

# How Rents and Expenditures Depreciate: A Case of Tokyo Office Properties

December 14, 2017

Hitotsubashi-RIETI Workshop on Real Estate and the Macro Economy

---

JIRO YOSHIDA (PENN STATE & UNIV. OF TOKYO)

KOHEI KAWAI (XYMAX REAL ESTATE INSTITUTE)

DAVID GELTNER (MIT)

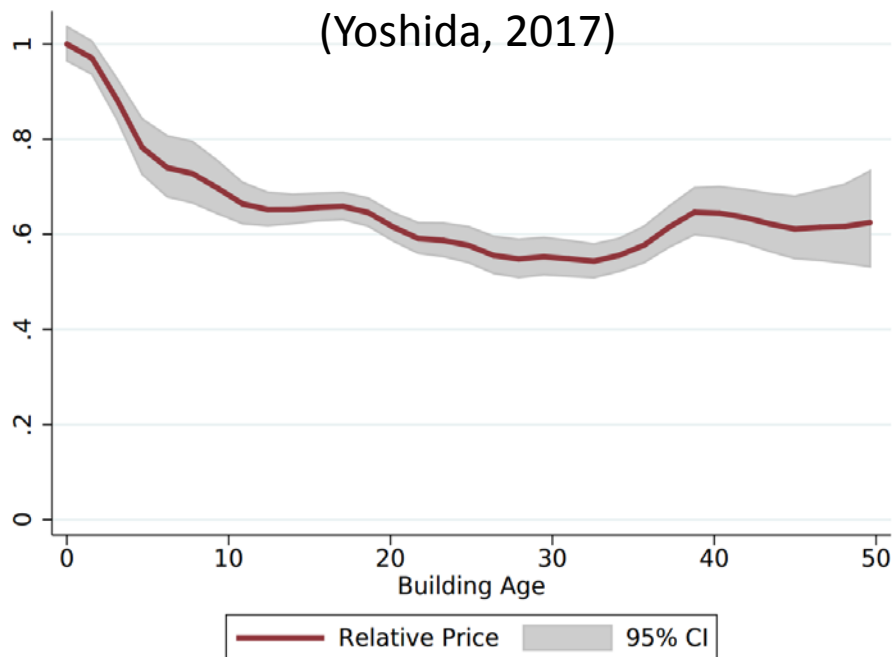
CHIHIRO SHIMIZU (NIHON UNIVERSITY)

# Motivation

The property value depreciates at a decreasing rate.

Age profile of commercial property value in Tokyo

(Yoshida, 2017)



Depreciation Rates:  
5.3%/y for 1-5 years,  
2.1%/y for 21-25 years,  
0.9%/y for 41-45 years

What causes this pattern?

# The link between cash flows and the property value

---

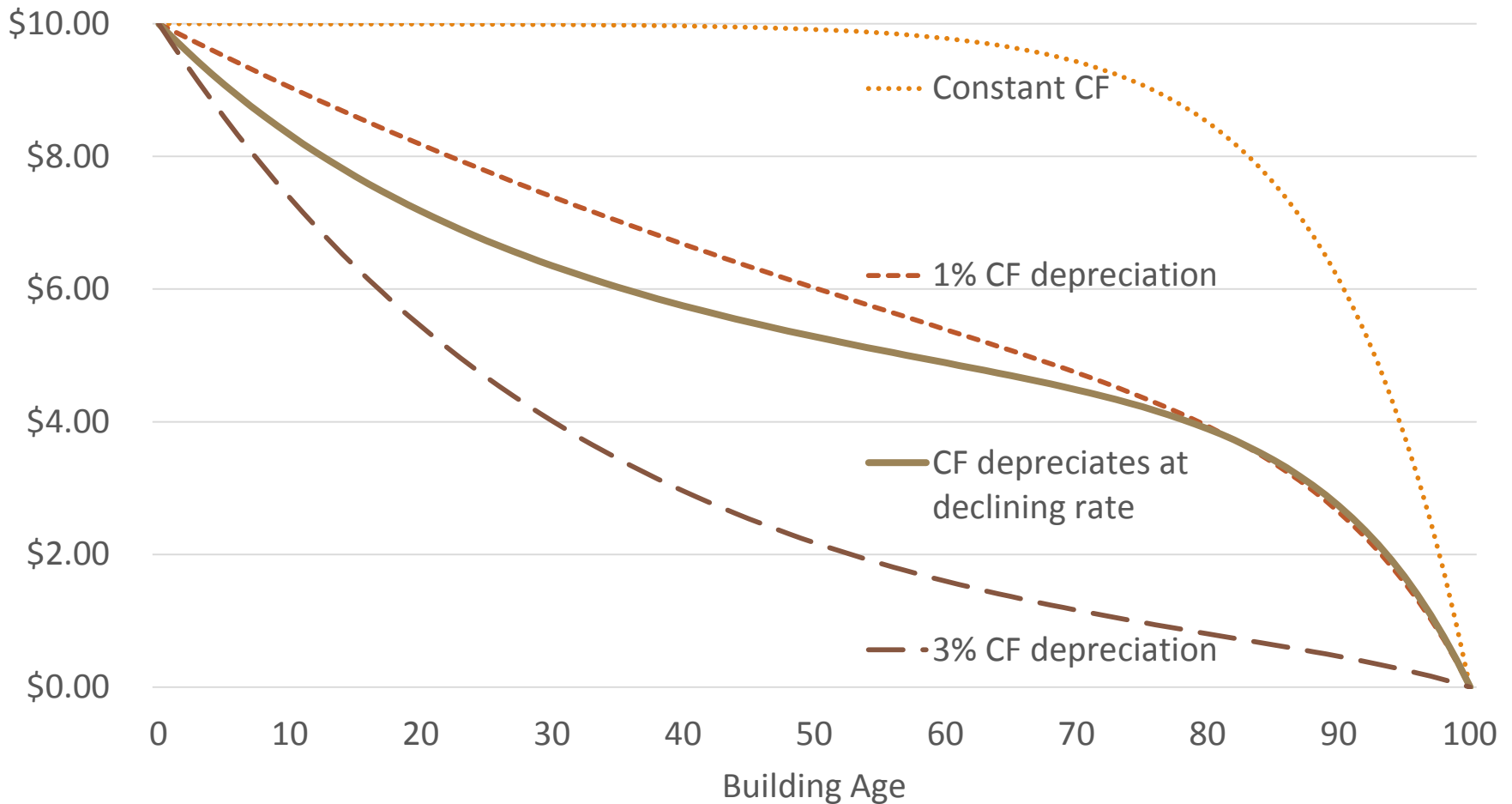
The value of a property of age  $a$ :  $V_a = S_a + O_a$

- $S_a = \int_a^T e^{-r(u-a)} N_u du$  is the value of the existing building
- $O_a$  is the value of a redevelopment option,  
which is exercised when  $V_0 - I - S_a = O_a$  and  $S'_a + O'_a = 0$ .

