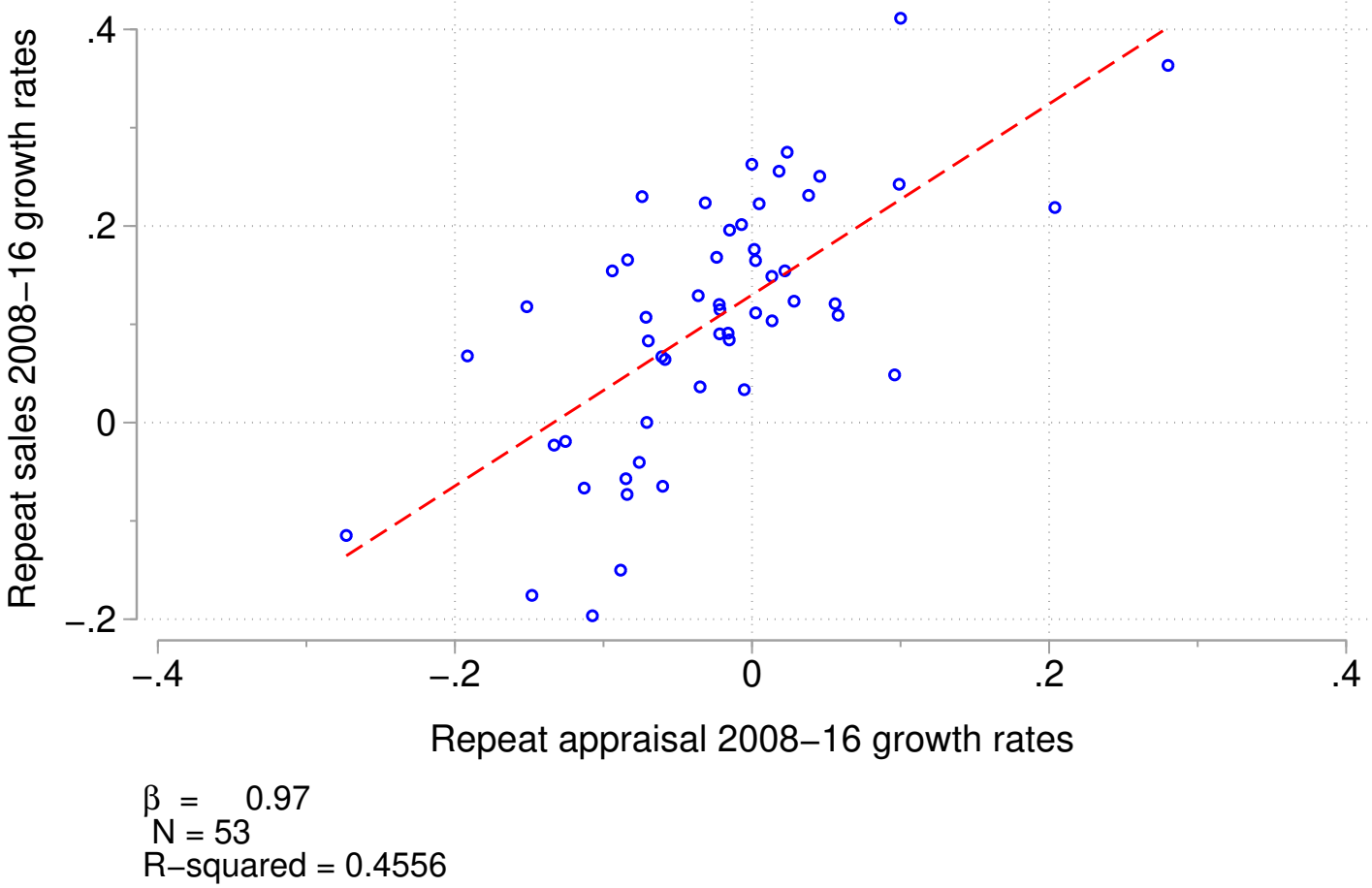
$$\log p_{i,t}^{c} = \delta_t^c + \eta_i^c + \epsilon_{i,t}^c \tag{1}$$

$$P_t^c = \exp(\delta_t^c) \tag{2}$$

- Individual FEs control for time-invariant characteristics of land plot i
  - Same set of variables used in Case-Shiller repeat sales methods
  - Advantages: do not need to take a stance on variables in $X_{i,t}$ vector or throw away observations
- Similar results for other indexing methods
  - Different weighting methods change magnitude of price changes but leave cross-sectional distribution intact

Main deck

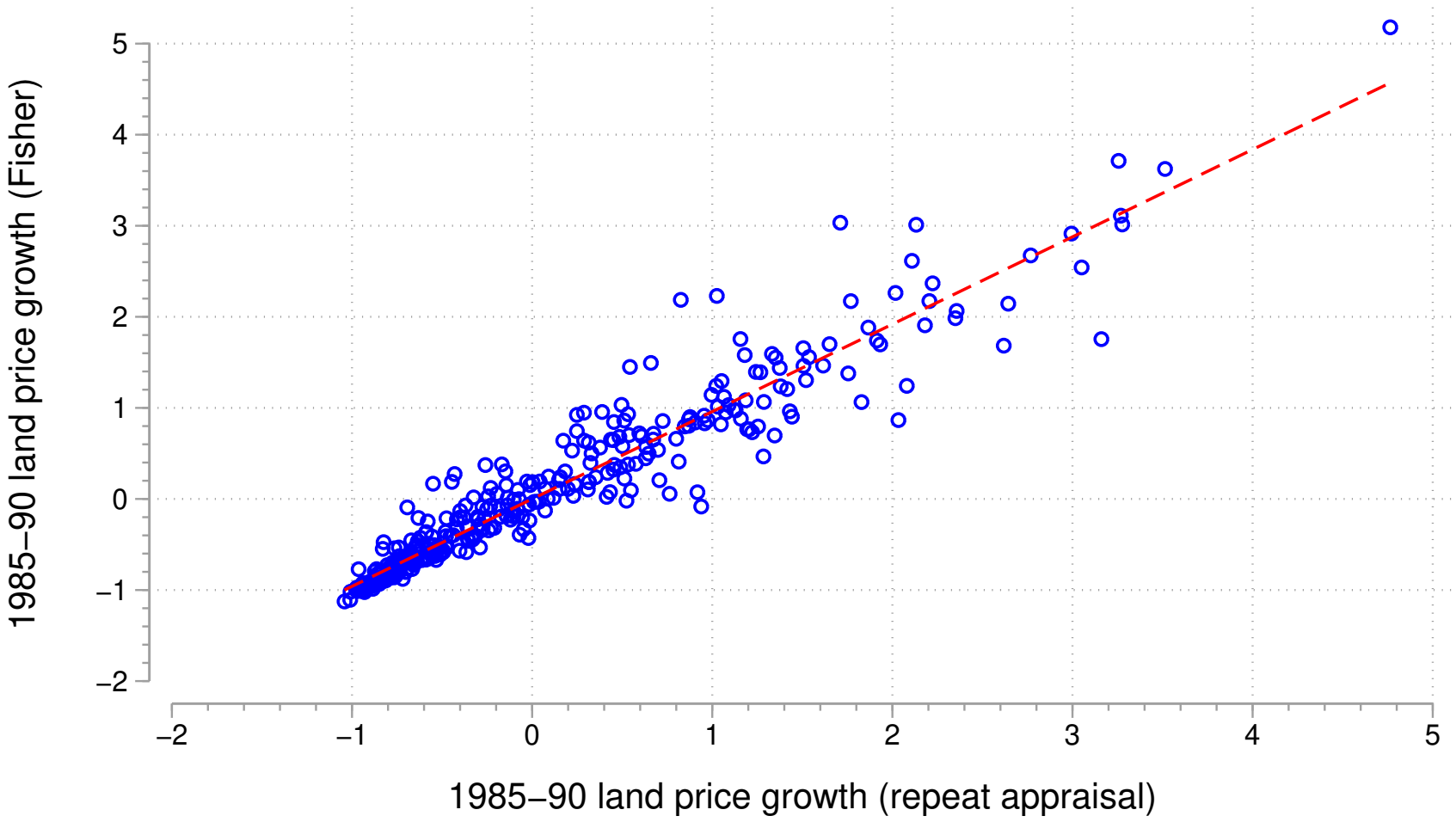
Sales and Appraisal Prices Highly Correlated



- For large cities (pop. $>$ 400,000) cross-sectional correlation is 0.7
- $>$ 90% of corporate RE in these cities

Main deck

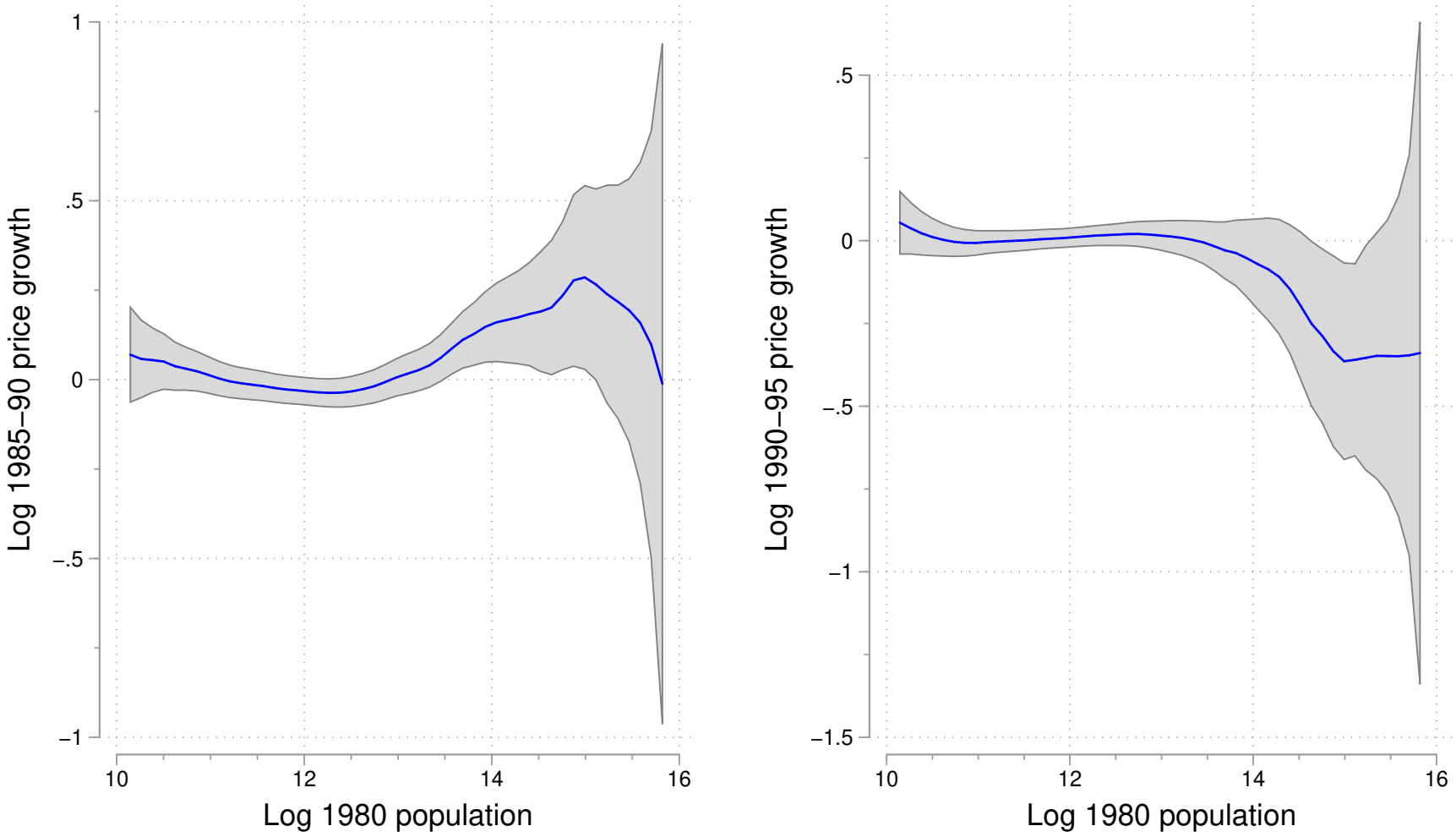
Commercial land: regression-based vs. Fisher indices



