Economic Depreciation of Property Rents and Prices

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My depreciation studies

- Yoshida and Sugiura (2015) find more rapid price depreciation for non-green condominiums in Japan
- Yoshida (2020) finds large variation in property price depreciation rates by country, city, property type, age and size
  - It also proposes a method to correct for a survivorship bias
  - It uses both transaction and demolition data
- Lopez and Yoshida (2021) suggest a large aging adjustment in inflation rates for Las Vegas partly due to fast functional obsolescence of housing
  - It separates functional obsolescence from physical deterioration
  - It demonstrates depreciation heterogeneity by neighborhood
- **My ongoing projects focus on functional obsolescence for residential and commercial property rents and prices**
- **A study on the production function for housing services**

Capital depreciation is

important for

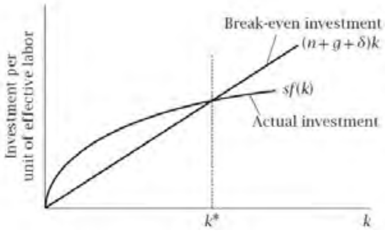
- Taxes (accounting depreciation)
- Financial investment (income and appreciation returns)
- Capital investment (irreversibiltiy, replacement)
- Sustainability (demolition frequency)
- Macroeconomics (real interest rate)
- Economic statistics (inflation and TFP measurement)
- Consumption expenditures (user cost of durables)

interesting because

- it provides a "shadow rate of technological progress"
- it creates variations in factor composition for housing service production

Solow model with exogenous savings

- Capital growth: $\dot{k}(t) = sk(t)^{\alpha} - (n + g + \delta)k(t)$.
- Steady-state capital: $k(t)^{*} = [s/(n + g + \delta)]^{1/(1-\alpha)}$.



Greater δ lowers $\dot{k}(t)$ and $k(t)^{*}$, ceteris paribus.
In growth accounting, **the wrong δ distorts the TFP measurement**.

Ramsey (and DSGE) model with endogenous savings

- The firm maximizes profit: $\hat{L}\left[f(\hat{k}) - (r+\delta)\hat{k} - we^{-gt}\right]$ by setting MPK to $f'(\hat{k}) = r + \delta$ (where $\hat{k} \equiv K/\hat{L}$).
- The household takes the interest rate as given (depreciation is implicit except for durable consumption). $\max_{c,a} \int_0^\infty u(c_t)e^{nt}e^{-\rho t}\,dt$ $s.t.$ $\dot{a}_t = w_t + (r-n)a_t - c_t$.
- The steady state is characterized in a $\hat{c} - \hat{k}$ phase diagram by $\dot{\hat{c}} = 0$ locus : $f'(\hat{k}^*) = \delta + \rho + g/\sigma$. $\dot{\hat{k}} = 0$ locus : $\hat{c} = f(\hat{k}) - (n+g+\delta)\hat{k}$.

Greater δ results in smaller capital and consumption (empirical support by Hsiang and Jina (2015)).
Depreciation is **important for the business cycle** (Feldstein and Rothschild, 1974; Ambler and Paquet, 1994; Rogerson, 2008; Liu et al., 2011; Gschwandtner and Lambson, 2012; Furlanetto and Seneca, 2014; Livdan and Nezlobin, 2021).

Estimated depreciation rates vary

- Early studies support a constant depreciation (e.g., Hulten and Wykoff, 1981b,a; Mankiw et al., 1992), but the estimated single rate varies significantly from 6% (Nadiri and Prucha, 1996) to 13% (Epstein and Denny, 1980).
- Depreciation rates do **vary over time and across types** (Epstein and Denny, 1980; Ambler and Paquet, 1994; Hulten and Wykoff, 1996; Jorgenson, 1996; Tevlin and Whelan, 2003).
- Depreciation is **pro-cyclical due to utilization and maintenance** (Greenwood et al., 1988; Albonico et al., 2014; Deli, 2016).
- Economic depreciation includes **obsolescence due to technological progress** (Greenwood et al., 1997; Whelan, 2002; Boucekkine et al., 2008; Gertler and Kiyotaki, 2010).