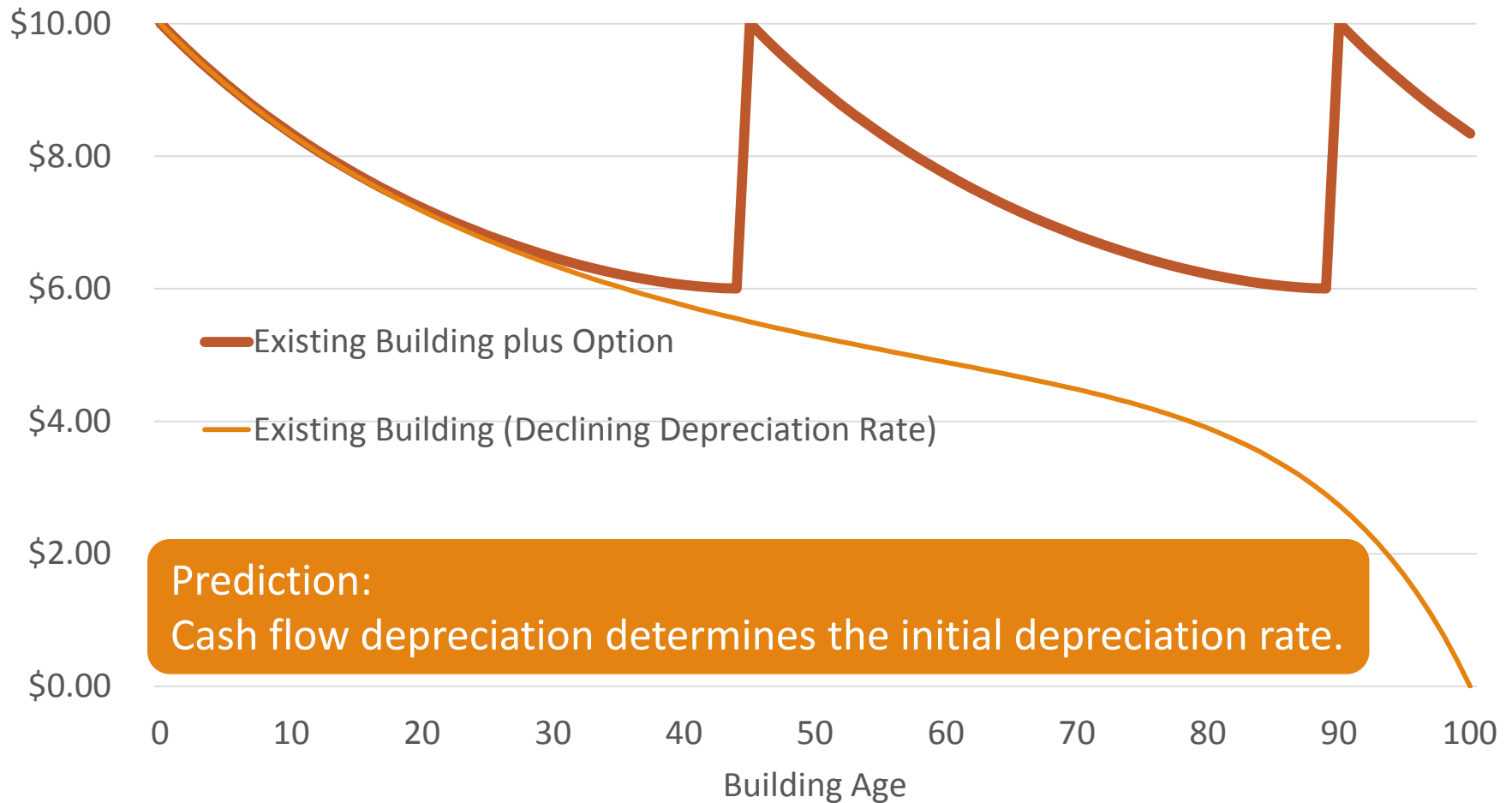
The age profile of the property value is determined by

1. The age profile of cash flows  $N_a$
2. A shorter remaining physical life ( $a \rightarrow T$ )
3. The redevelopment option value

# Numerical Example: Value of the Existing Building



# Property Value = Existing Bldg. + Option



# Literature

---

## Structure value depreciation

- Commercial real estate
  - Japan
    - 5.7%-7.2% based on National Accounts (Hayashi, 1991 and ESRI, 2011)
    - 9.8-10.8% (Yoshida, 2017)
    - Early demolition (Diewert and Shimizu, 2015, and Yoshida, 2017)
  - U.S.
    - 2.0% for retail, 2.5% for office, 2.7% for warehouse, and 3.6% for factory based on asset prices (Hulten and Wikoff, 1981)
    - 5.2%-7.2% based on the National Accounts (Hulten and Wykoff, 1981b, Hayashi, 1991).
    - 3% for all commercial real estate and 3.3%-4.0% for apartments (Fisher et al., 2005, Geltner and Bokhari, 2015).
- Residential
  - Japan
    - 1%-2% (Seko, 1998) to 15% (Yoshida and Ha, 2001), 8.5%-9.9% (Hayashi, 1991) 4.7%-5.4% (ESRI, 2011), 6% (Yoshida, 2017)
  - US
    - 1.36% (Leigh, 1980), 1.89% (Knight and Sirmans, 1996), and 1.94% (Harding, Rosenthal, and Sirmans, 2007), 1.57% between 1948 and 2001 (Davis and Heathcote, 2005). 1.1% and U-shaped (Coulson and McMillen, 2008)

## Small literature on the rent and expenditure depreciation, all on the US

- Residential rent depreciation ranges from 0.11% to 0.36%/year in the United States (Lane, Randolph, and Berenson, 1988).
- Age profile of operating expenses (Taubman and Rasche, 1969)
- Age profile of capital expenditures (Geltner and Bokhari, 2015)

# This Study

---

Estimates the age profile of office cash flows

- New rents, rents for sitting tenants, average rents, operating expenses, net operating income, capital expenditures, and net cash flow

Proprietary data from Xymax, a major property management firm in Tokyo.