β = 0.96
N = 386
R–squared = 0.9200

Main deck

Patterns not easily explained by city size or income



Main deck

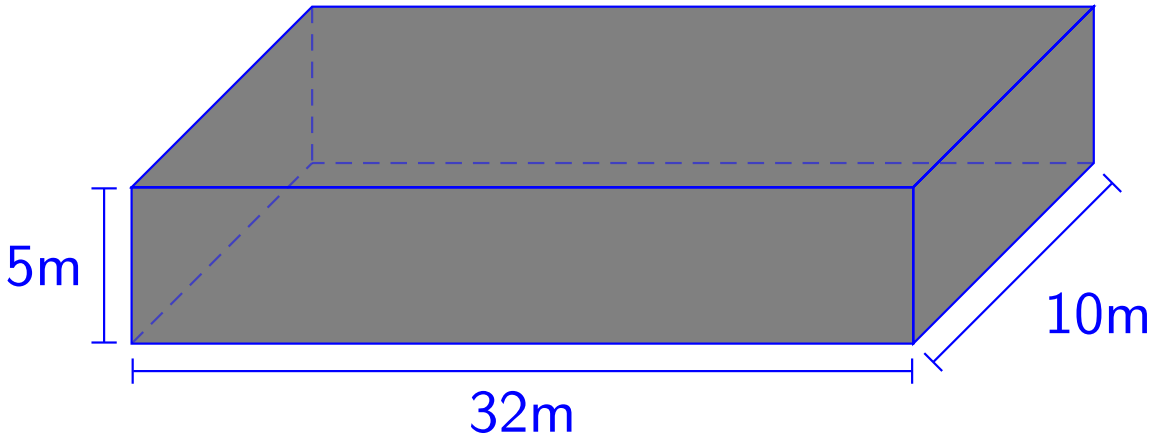
Measures of local exposure to land use reform

1. Median or average road width Main deck
   - More constrained areas have narrower roads on average
   - Without conditioning on other exposure measures, wider roads associated with lower ΔP_{85-90}
2. Share of plots eligible for an increase in FAR limits
   - Observation: areas with wider roads more likely to experience inc. in FAR limit after reform
   - $\implies$ constrained areas have a lower share of plots which experience an inc. in FAR limits

- Other provisions of the reform mainly apply to residential use land, so not appropriate instruments for commercial RE
- Pool commercial/industrial land since subject to same policy rules

Example: building constraints in practice

- Consider a commercially zoned land plot of $400m^2$ with an FAR limit of 500%, with all other parameters standard
- Assume plot is on an avenue, so no absolute height limit
- On commercial plots can only build out up to 80% of the plot area
- Take an office building where each floor has dimensions:



- With each floor at $320m^2$ the FAR limit means a building must have $\leq (5 \times 400)/320 = 6.25$ floors Main deck

FAR limit share measure

(I) For plots with front road width $\geq$ 12m, floor-to-area ratio (FAR) limit determined by a statutory maximum **y** which depends on the zone classification Main deck

(II) If road width $<$ 12m, FAR limit is $maxFAR = \min\{x, \mathbf{y}\}$ where x is:

$$x = 100 \times \begin{cases} 0.4 \cdot roadwidth & \text{if residential} \\ 0.6 \cdot roadwidth & \text{if commercial/industrial} \end{cases}$$

- Do not observe y directly, so for (II) exposure means $x > min\{x, \mathbf{y}\}$
- Since y is the policy parameter changed by the reform construct exposure measure as:

$$T_j^{Pre} = \frac{\#\text{ plots satsifying (I) or (II)}}{\text{total }\#\text{ of plots in city planning area}}$$

- Idea: T_j^{Pre} captures how much market capitalizes shock to FAR

Valuing corporate RE assets

- Balance sheets provide value of property based on historical cost
- Two methods for converting to market value: Main deck

1. Traditional method (Chaney et al. 2012): compute avg. property age and use commercial price index in HQ city to inflate net book value
   - ★ Assumption: majority of firm RE assets located near the HQ
   - ★ On average $\approx$ 40% of employment and RE assets in the HQ city
   - ★ Key parameter: RE depreciation rate ($\delta = 2\%$)
2. New method: hand-collect location of RE assets from financial disclosure documents
   - ★ Impute market value by doing book-to-market conversion taking into account shares of RE or employment at each facility

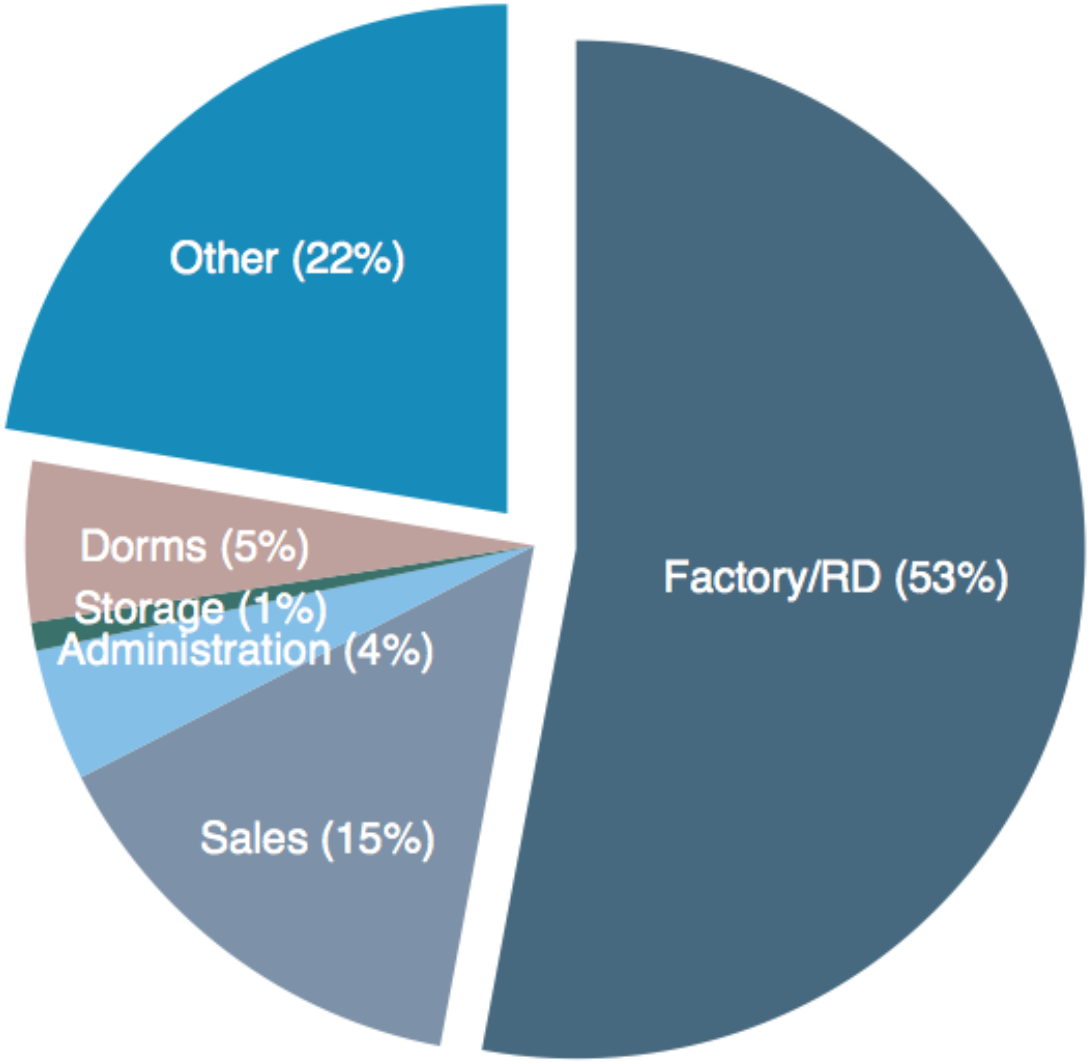
High rate of RE ownership in HQ city

	HQ facility ownership	RE ownership in HQ city	RE improvements in HQ city	Total
Full sample	1,312 (83.6%)	1,427 (90.9%)	1,495 (95.2%)	1,570
Estimation sample	1,249 (83.9%)	1,354 (91.0%)	1,416 (95.2%)	1,488
Excluding non-standard reports	1,235 (86.9%)	1,318 (92.8%)	1,373 (96.6%)	1,421

- Assigning shock at HQ level is not a placebo for $> 90\%$ of firms
- Ownership: firm reports amount of building or land assets > 0 attached to HQ site
  - Conservative definition because does not tie ownership to investment in furnishings for rented space

Main deck

Corporate RE assets primarily used for production



- On average, 94% of RE is comm/ind. use (including multiuse sites)

Main deck

First stage estimates

$$RE^j_{i,t} = \alpha_i + \delta_t + \psi' \cdot (\mathbf{T^{Pre}_j} \times Post_t) + \eta^j_{i,t}$$

	$\delta = 2\%$		$\delta = 4\%$	
	(1)	(2)	(3)	(4)
Average road width × Post	0.15***		0.03**	
	(3.69)		(2.24)	
Median road width × Post		0.21***		0.05***
		(4.57)		(2.75)
FAR limit share × Post	8.87***	12.39***	2.72***	3.51***
	(4.86)	(7.66)	(4.58)	(5.91)
Montiel Olea & Pflueger F-test	17.89	32.25	12.96	16.97
First stage F-test (cluster-robust)	12.26	31.78	10.54	18.72
First stage F-test (Cragg-Donald)	270.60	311.86	173.11	195.00
Sargan-Hansen J-test (p-value)	0.96	0.59	0.63	0.86
N	27,925	27,925	27,925	27,925
# Firms	1,488	1,488	1,488	1,488
# Cities	160	160	160	160
Adj. R^2	0.36	0.36	0.28	0.28

Main deck

First stage estimates: counterfactual w/ $\Delta GBRE = 0$

$$\widetilde{RE}^j_{i,t} = \alpha_i + \delta_t + \psi' \cdot (\mathbf{T}^{\mathbf{Pre}}_{\mathbf{j}} \times Post_t) + \eta^j_{i,t}$$

$$\widetilde{RE}^j_{i,\tau+1} = (1-\delta)^k \times RE^j_{i,\tau} \times P_{j,\tau+k}/P_{j,\tau} + \Delta GBRE_{i,t,t+1}$$