Technological change and economic depreciation

The rate of economic depreciation will exceed the rate of physical depreciation because investment-specific technological change obsoletes the old capital stock (Greenwood et al., 1997).

When a unit of new capital is q/q_{-1} times more productive than a unit of old capital, q is the investment-specific technology as well as the price deflator.

$\tilde{z}\tilde{k}^{\alpha}\ell^{1-\alpha} = c + i$, and $\tilde{k}' = (1-\tilde{\delta})\tilde{k} + i$,
where $\tilde{k}' = k'/q$, $1-\tilde{\delta} = (1-\delta)(q_{-1}/q)$, and $\tilde{z} = z(q_{-1})^{\alpha}$.

The difference between economic and physical depreciation rates gives the rate of investment-specific technological change: $(1-\delta)/(1-\tilde{\delta}) = q/q_{-1}$.

Housing Depreciation is particularly important for Japan

- Hayashi (1986, 1989) attributed **Japan's high post-war saving rate to a large housing depreciation rate** evaluated at replacement cost instead of book value.
- Dekle and Summers (1991) cast a doubt about Hayashi's large depreciation estimate.
- Hayashi (1991) replied by emphasizing that housing depreciation rates are approximately 9% in Japan.
- Hayashi and Prescott (2002) also used large depreciation in explaining the stagnant Japanese economy in the 1990s.
- More recently, Chen et al. (2006) find that **large and changing depreciation rates and TFP explain saving rates in Japan**.

Today's talk about depreciation

	Prices		Rents	
	Residential	Commercial	Residential	Commercial
Japan			$\Longrightarrow$	
Depreciation	Y (2020)	Y (2020)	NEW	Y etal (2018)
Deterioration			NEW	Y etal (2018)
Obsolescence			NEW	Y etal (2018)
			$\Uparrow$	$\Downarrow$
USA				
Depreciation	Y (2020)	NEW	L&Y (2021)	NEW
Deterioration	NEW	NEW	L&Y (2021)	NEW
Obsolescence	NEW	NEW	L&Y (2021)	NEW
	$\Longleftarrow$		$\Longleftarrow$	

Land-structure share and housing service production

Japan	NEW
USA	NEW

US Residential Rents

Summary of Lopez and Yoshida (2021)

We estimate housing rent depreciation rates with two objectives

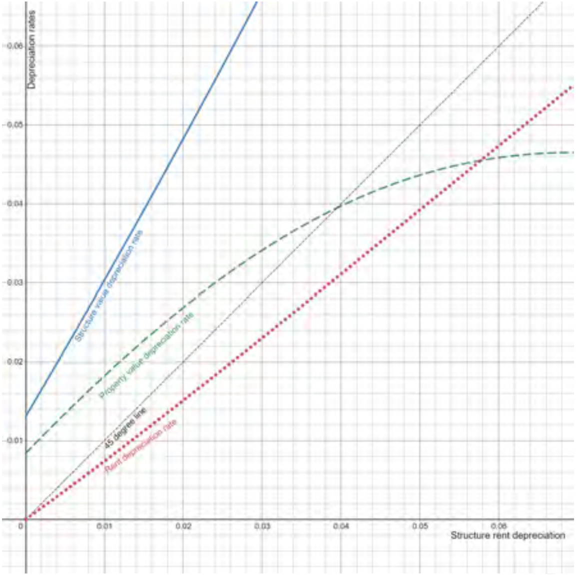
1. To improve inflation measurement
   - To estimate constant-quality CPI inflation, BLS adds a separately estimated rent depreciation rate to rent changes (Lane et al., 1988; Randolph, 1988; Campbell, 2006)
     - 0.11% for Houston
     - 0.36% for New York and Boston
   - We find 0.90% (new single family) and 1.50% (new condominiums) for Las Vegas partly due to functional obsolescence.