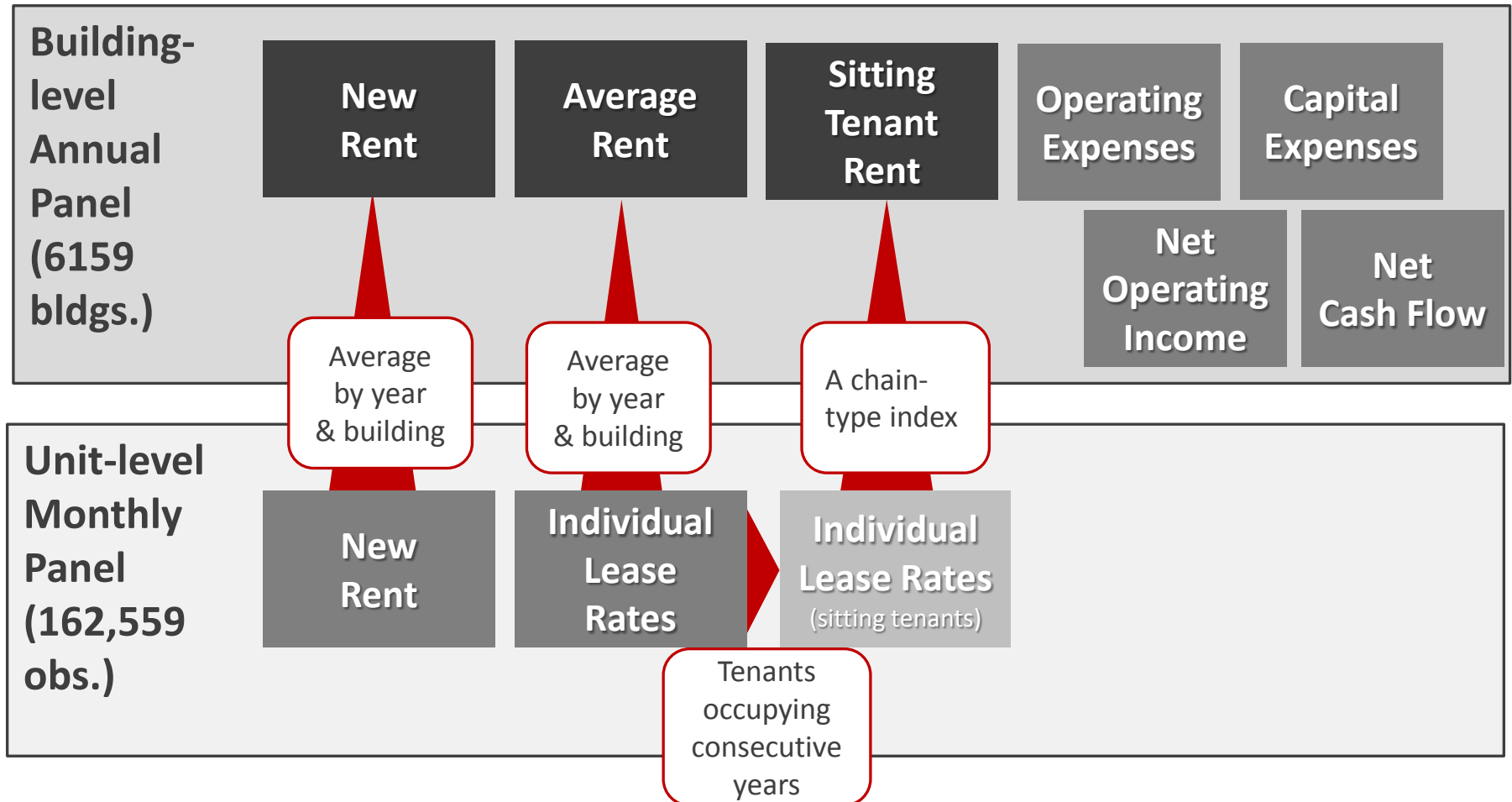
# Main Results

---

1. The rent depreciation rate is 0.8% for new leases, 0.4% for sitting tenants, and 0.5% on average
2. Rents depreciate at a declining rate.
3. Smaller buildings experience larger rent depreciation.
4. A tenant occupying a larger proportion of building experiences larger rent depreciation.
5. Operating expenses depreciate annually at 0.6%.
6. Net operating income depreciates annually at 0.4%.
7. Capital expenditures generally increase over time.
8. Net cash flows depreciates at 0.6% per year.



# Rent and Cash Flow Data



## Descriptive Statistics: Entire building panel (bldg. & year)

Variable	n	mean	sd	median	min	max
BLDG_ID	21,415	7,143.753	7,250.650	4,629.000	1.000	36,294.000
YEAR	21,415	2,011.268	3.323	2,011.000	2,005.000	2,016.000
NEW_RENT	19,993	64,177.906	22,696.630	58,080.002	22,143.001	254,100.010
AVG_RENT	1,930	63,350.561	17,225.231	60,169.777	32,514.430	165,010.293
SIT_RENT	1,930	67,934.411	17,599.644	65,066.088	32,670.001	157,894.326
CAPEX	1,965	4,151.942	9,280.731	1,767.917	2.264	222,806.522
OPEX	897	18,443.338	12,426.174	16,637.749	295.432	164,039.653
Net Operating Income	816	46,647.814	20,518.152	45,775.612	-118,565.427	141,168.308
Net Cash Flows	680	42,760.880	21,948.160	41,369.957	-127,933.144	141,015.083
GFA	21,415	12,374.030	27,971.174	4,196.562	285.289	379,447.920
NRA	21,415	7,326.374	14,760.149	2,911.008	115.008	182,443.993
HEIGHT	21,345	10.310	6.154	9.000	2.000	60.000
DISTANCE	21,415	288.529	156.170	267.375	1.764	1,177.446
MINUTES	21,415	4.960	2.442	4.633	0.000	23.683
AGE	21,415	22.725	10.704	22.000	1.000	50.000
COMPLETION_YEAR	21,415	1,988.543	10.448	1,990.000	1,956.000	2,015.000
RENEWAL	21,415	0.164	0.371	0.000	0.000	1.000
RENEWAL_YEAR	4,266	2,005.124	7.414	2,006.000	1,964.000	2,017.000
DEMOLITION	21,415	0.032	0.175	0.000	0.000	1.000
DEMOLITION_YEAR	561	2,013.879	2.345	2,014.000	2,002.000	2,017.000

# Empirical Strategy

---

## Rents, Operating Expenses, Capital Expenditures

$$\ln V_{it} = a_0 + f(A_{it}) + \mathbf{X}_{it}\mathbf{b} + Y_t + C_d + \epsilon_{it},$$

- $V_{it}$ : the variable of interest for building  $i$  at time  $t$ ,
- Age function  $f(A_{it})$ 
  - (1) the linear model,  $f(A_{it}) = a_1 A_{it}$
  - (2) the spline function,  $f(A_{it}) = \sum_{n=0}^T a_{1,n} I_n$ , where  $I_n$  is the age dummy.
- $Y_t$ : year fixed effects
- $C_d$ : decennial cohort (vintage) effects
- $\mathbf{X}_{it}$ : log gross floor area, walk minutes from station, city, past renovation