	(1)	(2)	(3)	(4)
FAR limit share × Post	7.92***	9.29***	10.82***	14.48***
	(4.32)	(4.59)	(4.80)	(6.47)
Median road width × Post			0.15**	0.27***
			(2.55)	(4.35)
Counterfactual	Yes	No	Yes	No
Montiel Olea & Pflueger F-test	17.34	19.54	11.88	23.15
First stage F-test (cluster-robust)	18.70	21.06	11.86	21.22
First stage F-test (Cragg-Donald)	318.16	420.11	224.61	415.57
N	20,377	20,377	20,377	20,377
# Firms	158	158	158	158
# Cities	1,486	1,486	1,486	1,486
Adj. R^2	0.85	0.63	0.85	0.63

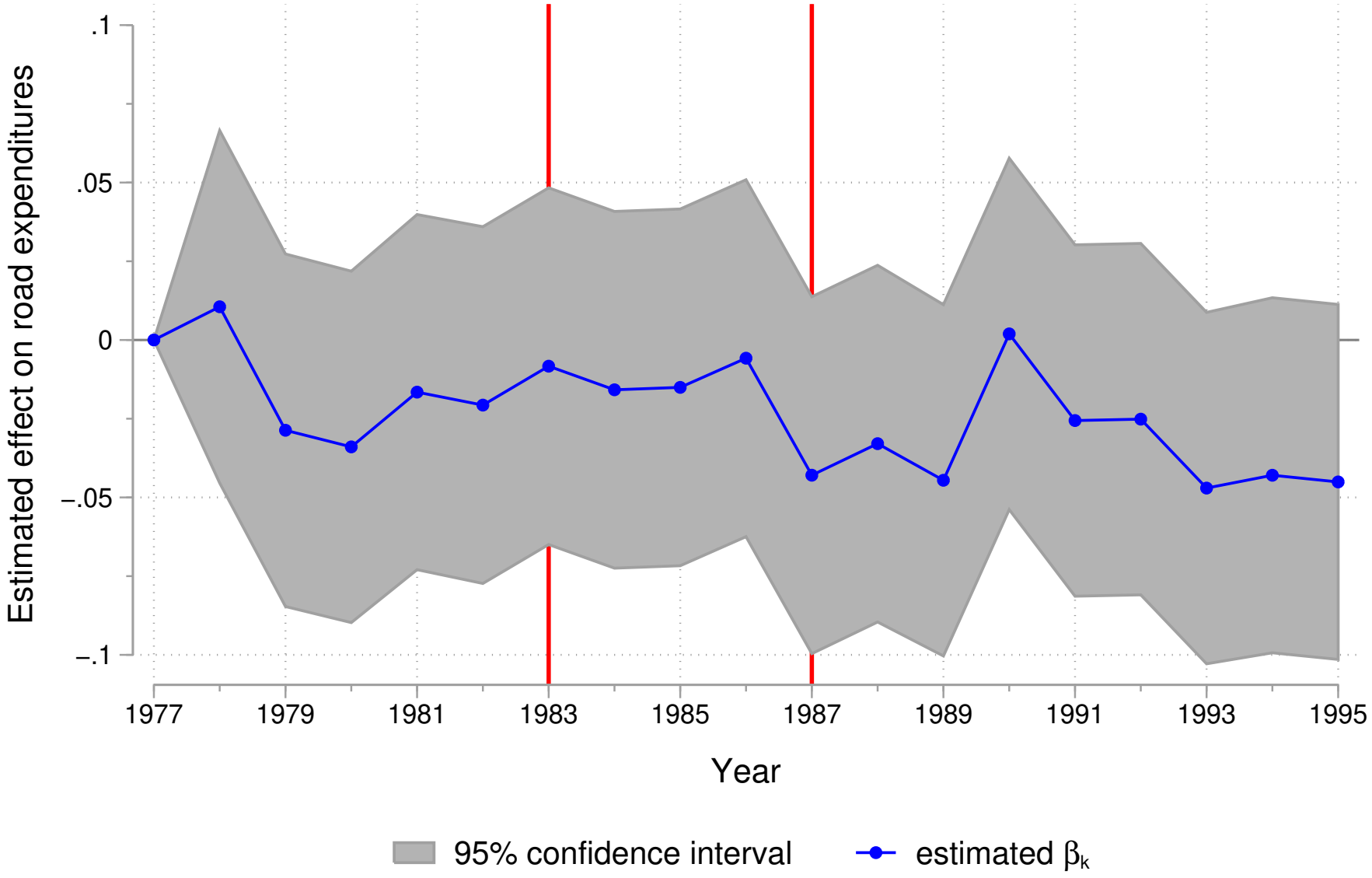
Main deck

Balance on pre-reform observables (FAR measure)

	More exposed	Less exposed	Difference
Assets (100 billion JPY)	1.35	1.07	0.28
Employees	2,613	2,505	108
Firm age	52.35	50.34	2.02
RE firm	0.15	0.16	−0.01
Tokyo/Osaka HQ	0.72	0.65	0.07***
Avg. RE age	21.44	21.27	0.17
Number of creditors	18.32	17.90	0.42
Main bank loan share	0.31	0.32	−0.01
Interest coverage	8.71	12.07	−3.36
ROA	0.06	0.06	0.00
Market to book	3.18	2.60	0.58
PPE/assets	0.23	0.24	−0.01*
Short-term loans/assets	0.13	0.12	0.01
Long-term loans/assets	0.15	0.14	0.01
Bonds payable/assets	0.02	0.02	0.00
N	363	1,126	1,489

Main deck

No clear response of municipal road construction



Main deck

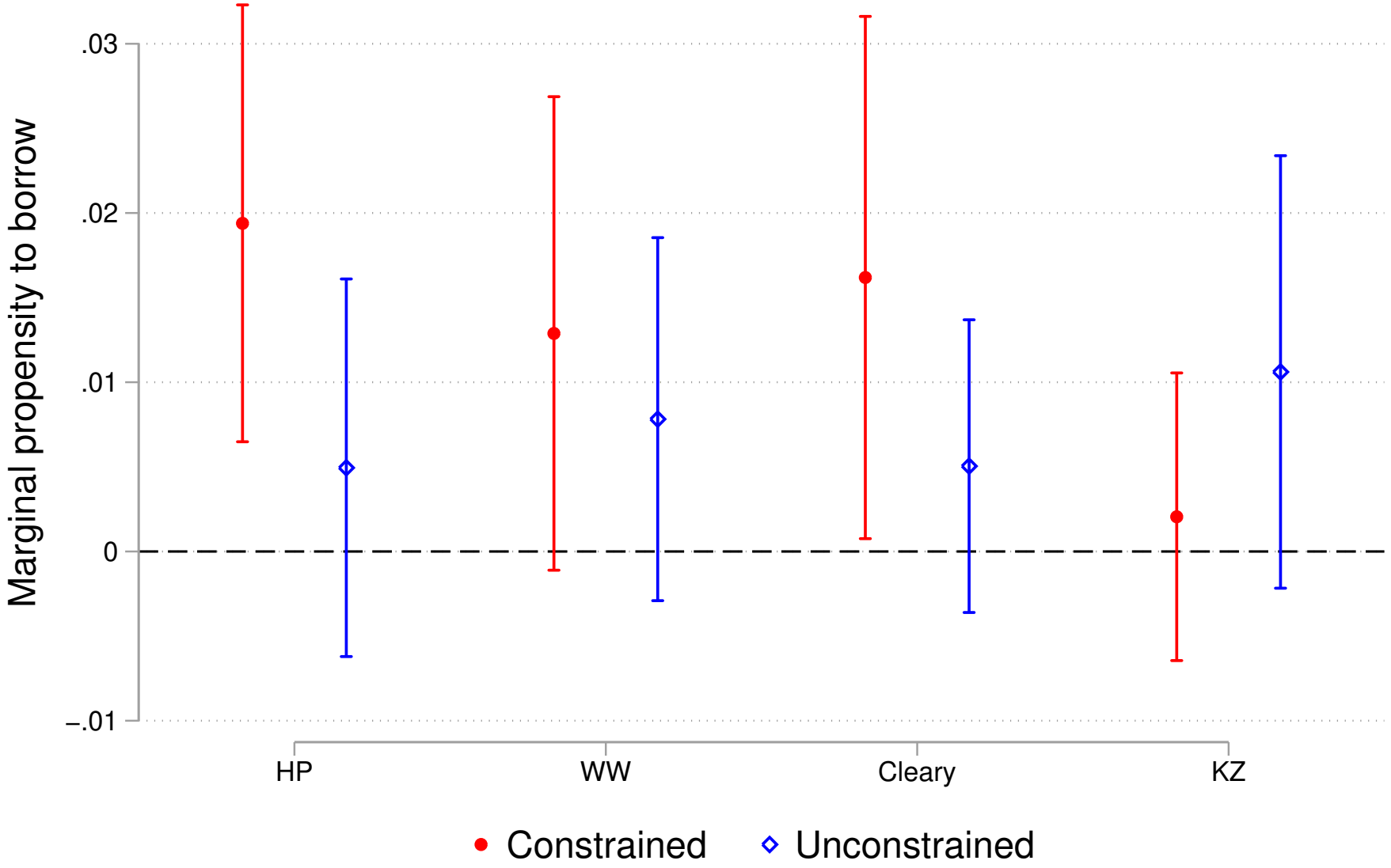
Q RATIO NOT RESPONDING TO REFORM

$$Q^j_{i,t} = \alpha_i + \delta_t + \psi' \cdot (\mathbf{T^{Pre}_j} \times Post_t) + \eta^j_{i,t}$$

	1977-1995		1977-1990	
	(1)	(2)	(3)	(4)
FAR limit share × Post	0.158	−0.128	0.239	−0.090
	(0.166)	(0.095)	(0.214)	(0.107)
Median road width × Post	0.004	0.001	0.004	0.002
	(0.004)	(0.002)	(0.005)	(0.002)
Controls X year FEs		✓		✓
N	27,812	27,684	20,487	20,392
# Firms	1,486	1,478	1,486	1,478
# Cities	158	158	158	158
Adj. R^2	0.43	0.73	0.48	0.76