2. To obtain the basis for a capital value depreciation rate
   - Next slide

Relationship between rent and value depreciation

- Setting: Deterministic rents in a non-stochastic stationary urban economy without growth
- Housing rents are the sum of land rents C_L and structure rents $C_S(t) = C_{S1}(1-\delta)^{t-1}$ (DiPasquale and Wheaton, 1995)
- Rent depreciation rate is $\delta_C = -d \ln C(t)/dt$
- Land value is $L(t) = C_L/r$, and structure value is
$$S(t) = \frac{C_{S1}(1-\delta)^t}{r+\delta}\left[1 - \left(\frac{1-\delta}{1+r}\right)^{T-t}\right]$$
- Structure value depreciation rate is $\delta_S = -d \ln S(t)/dt > \delta$
- Property value depreciation rate is $\delta_V = -d \ln V(t)/dt \lesseqgtr \delta_C$

Relationship between rent and price depreciation



x: structure dep. (δ)

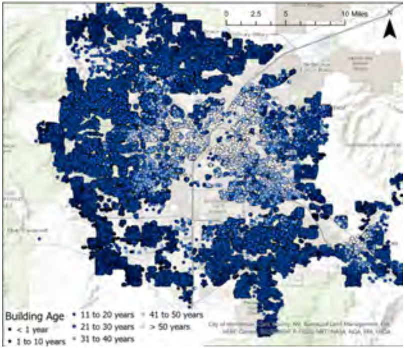
red: rent dep. ($\delta_C < \delta$)

blue: structure value dep. ($\delta_S > \delta$)

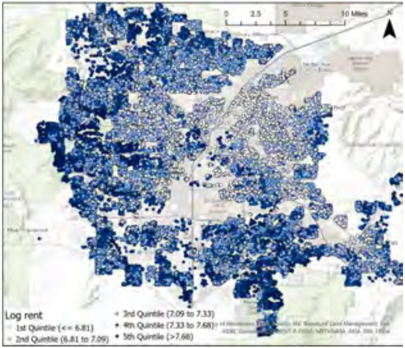
green: prop. value dep. ($\delta_V \lesseqgtr \delta$)

Data: Las Vegas MLS merged with Tax Assessor Records

283,818 leased and 45,976 withdrawn/expired listings for 2009Q1 – 2019Q1 (compared to 32K rental units in the CPI Housing Survey)



Building age



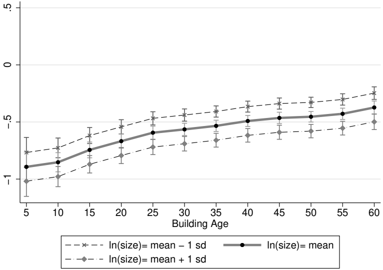
Log rents

Estimation

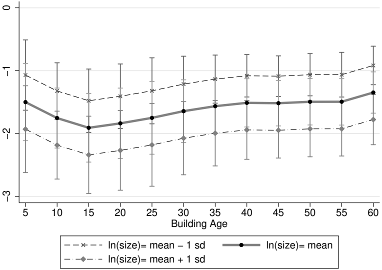
We use cross-sectional variation in log rents by age:
$\ln Y_{it} = A_i C_i \delta + X_i \beta + \alpha_j + \tau_t + \epsilon_{it},$

- Y_{it}: contract rent of property i at time t
- A_i: building age A_i
- C_i: interaction terms C_i
  - $C_i^1 = [1\ A_i\ Size_i]$, ($Size_i$: demeaned log square-footage)
  - $C_i^2 = [G_g\ Size_i]$, (G_g: indicators for 5-year age groups)
  - $C_i^{3,1} = \left[C_i^1\ CensusTract_j\right]$,
  - $C_i^{3,2} = \left[C_i^2\ CensusTract_j\right]$
- δ: vector of age coefficients
- X_i: observable characteristics
- α_j: location (census tract) fixed effects
- τ_t: time (listing year-quarter) fixed effects.