## Cash Flows (NOI, NCF)

$$CF_{it} = a_0 + f(A_{it}) + \mathbf{X}_{it}\mathbf{b} + Y_t + \epsilon_{it}$$

# Result

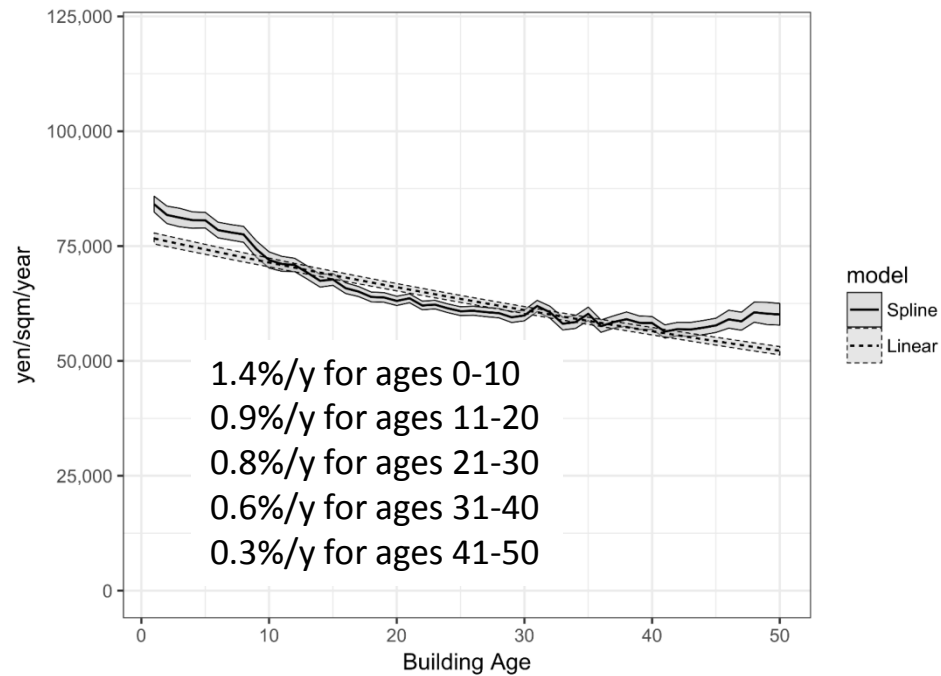
---

## Newly Contracted Rents: Building Panel

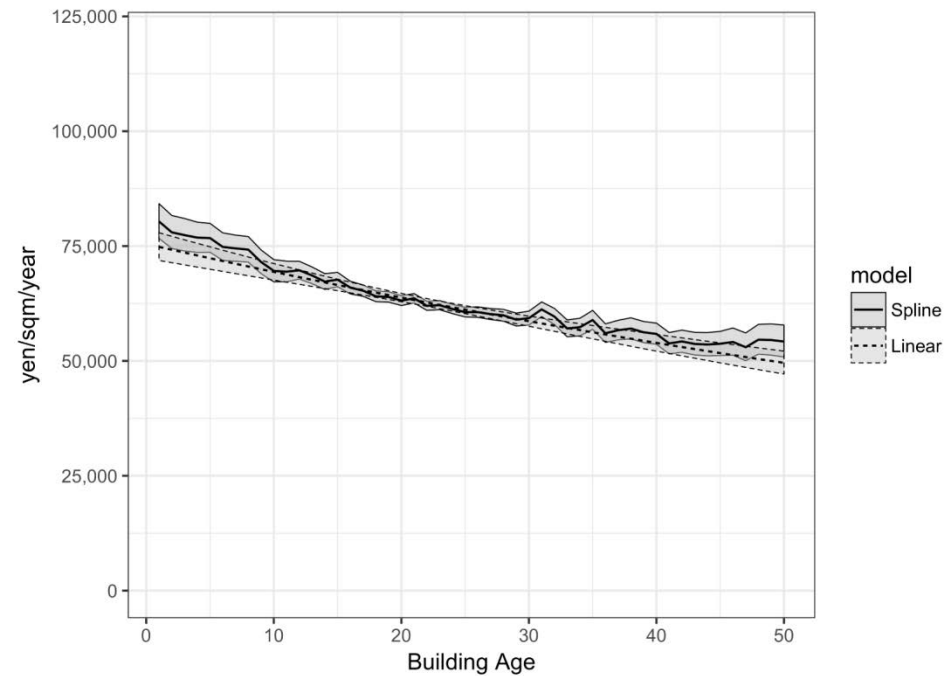
LHS:	(1)	(2)	(3)	(4)
log new rents				
GFA_LOG	0.153***	0.145***	0.144***	0.144***
MINUTES	-0.0235***	-0.0220***	-0.0220***	-0.0219***
RNW	0.0472***	0.0377***	0.0361***	0.0356***
AGE	-0.00783***		-0.00840***	
_cons	10.04***	10.19***	10.33***	10.32***
AgeFE(1yr)	No	Yes	No	Yes
CohortFE	No	No	Yes	Yes
YearFE	Yes	Yes	Yes	Yes
CityFE	Yes	Yes	Yes	Yes
<i>N</i>	19993	19993	19993	19993
adj. <i>R</i> <sup>2</sup>	0.722	0.738	0.738	0.739