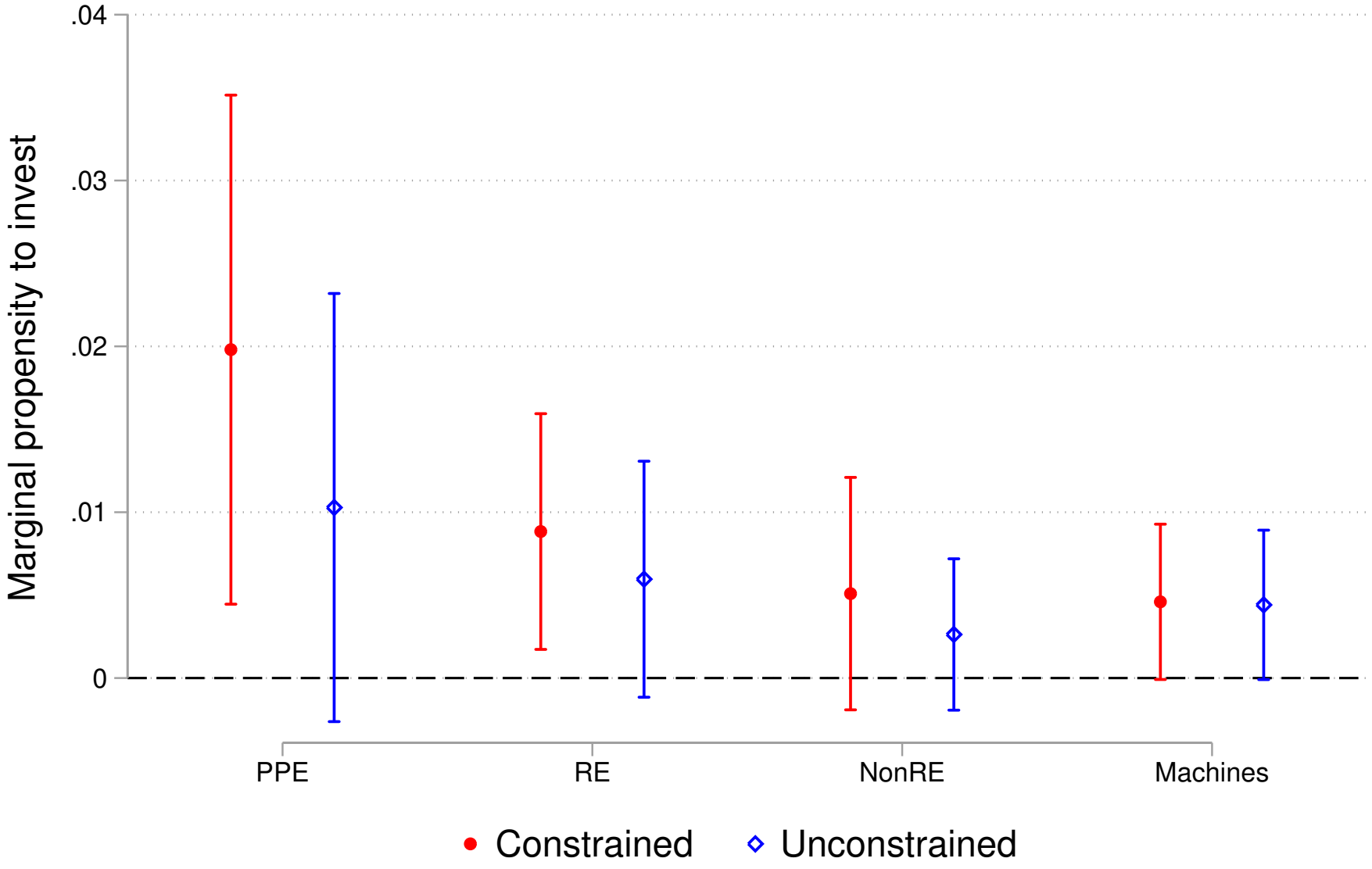
- Land use reform shock unlikely to be driving investment opportunities independently of RE market Main deck

Credit constrained firms more likely to borrow



Main deck

Credit constrained firms also more likely to invest!



Main deck

RE important even conditional on cash flows

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Market RE	0.007***	0.004***	0.010**	0.010**	0.008**	0.014*	0.013
	(0.001)	(0.001)	(0.004)	(0.004)	(0.004)	(0.008)	(0.009)
EBITDA		0.044***		0.059***	0.087***	0.076***	0.045***
		(0.008)		(0.008)	(0.010)	(0.014)	(0.010)
OCF		−0.094***			−0.092***	−0.092***	−0.095***
		(0.006)			(0.007)	(0.008)	(0.007)
Lagged cash		−0.005***					−0.006***
		(0.001)					(0.001)
Q		0.007***					0.006***
		(0.001)					(0.001)
Estimation	OLS	OLS	IV	IV	IV	IV	IV
Controls X year FEs		✓				✓	✓
First stage F-test (cluster-robust)	–	–	33.08	30.99	31.46	23.19	24.07
First stage F-test (Cragg-Donald)	–	–	294.67	298.00	299.81	94.36	80.87
N	27,744	26,330	27,687	27,687	27,687	26,829	25,458

Main deck

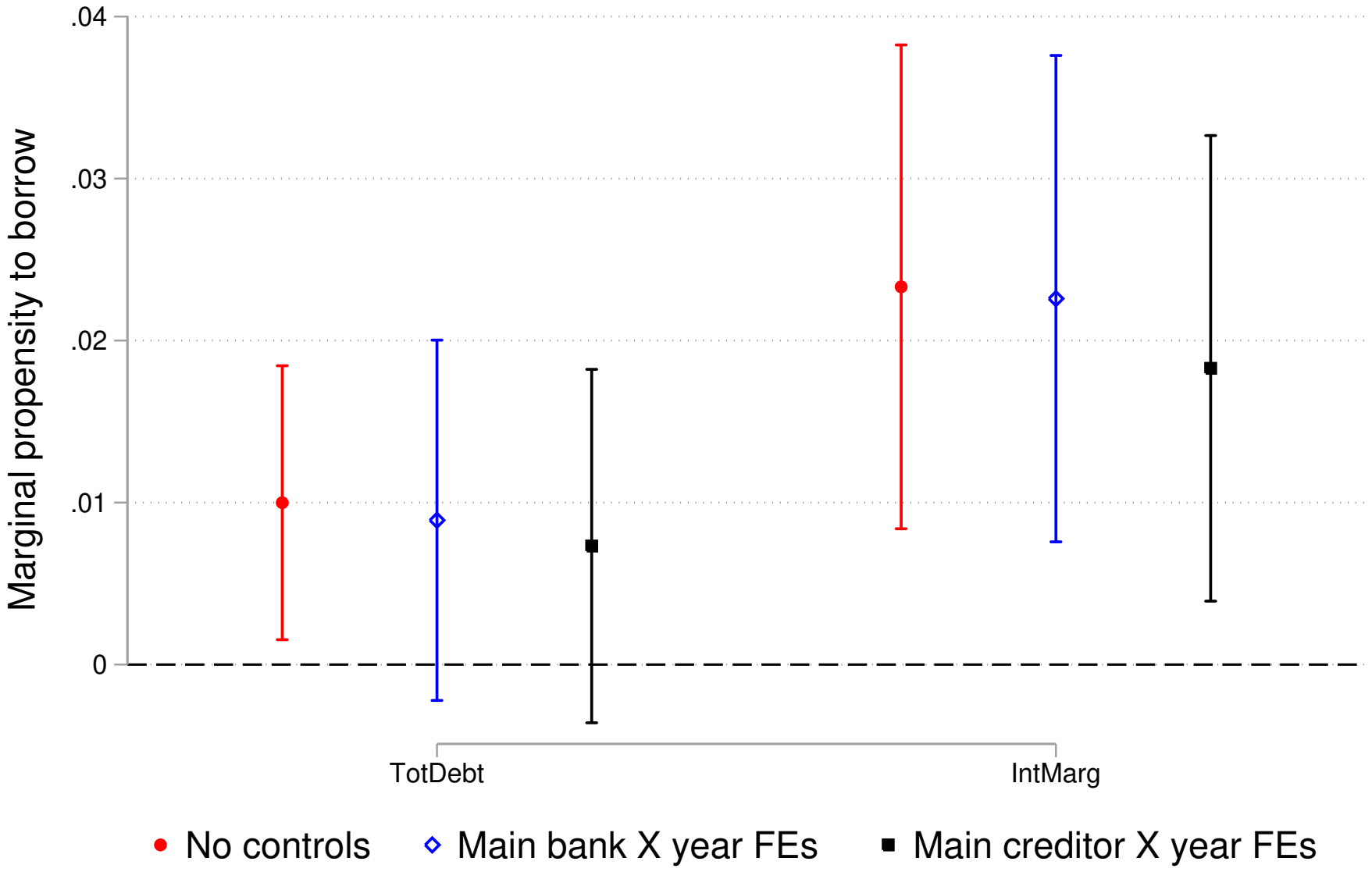
Similar results using firm-level reform exposure

	Total debt issues				Real estate investment			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Market RE	0.008***	0.007***	0.009**	0.006***	0.014***	0.013***	0.006**	0.003**
	(0.001)	(0.001)	(0.004)	(0.002)	(0.001)	(0.001)	(0.003)	(0.001)
Effect in standard deviations	0.11	0.15	0.12	0.13	0.44	0.66	0.19	0.15
Estimation	OLS	OLS	IV	IV	OLS	OLS	IV	IV
RE valuation	HQ	Firm	HQ	Firm	HQ	Firm	HQ	Firm
Montiel Olea & Pflueger F-test	–	–	23.46	104.94	–	–	21.72	120.36
First stage F-test (cluster-robust)	–	–	24.27	127.03	–	–	20.22	174.29
First stage F-test (Cragg-Donald)	–	–	257.94	633.62	–	–	264.00	485.78
N	24,998	24,998	24,998	24,998	25,182	25,182	25,182	25,182
# Firms	1,341	1,341	1,341	1,341	1,341	1,341	1,341	1,341
# Cities	151	151	151	151	151	151	151	151

- Much stronger first stage, but smaller point estimates because RE/transport sector firms do not itemize facilities