Age coefficients without controlling for cohort effects



Single Family



Condominiums

Depreciation rates are larger for newer and larger structures

A challenge in controlling for cohorts

- Cohort effects are assumed away in CPI
- Cohort effects are large (Coulson and McMillen, 2008) and include functional obsolescence in addition to vintage effects. (Francke and van de Minne, 2017).
- But the following model is unidentified (collinearity)
  $\mathcal{Y} = [\mathit{age\ period\ cohort}]\theta + \epsilon$,
  - $\mathcal{Y}$ is characteristics-controlled log rents,
  - $[\mathit{age\ period\ cohort}]$ are age, period, cohort group dummies
  - $\theta = (\gamma_0, \gamma_5, \ldots, \gamma_{55}, \tau_{2005}, \tau_{2010}, \kappa_{1945}, \kappa_{1950}, \ldots, \kappa_{2010})'$

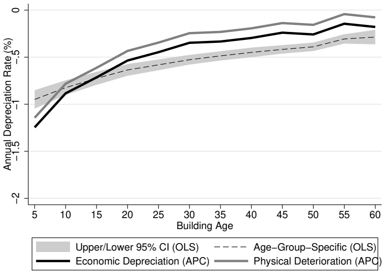
Intrinsic estimator to decompose age, period, and cohort

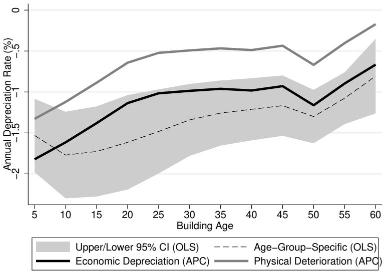
- We use the Intrinsic Estimator (IE) method to address the collinearity issue (Yang et al., 2004, 2008).
- $Z \equiv [\textit{age period cohort}]$ is one less than full column rank
- Parameter vector θ is the sum of two perpendicular linear subspaces: $\theta = T + sT_0$
  - $s \in \mathbb{R}$ and T_0 is the unit eigenvector corresponding to the unique zero eigenvalue of $Z'Z$, i.e., $(ZT_0 = 0)$
- Parameter vector T is IE, which is perpendicular to T_0.
- Computationally, we apply a principal components regression.
- IE is used in epidemiological research, economics (Diamond et al., 2020), and finance (Fagereng et al., 2017).

Cohort effects on housing rents

Cohort effects include both a trend (average functional obsolescence) and cycles (vintage effects).

Decomposition of rent depreciation rates





	Single Family	Condominiums
Physical:	(0.1-1.1%)	(0.2-1.3%)
Obsolescence:	(0.1%)	(0.5%)
Economic:	(0.2-1.2%)	(0.7-1.8%)

Physical deterioration is comparable but obsolescence is larger for condos than for SFR

Navigation

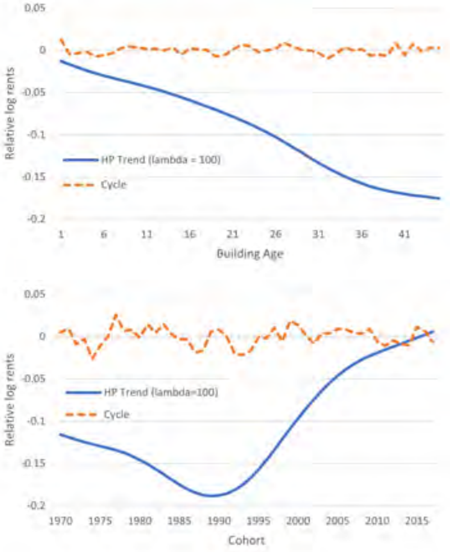
Japan's Residential Rents

Japan residential rent data

- Source: LIFUL (one of the largest rental housing listing sites)
- Area: Greater Tokyo Metropolitan Area (Shuto-ken)
- Sample size: 4,868,740 listings
- Sample period: 2015-2017
- Variables: log rents, floor configuration and number of rooms, floor area, floor number, number of stories, "mansion"/apartment distances to two nearest stations, railway types for two nearest stations, immediate availability, prefecture

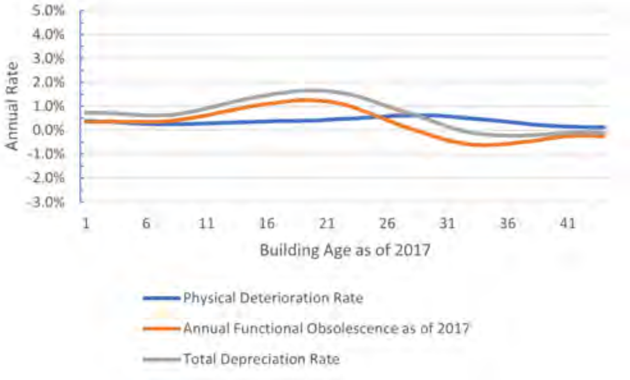
Age and cohort effects on Tokyo residential rents