# Newly Contracted Rents: Building Panel

## Baseline



## Control Cohort

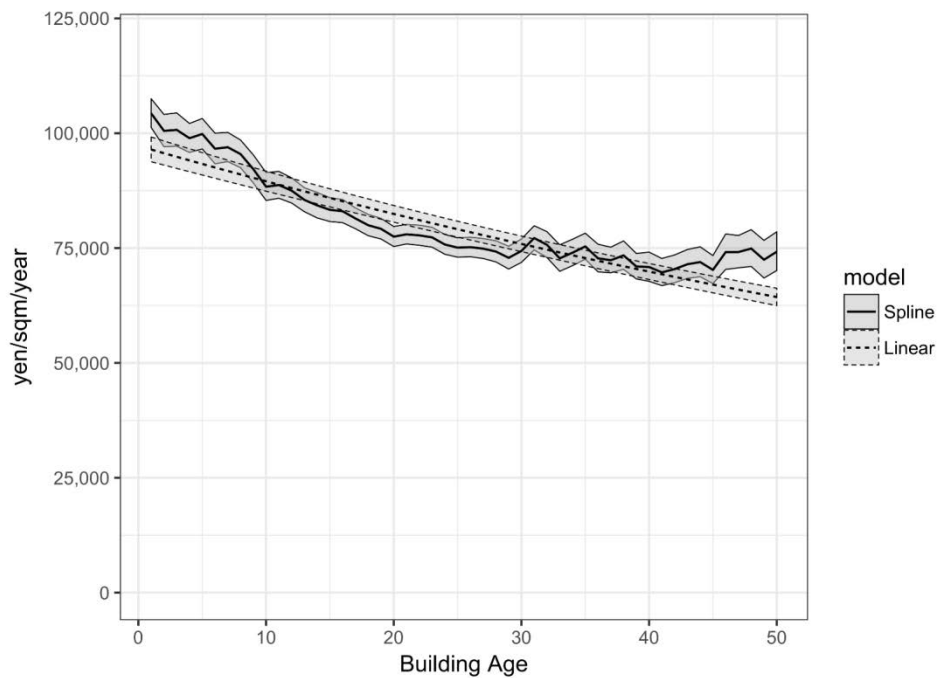


## Newly Contracted Rents: Large/Small Buildings

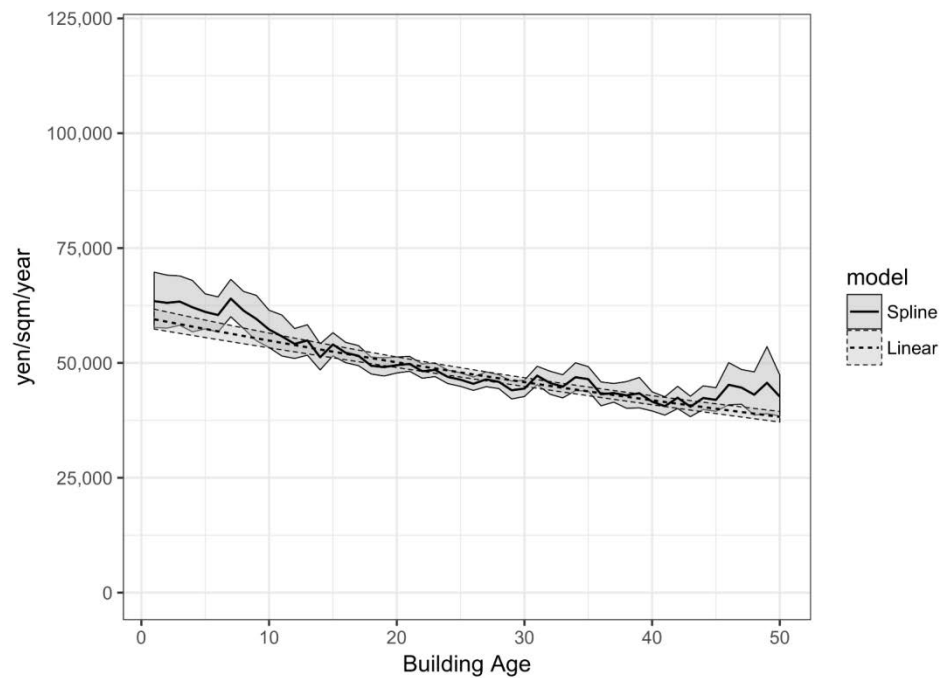
LHS: log	(1)	(2)	(3)	(4)
new rents	Large25%	Large25%	Small25%	Small25%
GFA_LOG	0.143***	0.137***	0.156***	0.159***
MINUTES	-0.0265***	-0.0238***	-0.0233***	-0.0225***
RNW	0.0571***	0.0445***	0.0412*	0.0335*
AGE	-0.00826***		-0.00901***	
_cons	10.22***	10.34***	10.01***	10.03***
AgeFE(1yr)	No	Yes	No	Yes
YearFE	Yes	Yes	Yes	Yes
CityFE	Yes	Yes	Yes	Yes
<i>N</i>	7486	7486	2762	2762
adj. $R^2$	0.728	0.744	0.565	0.581

# Newly Contracted Rents: Large/Small Buildings

## Large



## Small



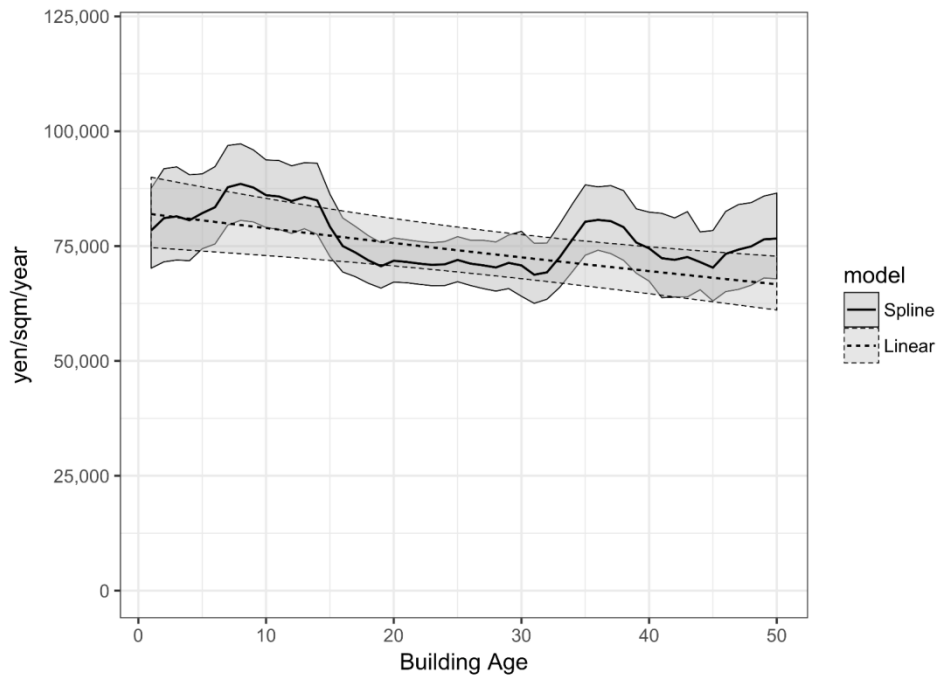


## Rents for Sitting Tenants

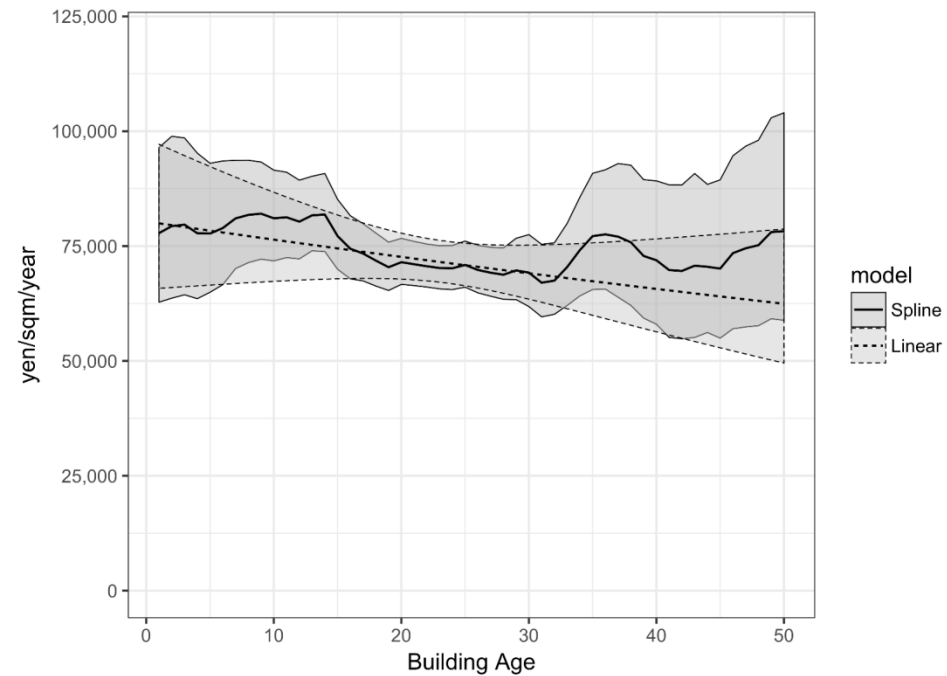
LHS: log sitting tenant rents	(1)	(2)	(3)	(4)
GFA_LOG	0.117***	0.112***	0.114***	0.112***
MINUTES	-0.0155***	-0.0104*	-0.0117*	-0.0108*
RNW	-0.0125	-0.0140	-0.0140	-0.0136
AGE	-0.00421**		-0.00504	
_cons	10.39***	10.34***	10.44***	10.21***
AgeFE(1yr)	No	Yes	No	Yes
CohortFE	No	No	Yes	Yes
YearFE	Yes	Yes	Yes	Yes
CityFE	Yes	Yes	Yes	Yes
<i>N</i>	1930	1930	1930	1930
adj. <i>R</i> <sup>2</sup>	0.480	0.527	0.531	0.534