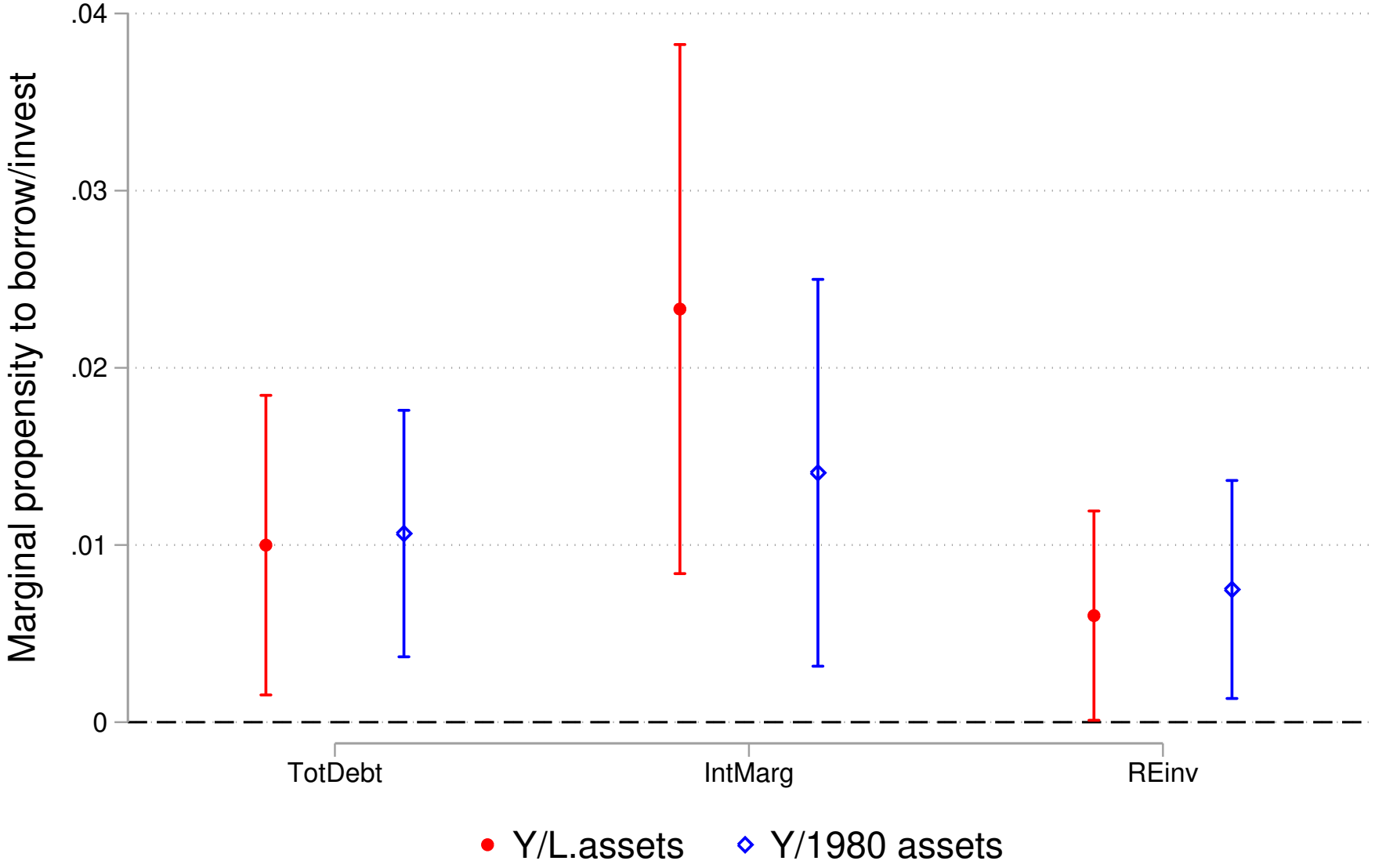
Main deck

Results not driven by credit supply channel



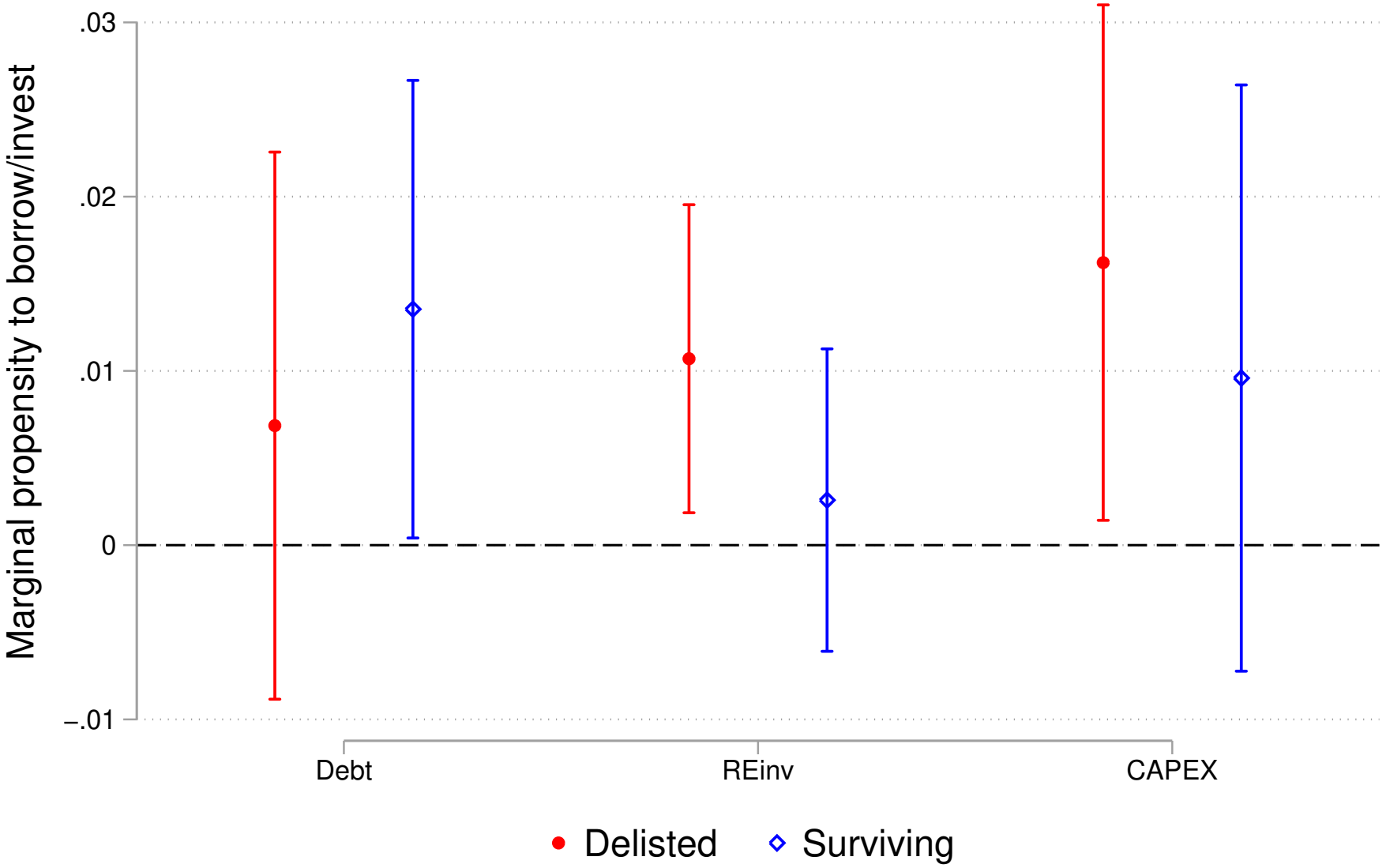
Main deck

Robustness to asset normalization



Main deck

Heterogeneous responses to RE shock by survivorship



Main deck

Identifying zombie firms

- Well-documented prevalence of "zombie firms" starting in mid-1990s
- Use zombie index measure of Caballero et al. (2008)
- Idea: compute average minimum required interest payment and compare to firms' actual payments:

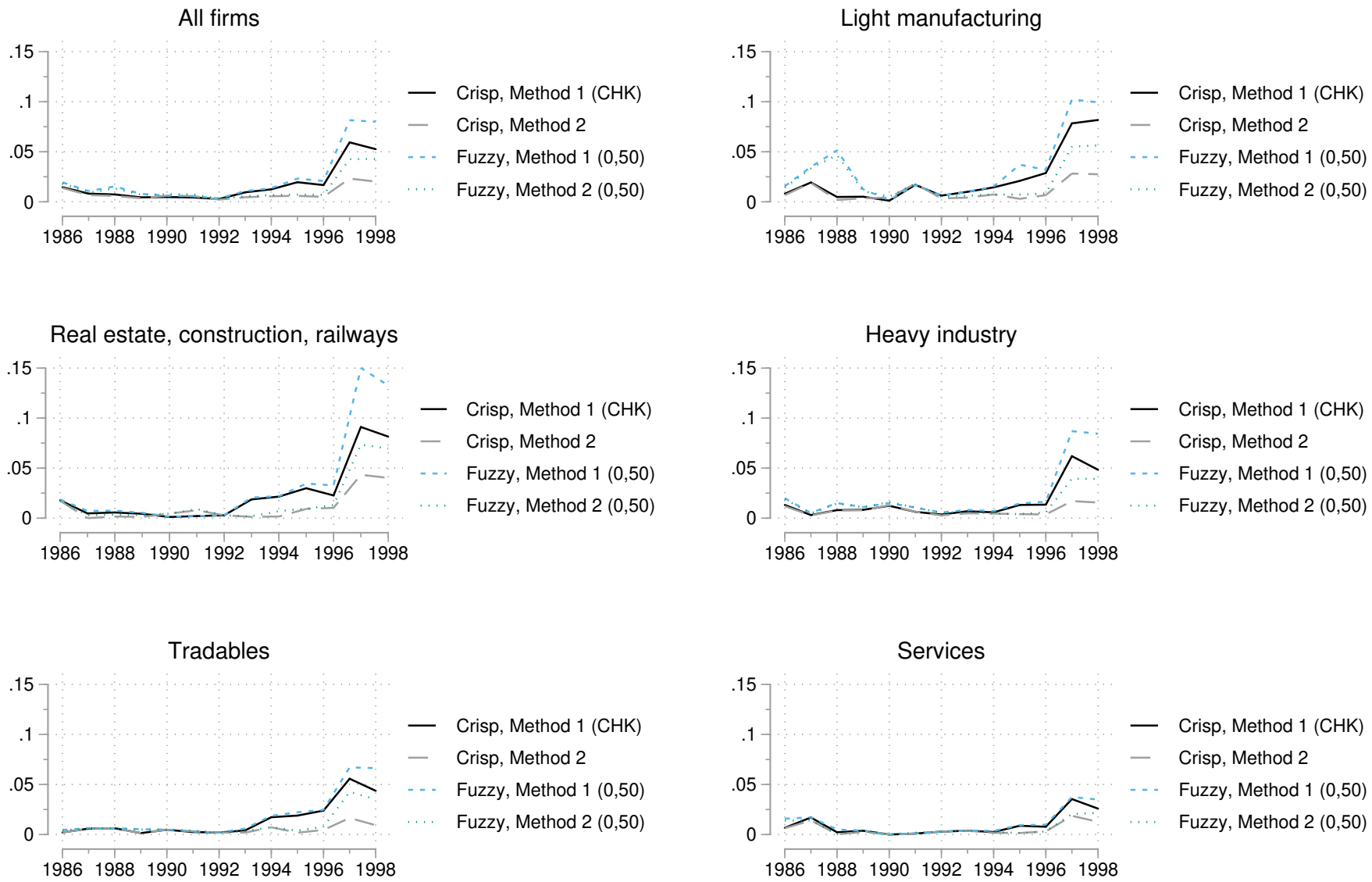
$$R^* = rs \cdot BS + rl \cdot BL + rcb \cdot Bonds \tag{3}$$

$$\text{Interest gap: } (R - R^*)/B \tag{4}$$

- Compute minimum interest payments using BOJ prime rate series
- Evergreening behavior often illicit and unlikely to show up in alternative measures based on accounting variables

Main deck

Mid-1990s uptick in zombie lending



Main deck

Linking land use deregulation to zombie firms

- Problem: firm locations might have changed during the RE boom
  - HQ in 1980 might have either changed locations or become less important as firms acquire new facilities
  - No effect on zombie lending when shock assigned purely based on HQ
- Solution: weighted version of FAR instrument that takes into account spatial distribution of firm i's production