Smoothed effects on Tokyo residential rents



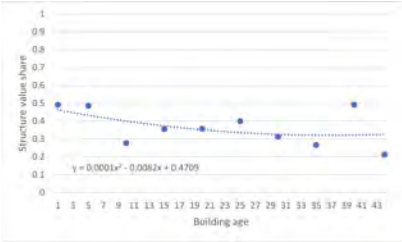
Decomposed depreciation (Tokyo residential rents)

Physical depreciation rate: 0.1 to 0.6% per year
Functional obsolescence rates: −0.6 to 1.3%
Economic depreciation rates: −0.2 to 1.7%



Structure depreciation (Tokyo residential rents)

Structure value share for small commercial properties: 0.2–0.5
Structure physical deterioration: 0.4 to 2.0% per year
Structure obsolescence: −2.0 to 3.6% per year
Structure economic depreciation: −0.8 to 4.8% per year
Caveat: Need a better estimate of structure rent share

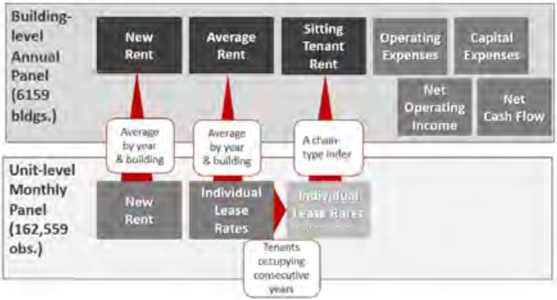


Navigation

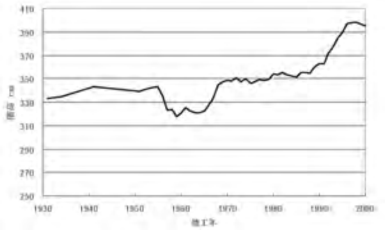
Japan's Commercial Property Rents

Japan Office Rents (Yoshida et al., 2018)

- Data: Xymax, a major property management firm
- Sample size: 6,159 office buildings in Tokyo
- Sample period: 2005-2016
- Variables: new rent, average rent, operating expenses, capital expenditures, height, distance, age, year built, renewal



Cohort effects on new rents

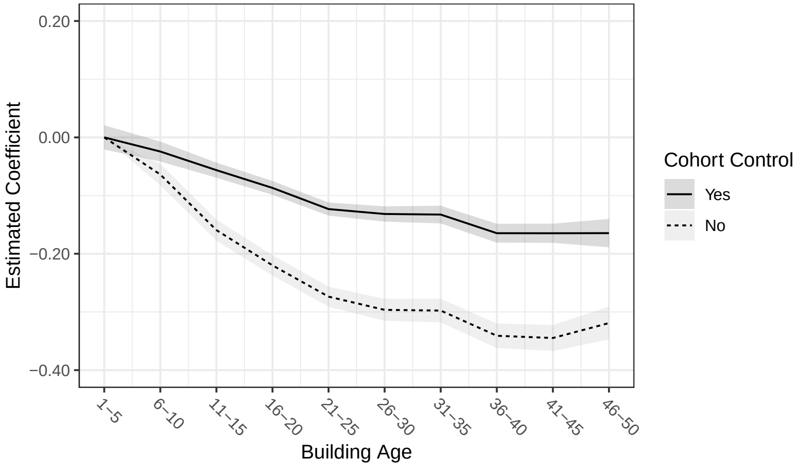


Top: Cohort effects are large since 1990s.