# Sitting Tenant's Rent

## Baseline

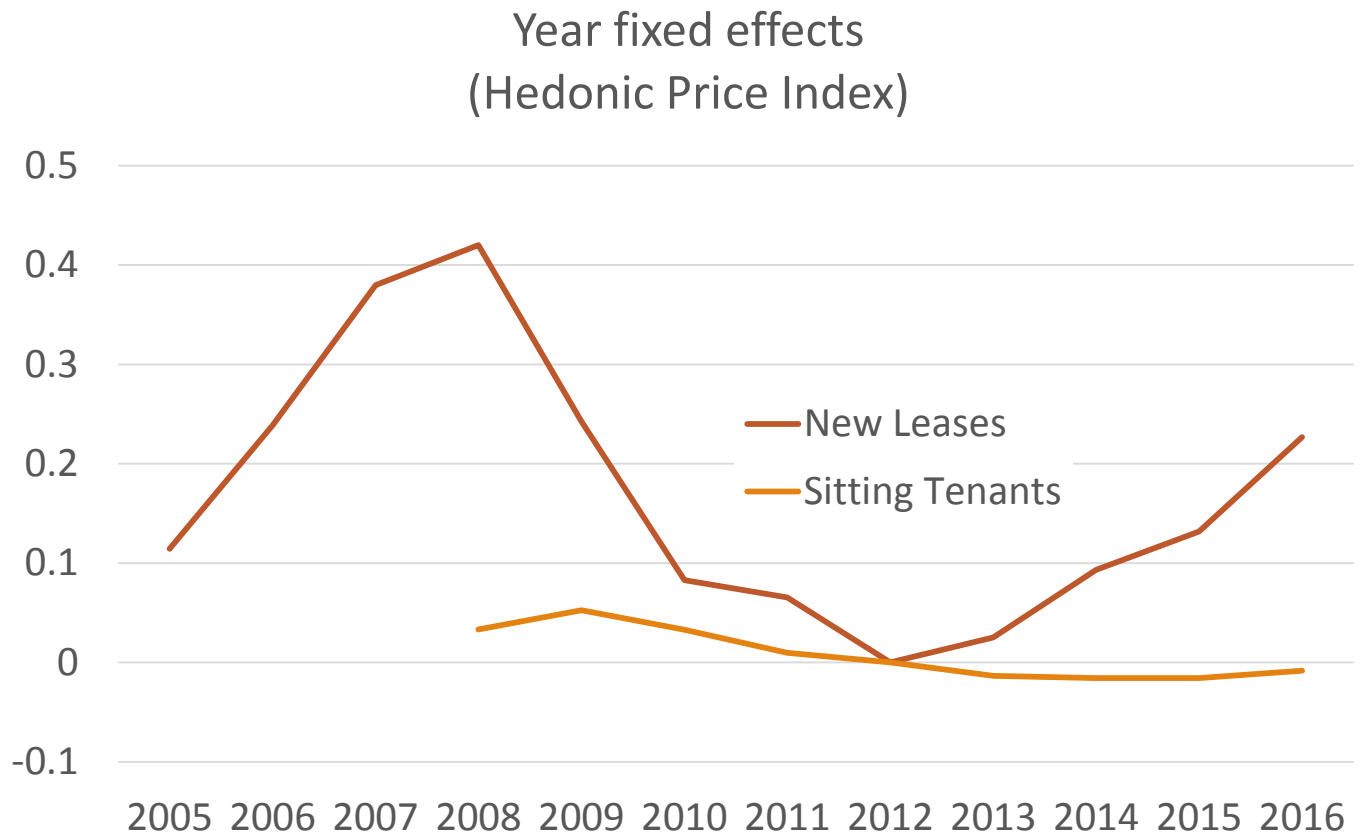


## Control Cohort



# New and Sitting Tenant Rents differently respond to market conditions

---

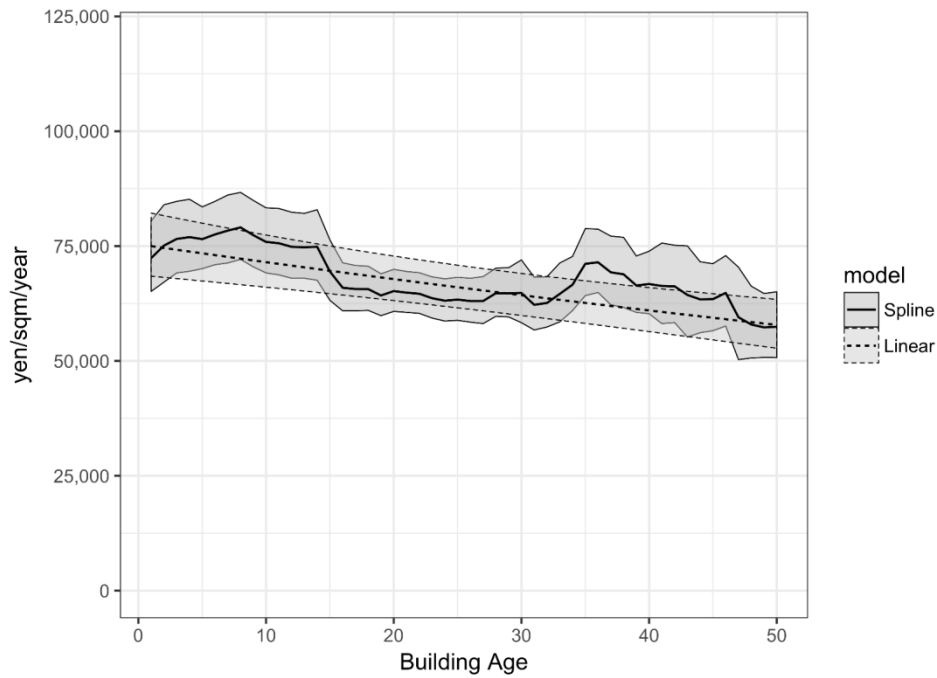


## Average Rents

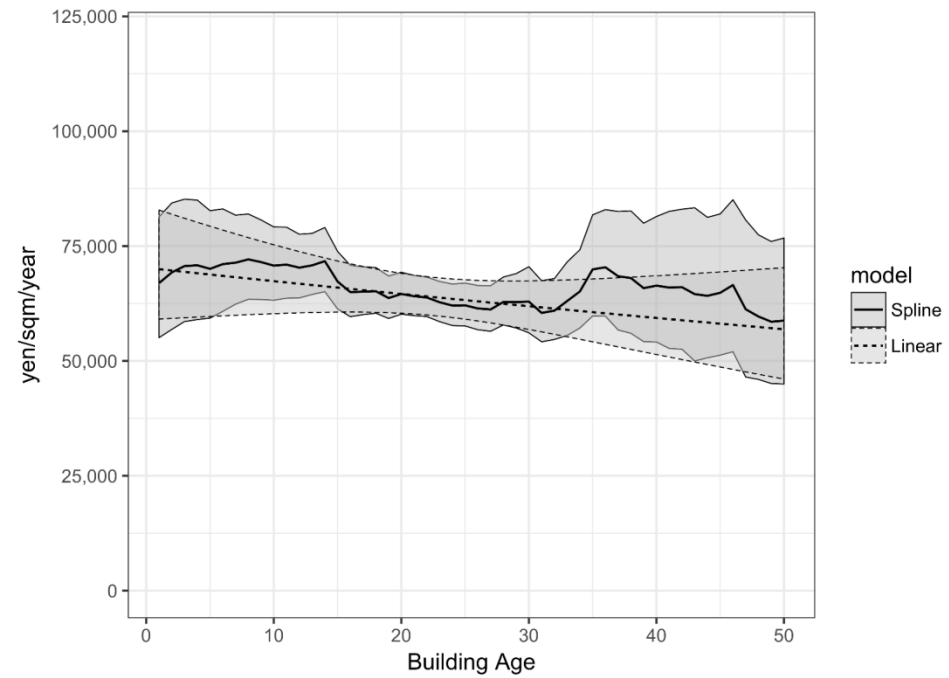
LHS: log average rents	(1)	(2)	(3)	(4)
GFA_LOG	0.113***	0.110***	0.109***	0.108***
MINUTES	-0.0197***	-0.0151***	-0.0164***	-0.0153***
RNW	-0.0227	-0.0264	-0.0260	-0.0264
AGE	-0.00530***		-0.00422	
_cons	10.46***	10.42***	10.45***	10.39***
AgeFE(1yr)	No	Yes	No	Yes
CohortFE	No	No	Yes	Yes
YearFE	Yes	Yes	Yes	Yes
CityFE	Yes	Yes	Yes	Yes
<i>N</i>	1930	1930	1930	1930
adj. $R^2$	0.520	0.550	0.555	0.554

# Average Rents

## Baseline



## Control Cohort



## Average Rents: Large/Small Buildings

	(1)	(2)	(3)	(4)
	Large25%	Large25%	Small25%	Small25%
GFA_LOG	0.114**	0.113**	-0.113	-0.315
MINUTES	-0.0303***	-0.0284***	-0.0115	-0.0120
RNW	-0.0381	-0.0275	-0.112	-0.191*