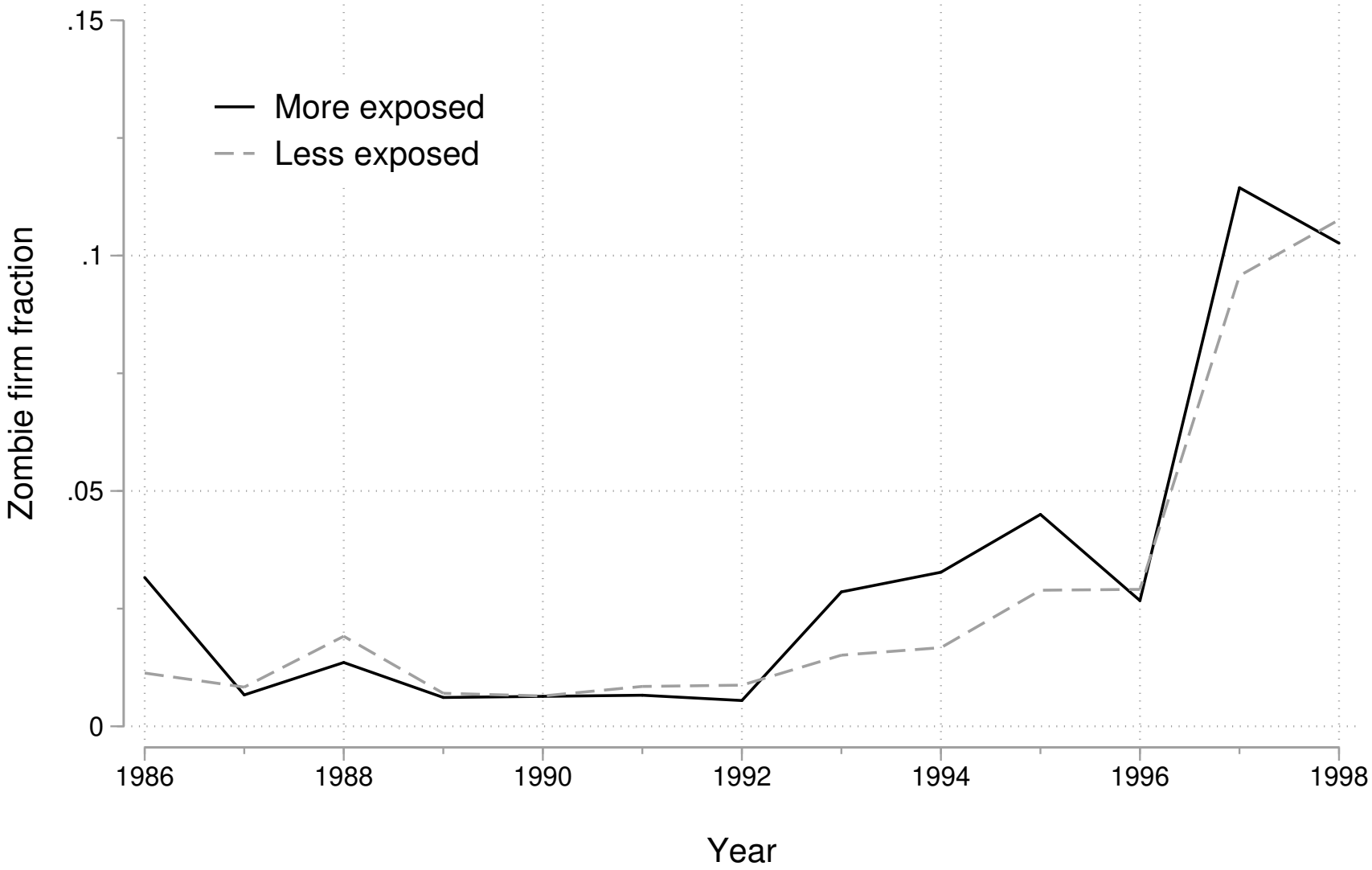
$$\overline{T}_i = \sum_{j=1}^{n_i} \omega_{i,j} \cdot \left(1 - T_j^{Pre}\right) \tag{5}$$

$$\omega_{i,j} = \frac{N_{i,j}}{\sum_{k=1}^{n_i} N_{i,k}} \tag{6}$$

- $\omega_{i,j}$ are employment or RE asset shares across n_i facility locations

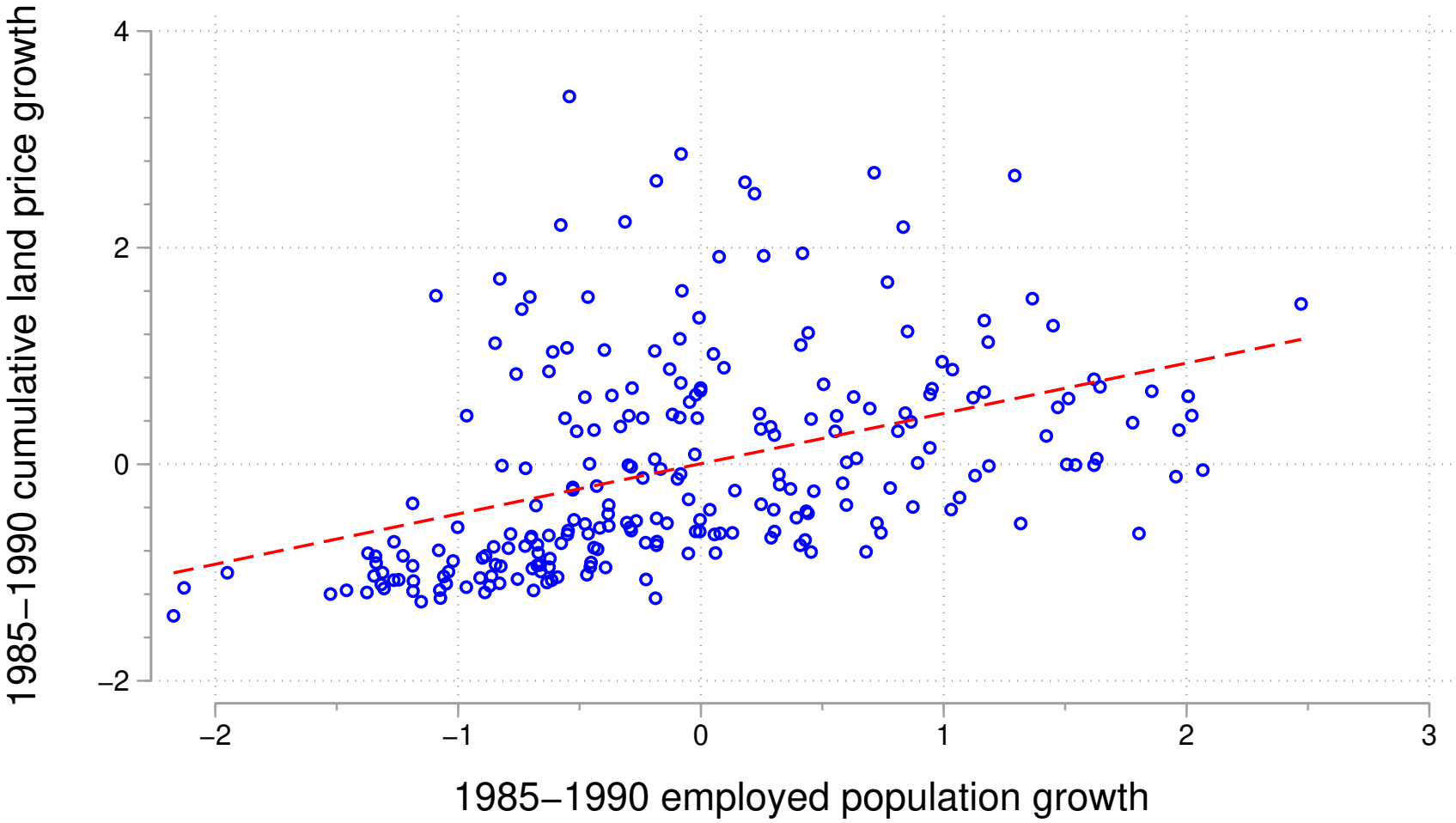
Main deck

Zombie incidence higher in land use constrained areas



Main deck

Employee flows highly correlated with price growth



β = 0.46
N = 237
R–squared = 0.1763

Main deck

Testing the model-implied exclusion restriction

- Sorting model suggests $\gamma \downarrow \implies L \uparrow$, which can impact firm decisions even if prices stay fixed (i.e. L and K are complements) Main deck

$$Y^j_{i,t} = \alpha_i + \delta_t + \beta RE^j_{i,t} + \Delta L_{i,t} + \epsilon^j_{i,t}$$

	Debt issues		RE investment	
	(1)	(2)	(3)	(4)
Market RE	0.009***	0.007	0.006**	0.009**
	(0.003)	(0.006)	(0.003)	(0.004)
YOY employment growth (100s of employees)	0.030***	0.024***	0.031***	0.030***
	(0.002)	(0.003)	(0.002)	(0.002)
Estimation	IV	IV	IV	IV
First stage F-test (cluster-robust)	29.41	15.79	29.41	15.79
First stage F-test (Cragg-Donald)	267.18	80.49	267.18	80.49
Controls X year FEs		✓		✓
N	27,433	26,926	27,433	26,926

Intuition: local feedback loops in the model

- Firms can borrow s.t. collateral constraint that depends on RE prices and invest in K^R and K^N

- Equilibrium price determined by agglomeration force $A \equiv L^{\omega}$ and local demand from workers and firms

$$P_{j,t} = \overline{P}_j \cdot \left[A(L_{j,t})\right]^{\xi} \cdot L_{j,t}^{\gamma_j} \cdot (K_{j,t}^R)^{\sigma} \tag{7}$$

- Compare pre-reform and post-reform steady state after $\gamma_j \downarrow$

$$\Delta \log P_j = \underbrace{\Delta\Big(\gamma_j \cdot \log L_j\Big) + \omega\xi \cdot \Delta \log L_j}_{\text{static}} + \underbrace{\sigma \cdot \Delta \log K_j^R}_{\text{dynamic}} \tag{8}$$

- Idea: land use shock induces firm RE investment, pushing up prices on top of static productivity effect

Full model Estimation Main deck

Employment and wages

- Each city j produces good with Cobb-Douglas production:

$$Y_j = A(N_j) \cdot L_j^{\alpha} K_j^{\eta} T_j^{1-\alpha-\eta}$$

- Perfect labor and capital markets: $W_j = MPL_j$, $R = MPK_j$
- Labor supply pinned down by utility maximization:

$$V = \frac{W_j \cdot Z_j}{P_j^{\beta}} \tag{9}$$

- Indirect utility = real purchasing power of amenities Z_j
- Assumes constant expenditure share of housing β

Main deck

Mapping FAR limits into supply inelasticity

- How does the deregulatory shock map into the model?
- FAR limits serve as a "tax" on RE developer profits

$$\pi_j = \max_{L_j^D} \left\{ P_j \cdot \left(1 - \frac{H_j}{\overline{H}_j}\right) \left(L_j^D\right)^{\rho} - W_j^D L_j^D \right\} \tag{10}$$

  - Developer draws L^D from a segmented labor market
  - Can only build up to limit on building stock $\overline{H}$ determined by FAR
  - Supply inelasticity proportional to building stock relative to slack in the FAR constraint

$$\gamma_j \propto \frac{\overline{H}_j}{\overline{H}_j - H_j} \tag{11}$$

Main deck

How does the model change with imperfect mobility?

- Imperfect mobility $\implies$ weaker spatial sorting channel, less separation between ghost towns and superstar cities
- Workers prefer some locations more than others w/idiosyncratic taste shocks $\epsilon_{i,j}$ drawn from extreme value distribution
- New worker sorting condition depends on $L \implies$ labor supply curve is no longer perfectly elastic

$$\overline{V} = \frac{W_j Z_j}{P_j^{\beta} L_j^{1/\nu}}$$

- New condition for $\gamma \downarrow$ shock to generate positive shock to prices: $\omega > 1 - \alpha - \eta + (1 - \eta)/\nu$
- With $1/\nu = 0.3$ from Hornbeck & Moretti (2018), need $\omega > 0.36$ for $P \uparrow$ absent any firm investment response Main deck

Full firm's problem (dynamic version)

- Firms choose $L_t, K^R_{t+1}, K^N_{t+1}, D_{t+1}$ subject to investment law of motion and CC

$$\mathcal{L} = \sum_{t=0}^{\infty} \theta^t \Bigg\{ A(N_t) \cdot L_t^{\alpha} K_t^{\eta} T_t^{1-\alpha-\eta} - W_t L_t - \Big(K_{t+1} - (1-\delta) \cdot K_t \Big)$$

$$- r_t D_t + \Delta D_{t+1} + \mu_t \cdot \Big[\psi P_t K^R_{t+1} - D_{t+1} \Big] \Bigg\} \tag{12}$$

- Aggregate $K = f(K^R, K^N)$ over RE and non-RE capital (machines)
- FOC w.r.t. D_{t+1}: $1 - \mu_t = \theta R_t$, so CC binds for all firms whenever $\theta R < 1$
- Can introduce heterogeneity in θ_j to get occasionally binding constraint in the cross-section Main deck

Local system of equilibrium conditions

- For each city solve the set of five equations in five unknowns:

1. Labor market equilibrium: $\alpha L^{\alpha+\omega-1}\left[f(K^R, K^N)\right]^{\eta} T^{1-\alpha-\eta} = VP^{\beta}/Z$
2. RE investment: $(1-\theta R)\psi P = [1-\theta(1-\delta)] \cdot f'_R - \theta L^{\omega} \cdot F'_{K^R}$
3. Non-RE investment: $\theta A(N) \cdot F'_{K^N} = [1-\theta(1-\delta)] \cdot f'_N$
4. Collateral constraint (for $\theta R < 1$): $\psi P K^R = D$
5. RE market equilibrium: $P = \overline{P} \cdot L^{\omega\xi+\gamma} \cdot (K^R)^{\sigma}$

Main deck

Are these mechanisms supported by the data?