Bottom: Office ceiling heights (Hara, 2006)

- -1950's: $\approx$ 345 cm
- 1950s-1960s: 320 cm by a 31 m maximum building height
- 1970s-1980s: 350 cm
- 1990s-: Increase by 50 cm due to double floor

New rent depreciation



Average depreciation rates

	(1)	(2)	(3)	(4)	(5)	(6)
	New Rents			Average Rents		
	Economic	Physical	Obsolescence	Economic	Physical	Obsolescence
From 1 to 10	1.28	0.49	0.79	-0.75	-0.93	0.18
From 1 to 15	1.59	0.56	1.03	0.25	-0.28	0.53
From 1 to 20	1.47	0.58	0.89	0.92	0.05	0.87
From 1 to 25	1.37	0.62	0.75	0.85	0.15	0.70
From 1 to 30	1.19	0.53	0.66	0.68	0.13	0.55
From 1 to 35	0.99	0.44	0.55	0.46	0.04	0.42
From 1 to 40	0.97	0.47	0.50	0.3	0.08	0.22
From 1 to 45	0.86	0.41	0.45	0.37	0.18	0.19
From 1 to 50	0.71	0.37	0.34	0.55	0.32	0.23

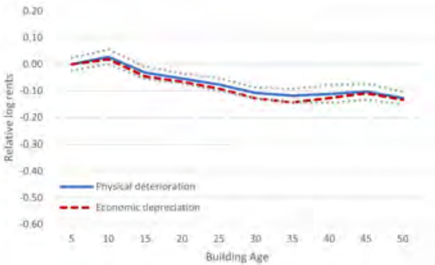
The 40-year average rent depreciation rate is 1%/year, half of which is due to obsolescence. Navigation

US Commercial Property Rents

US commercial rent data

- Data: Compstak
- Markets and Sample size
  - DC: 22,809 leases
  - NY: 30,369 leases
  - LA: 34,475 leases
  - SF: 18,667 leases
- Sample period: 2006-2021
- Variables: gross lease, leasing floor, building class, building size, direction from CBD, distance to CBD, ten submarket dummies

Washington DC office rents



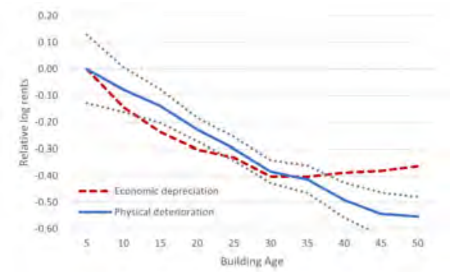
Physical and economic depreciation (5–45 years)

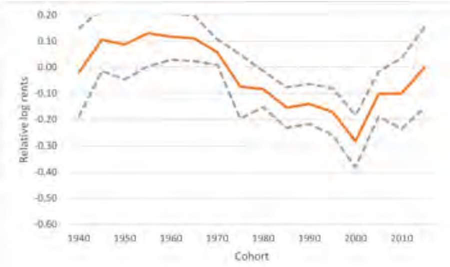
- Physical: 0.3%/year
- Obsolescence: 0.0%/year
- Economic: 0.3%/year

Cohort effects

- Obsolescence is negligible.

New York office rents





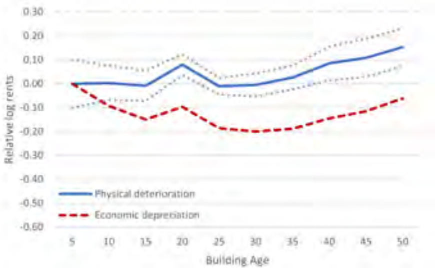
Physical and economic depreciation (5–45 years)

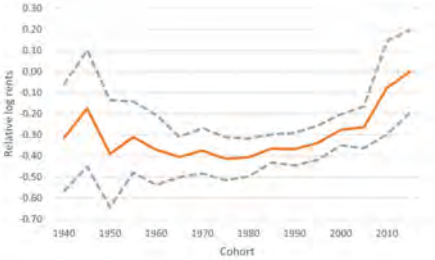
- Physical: 1.4%/year
- Obsolescence: −0.4%/year
- Economic: 1.0%/year

Cohort effects

- 1980s-1990s vintages have low rents.