AGE	-0.00537*		-0.00725	
_cons	10.59***	10.60***	12.02***	13.38***
AgeFE(1yr)	No	Yes	No	Yes
YearFE	Yes	Yes	Yes	Yes
CityFE	Yes	Yes	Yes	Yes
<i>N</i>	620	620	230	230
adj. <i>R</i> <sup>2</sup>	0.641	0.660	0.611	0.645

## Average Rents: Tenants with Large/Small Presence

	(1)	(2)	(3)	(4)
	Large25%	Large25%	Small25%	Small25%
GFA_LOG	0.0959***	0.0892***	0.142***	0.140***
MINUTES	-0.0186*	-0.0160*	-0.0209*	-0.0220**
RNW	0.00434	-0.0321	-0.0597	-0.00695
AGE	-0.00647***		-0.000793	
_cons	10.64***	10.71***	10.19***	10.03***
AgeFE(1yr)	No	Yes	No	Yes
YearFE	Yes	Yes	Yes	Yes
CityFE	Yes	Yes	Yes	Yes
<i>N</i>	39469	39469	39496	39496
adj. $R^2$	0.558	0.601	0.621	0.670

## Operating Expenses

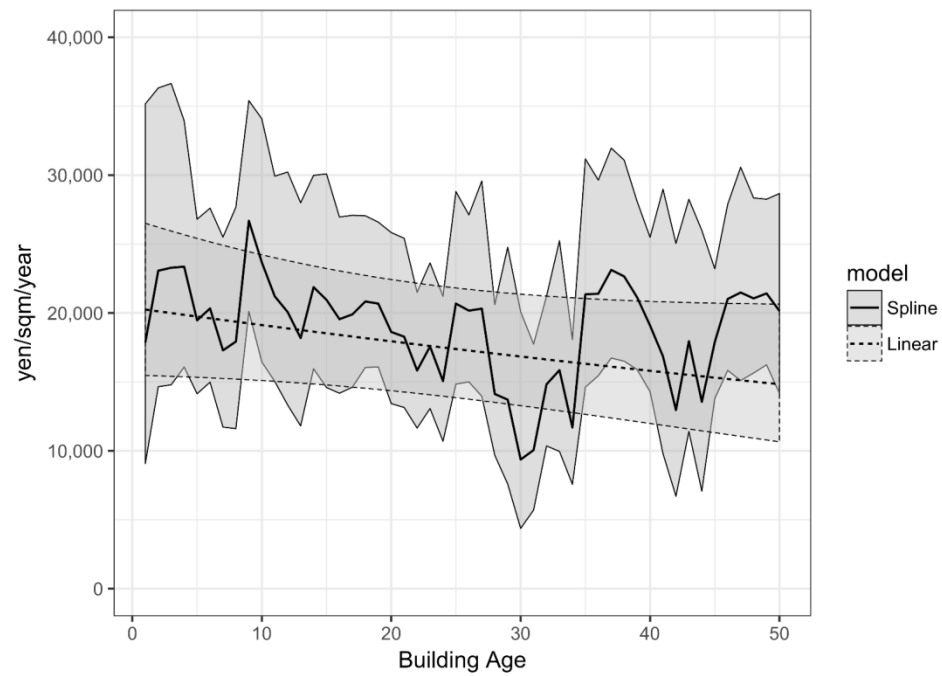
---

LHS: log operating expenses	(1)	(2)
GFA_LOG	0.0579	0.0526
MINUTES	-0.0110	-0.00965
RNW	-0.00685	-0.0184
AGE	-0.00635	
_cons	9.232***	9.040***
AgeFE(1yr)	No	Yes
YearFE	Yes	Yes
CityFE	Yes	Yes
<i>N</i>	897	897
adj. $R^2$	0.086	0.090