1. Run regressions implied by the model on the data
   - Static version: data assigns large role to agglomeration effect in 1980s, but negligible supply effect
   - Dynamic version: $\sigma \geq \omega$ during the 1980s
2. Solve for equilibrium in each city and calibrate ω, σ to match reduced form estimates
   - ω: reduced form effect of land use shock on value of RE assets fixed from a baseline period (static)
   - σ: reduced form effect of land use shock on RE inv. (dynamic)
   - Do separately for versions of model with full/partial/no CC binding

- Both methods yield $\sigma \approx 0.6, \omega \approx 0.3$ during the 1980s

Main deck

Model-implied regression using city-level data

$$\Delta \log P_j = a \cdot \Delta\left(\gamma_j \cdot \log L_j\right) + \omega\xi \cdot \Delta \log L_j + \sigma \cdot \Delta \log K_j^R$$

Time period:	1980-90	1980-85	1985-90
Panel A: Employed population			
a	-0.01	0.01^{***}	-0.01^{*}
ω	0.28^{***}	0.11^{***}	0.57^{***}
σ	0.45^{***}	0.12^{***}	0.40^{***}
Adj. R^2	0.76	0.56	0.76
Panel B: Overall population			
a	-0.01^{*}	0.01^{***}	-0.01^{**}
ω	0.23^{***}	0.13^{***}	0.60^{***}
σ	0.66^{***}	0.14^{***}	0.74^{***}
Adj. R^2	0.69	0.52	0.64

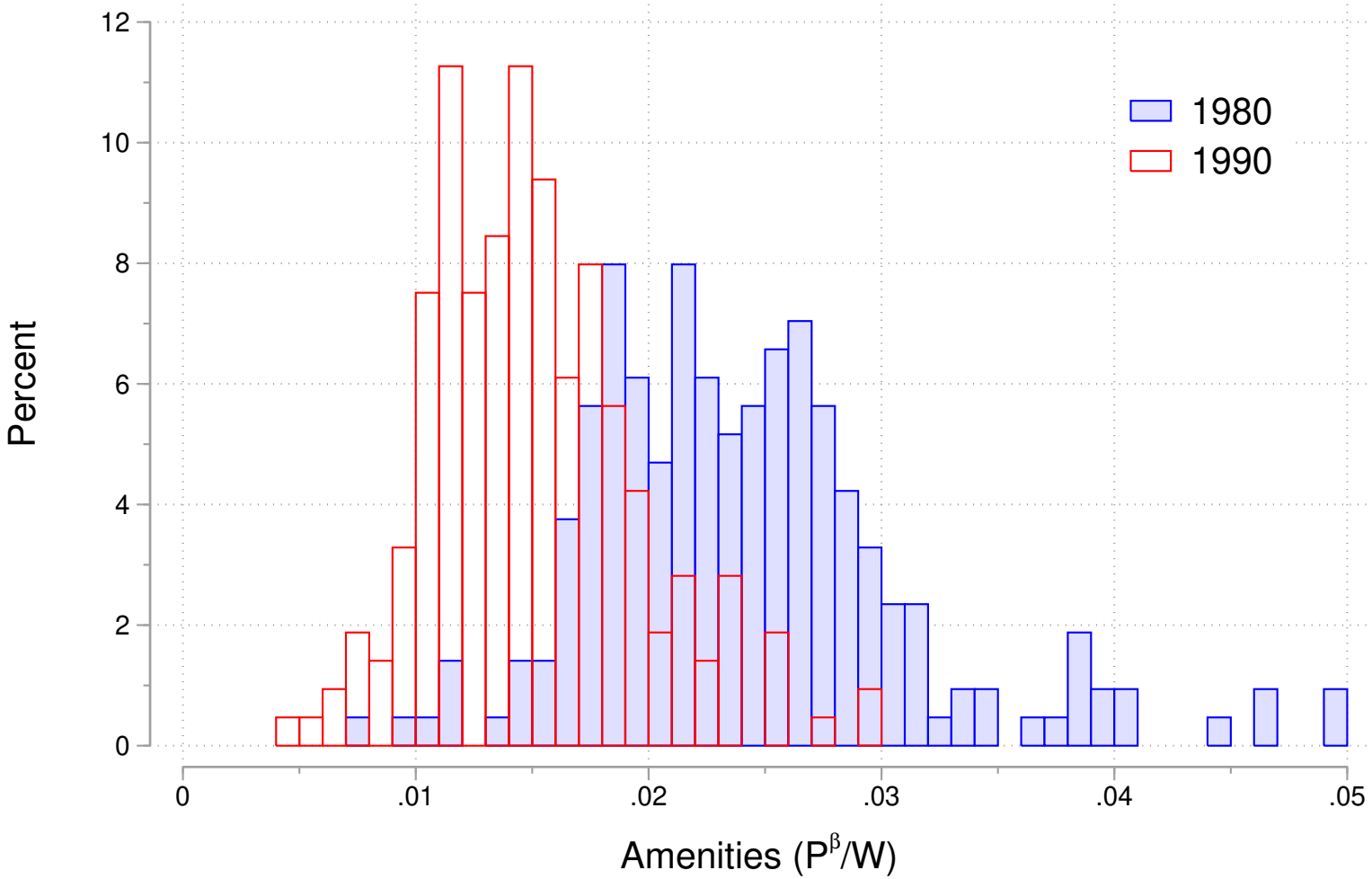
Main deck

Baseline calibration

Parameter	Notation	Value	Target/Source
Panel A: Global parameters			
Agglomeration elasticity	ω	0.30	Reduced-form evidence
Price elasticity of RE inv.	σ	0.60	Reduced-form evidence
Borrowing limit	ψ	0.45	Debt/market RE = median
Overall depreciation rate	δ	0.05	Input share-weighted depreciation
Net interest rate	r	0.05	BOJ LT prime rate
Firm discount factor	θ	0.95	Median WACC; $\theta R < 1$
Capital share	η	0.30	Karabarbounis & Neiman (2014)
Labor share	α	0.55	Karabarbounis & Neiman (2014)
RE share in capital	s	0.39	Share of fixed assets in DBJ data
Housing expense share	β	0.15	Family Income and Expenditure Survey
Panel B Local parameters			
RE supply inelasticity	γ_j	Varies	Statutory FAR limits
Land endowment	T_j	Varies	Available land share (à la Saiz)
Amenities	Z_j	Varies	Income residual: P_j^{β}/W_j

Main deck

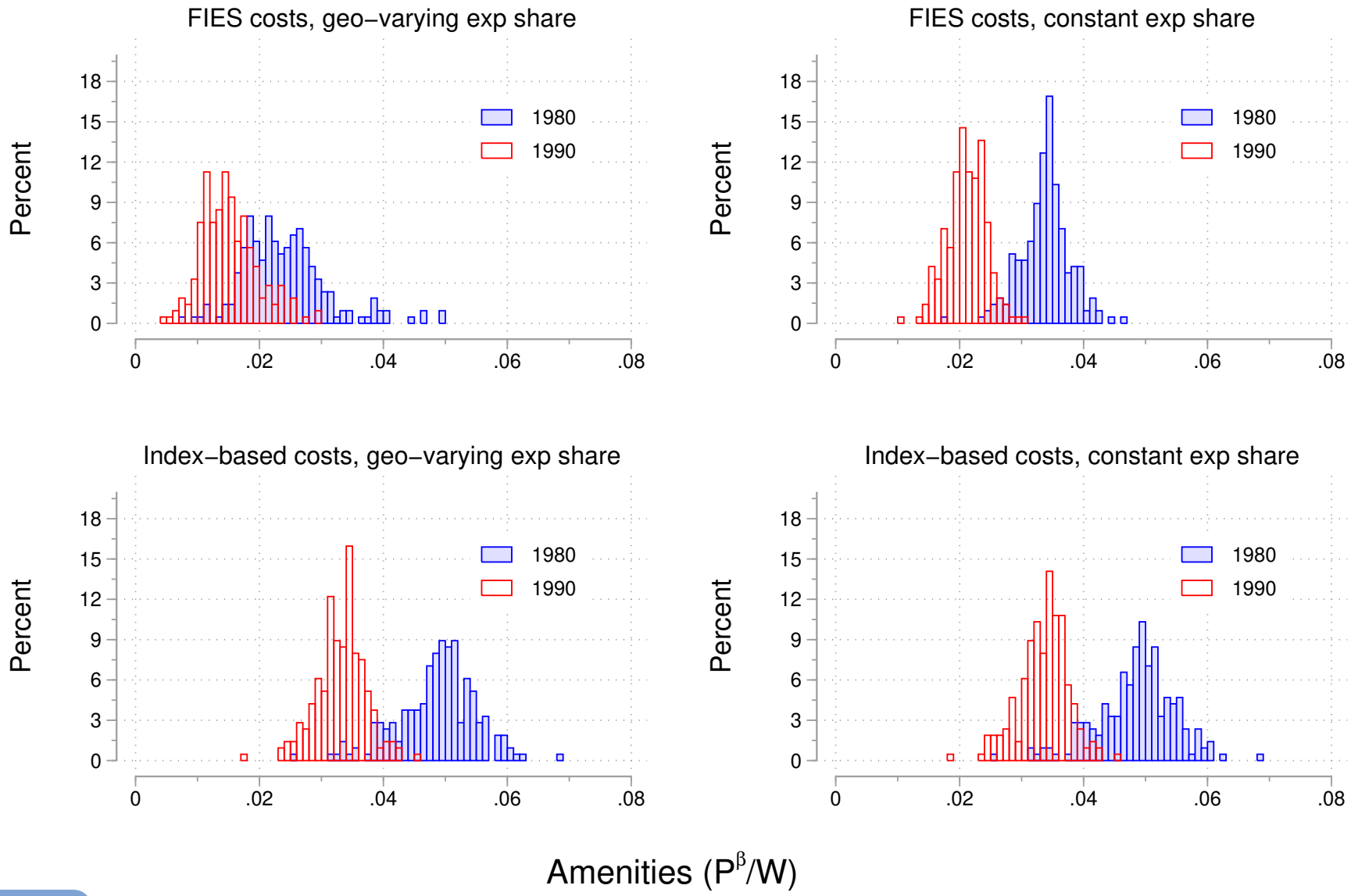
Distribution of amenities shifts inward during boom



- In expenditure microdata β stays roughly constant (sticky rents/homeowners), while wages grow in areas where prices grow