Los Angeles office rents





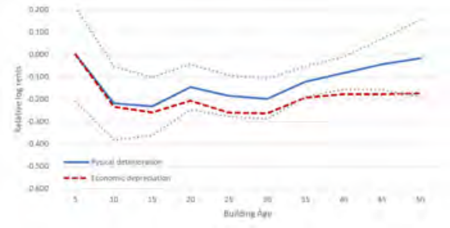
Physical and economic depreciation (5–45 years)

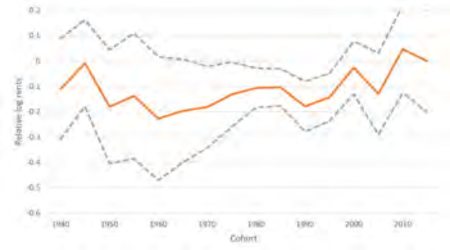
- Physical: $-0.3\%/\text{year}$
- Obsolescence: $0.6\%/\text{year}$
- Economic: $0.3\%/\text{year}$

Cohort effects

- Obsolescence is accelerating since 2000s.

San Francisco office rents





Physical and economic depreciation (5–45 years)

- Physical: 0.4%/year
- Obsolescence: 0.3%/year
- Economic: 0.1%/year

Cohort effects

- Obsolescence is continuous and gradual.

Navigation

US Commercial Property Prices

US office price data

Real Capital Analytics transaction data

Sample size:

- DC (1,973 transactions)
- LA (3,369 transactions)
- NY (1,947 transactions)
- Miami (1,882 transactions)
- SF (1,221 transactions)

Variables: floor area, I(average number of floors > 6), I(main city), I(north of CBD), I(east of CBD), Distance to CBD

Washington DC office property prices

Physical and economic depreciation (5–45 years)

- Physical: 1.5%/year
- Obsolescence: −0.3%/year
- Economic: 1.2%/year

Cohort effects

- Obsolescence is small except 1945-1955 and 2010

New York office property prices

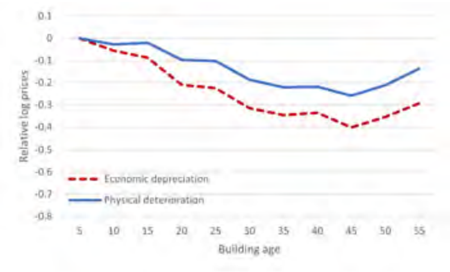
Physical and economic depreciation (5–45 years)

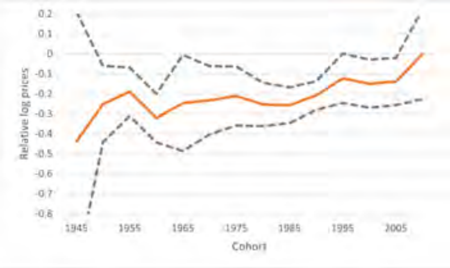
- Physical: 1.0%/year
- Obsolescence: 0.4%/year
- Economic: 1.4%/year

Cohort effects

- Obsolescence is small until early 1980s but large since 1990s

Los Angeles office property prices





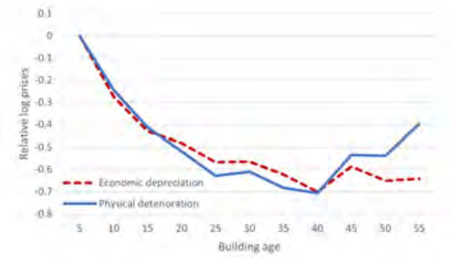
Physical and economic depreciation (5–45 years)

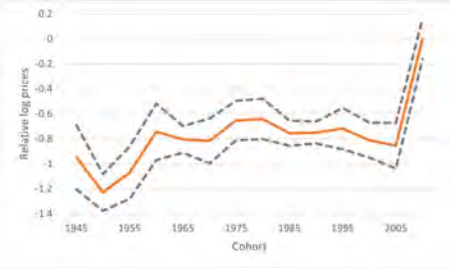
- Physical: 0.6%/year
- Obsolescence: 0.4%/year
- Economic: 1.0%/year

Cohort effects

- Functional obsolescence is continuous and gradual

San Francisco office property prices





Physical and economic depreciation (5–45 years)

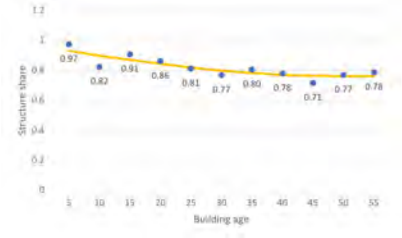
- Physical: 1.3%/year
- Obsolescence: 0.2%/year
- Economic: 1.5%/year