# Operating Expenses

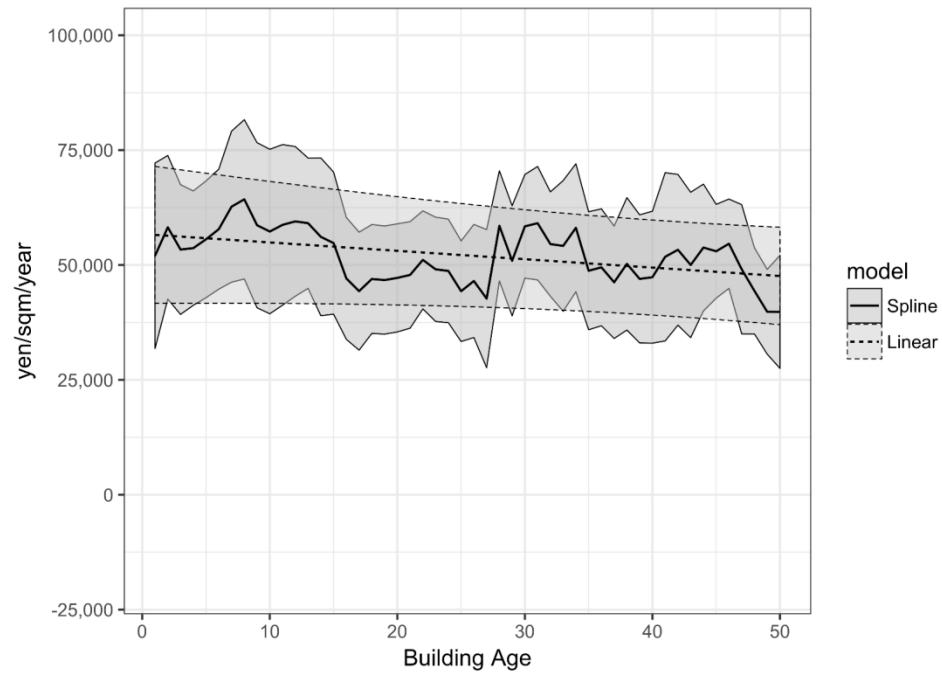
---



# Net Operating Income

LHS: net operating income	(1)	(2)	
GFA_LOG	8168.4**	7770.8**	
MINUTES	-1232.8*	-1010.7	
RNW	-2517.2	-1835.5	
AGE	-182.6		→ Rate ≈0.4%/year
_cons	-559.9	-1990.2	
AgeFE(1yr)	No	Yes	
YearFE	Yes	Yes	
CityFE	Yes	Yes	
<i>N</i>	816	816	
adj. <i>R</i> <sup>2</sup>	0.383	0.401	

# Net Operating Income

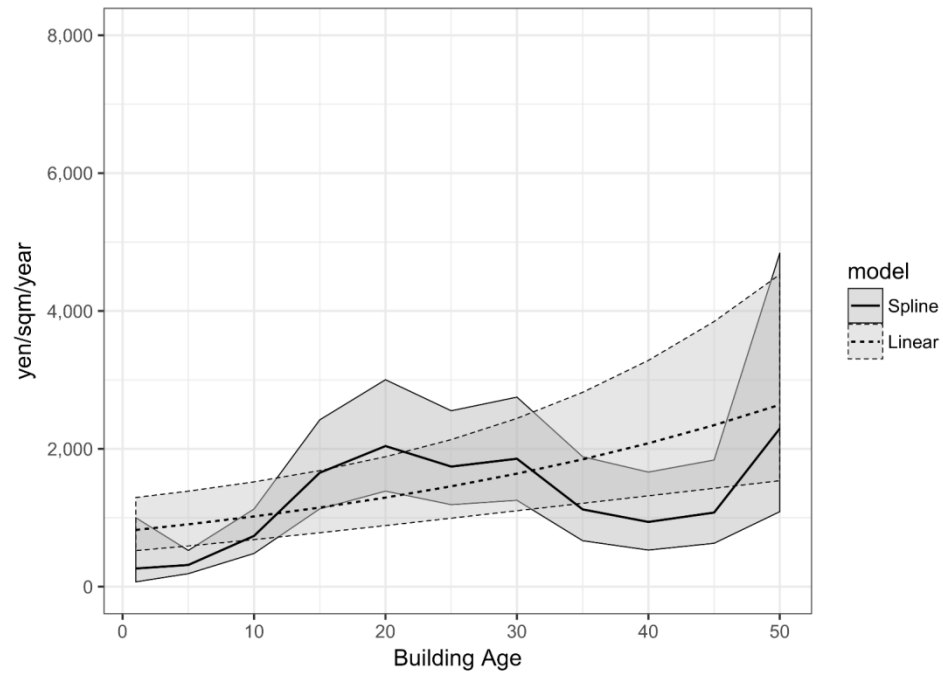


## Capital Expenditures

---


LHS: log capital expenditure	(1)	(2)
GFA_LOG	-0.0110	0.00973
MINUTES	-0.00158	-0.0325
RNW	0.112	0.226
AGE	0.0238***	
_cons	6.608***	5.424***
AgeFE(5yr)	No	Yes
YearFE	Yes	Yes
CityFE	Yes	Yes
<i>N</i>	1965	1965
adj. $R^2$	0.045	0.122

# Capital Expenditures

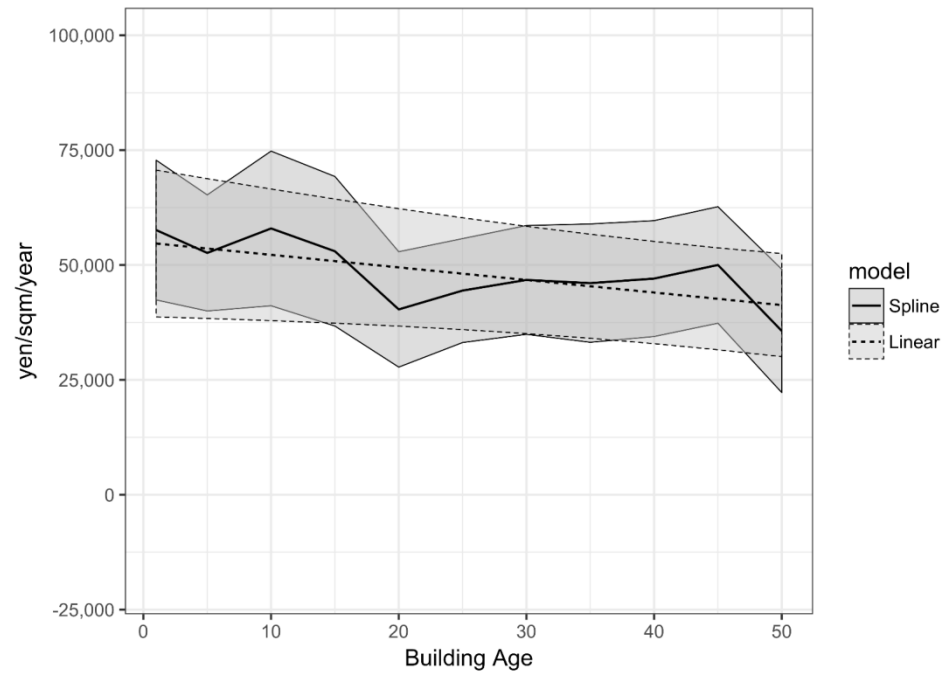


## Net Cash Flows

LHS: net cash flow	(1)	(2)
GFA_LOG	8303.1**	8035.6**
MINUTES	-984.4	-670.3
RNW	-5452.9	-5729.7
AGE	-273.6*	
_cons	-8205.3	-3112.2
AgeFE(5yr)	No	Yes
YearFE	Yes	Yes
CityFE	Yes	Yes
<i>N</i>	680	680
adj. $R^2$	0.327	0.365


 Rate  
 ≈0.6%/year

# Net Cash Flows



# Conclusion

---

CF depreciation rate is very small (0.4%-0.6%/year)

This number is not consistent with the property value depreciation rate (5.3% initial depreciation rate)

This is the first study to uncover this puzzle.

We plan to conduct additional analysis by introducing rent uncertainty, etc.