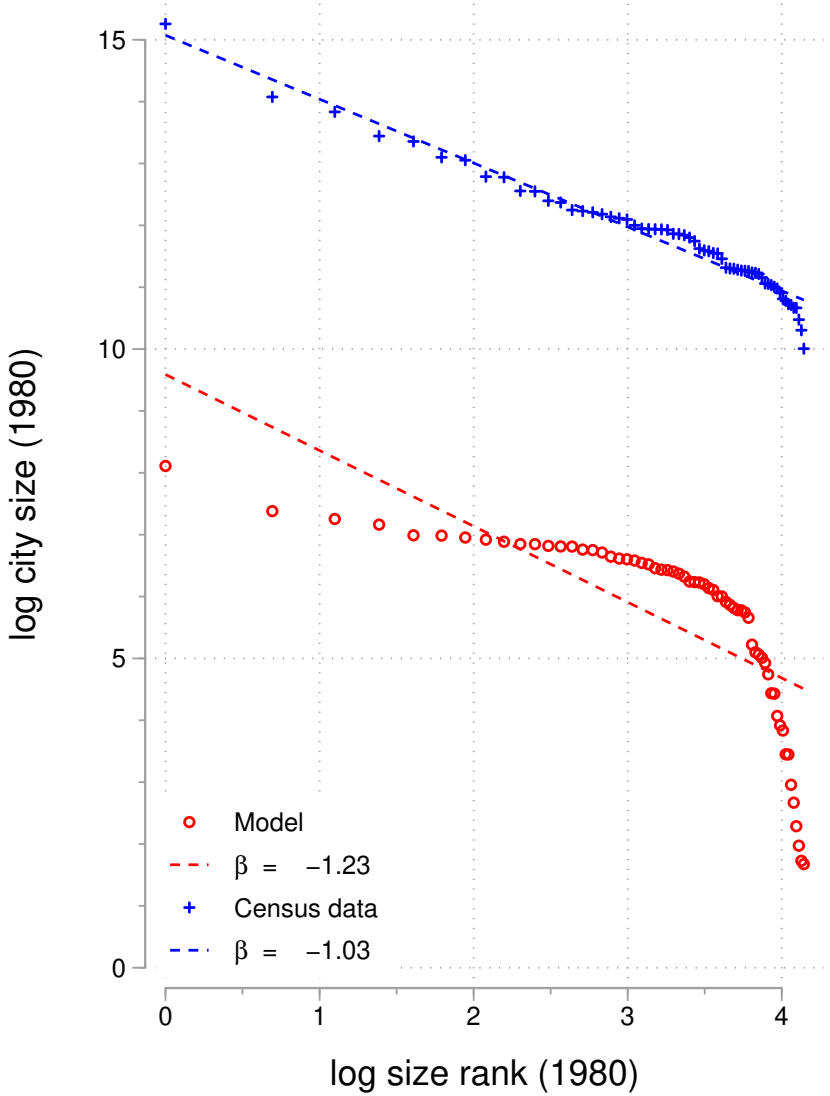
Main deck

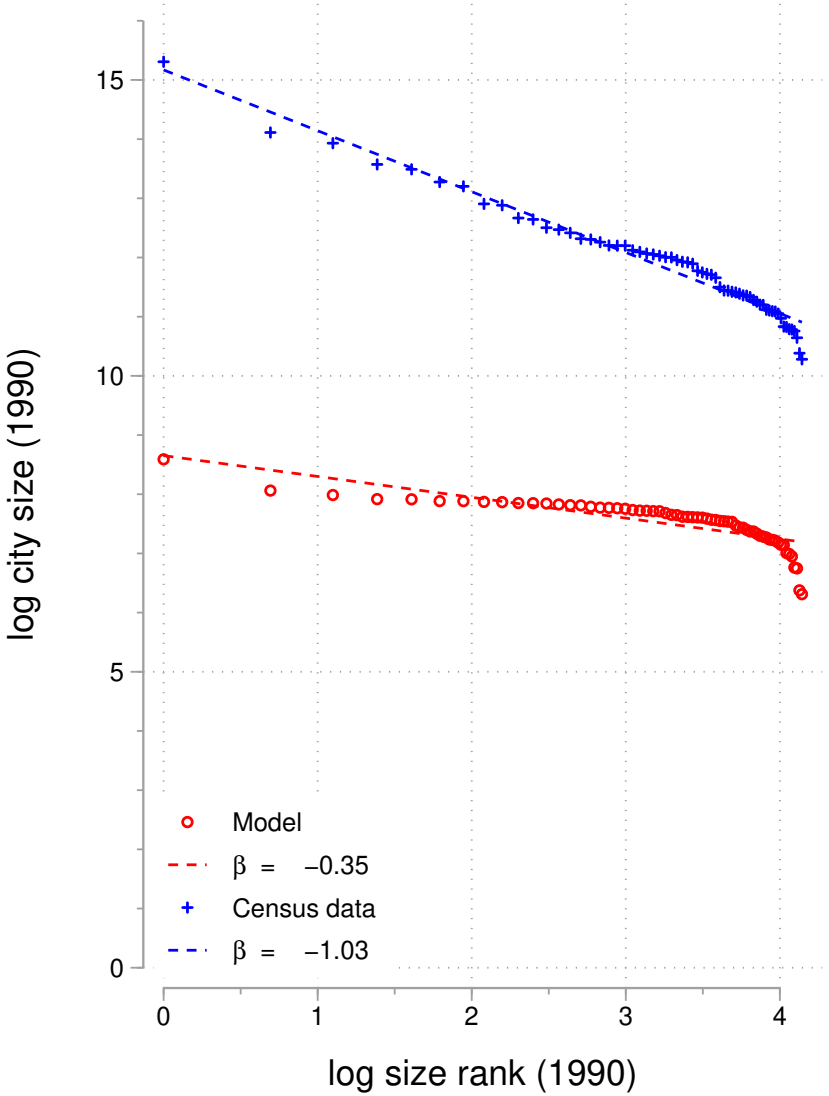
Robustness to different measures of amenities



Main deck

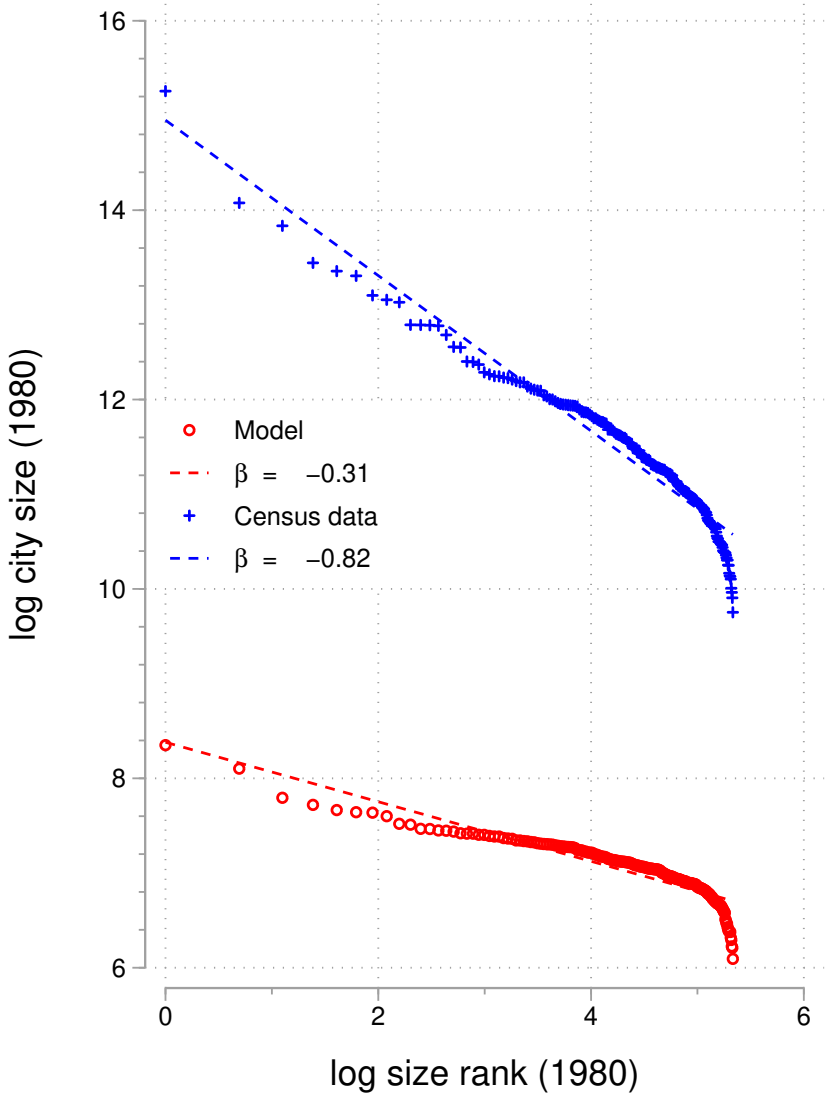
Partial CC model: superstar cities become more special

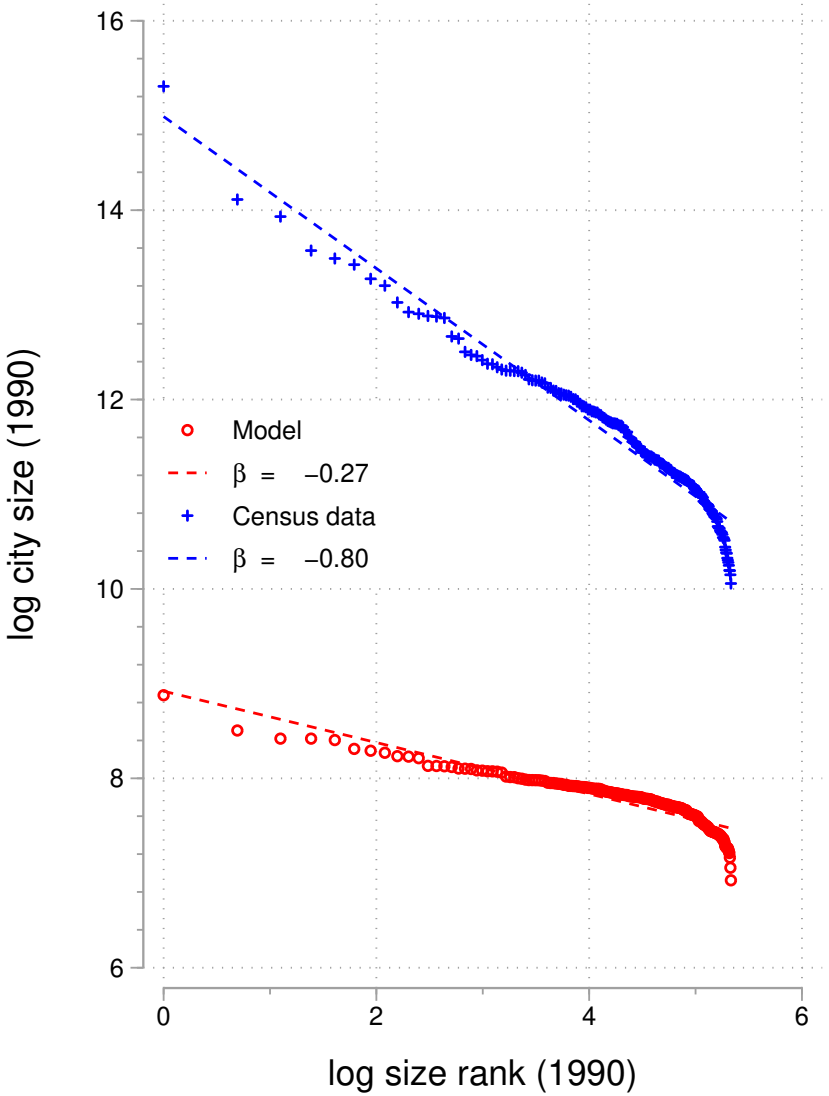




Main deck

Full CC model: little change in distribution





Main deck