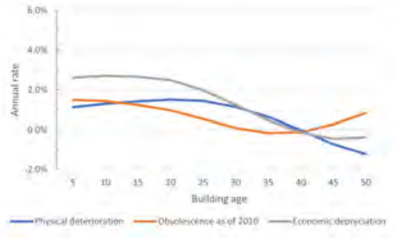
Cohort effects

- Obsolescence is small except 1950-1960 and 2010

Structure value depreciation (New York offices)

Structure value share is 0.71–0.97
Structure physical deterioration: −1.2 to 1.5% per year
Structure obsolescence: −0.2 to 1.5% per year
Structure economic depreciation: −0.5 to 2.7% per year





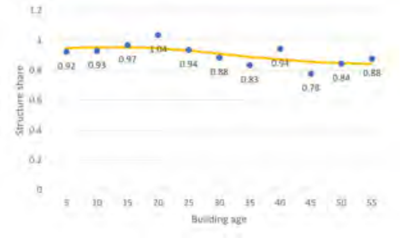
Structure value depreciation (Washington DC offices)

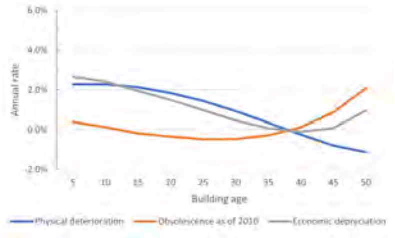
Structure value share is 0.78–1.04

Structure physical deterioration: −1.1 to 2.3% per year

Structure obsolescence: −0.5 to 2.1% per year

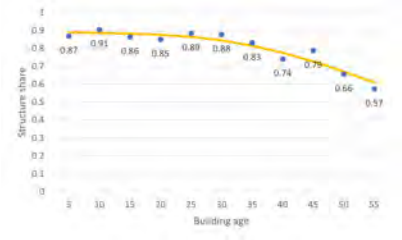
Structure economic depreciation: −0.1 to 2.7% per year

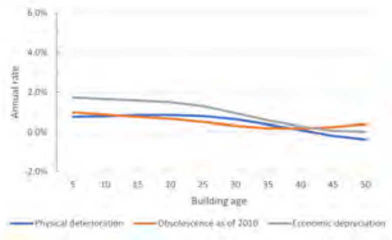




Structure value depreciation (Los Angeles offices)

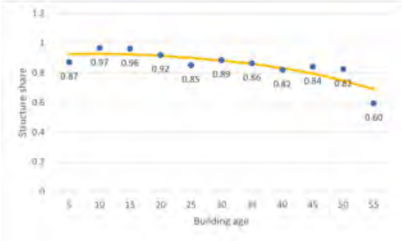
Structure value share is 0.57–0.91
Structure physical deterioration: −0.4 to 0.8% per year
Structure obsolescence: 0.2 to 1.0% per year
Structure economic depreciation: 0.0 to 1.7% per year

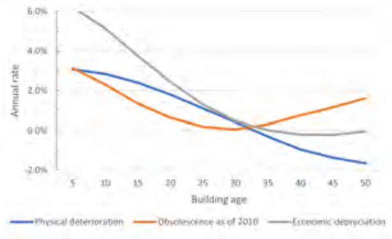




Structure value depreciation (San Francisco offices)

Structure value share is 0.60–0.97
Structure physical deterioration: −1.7 to 3.0% per year
Structure obsolescence: 0.1 to 3.1% per year
Structure economic depreciation: −0.2 to 6.2% per year





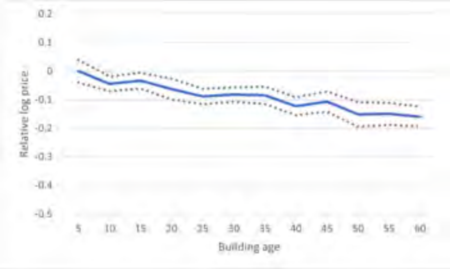
Navigation

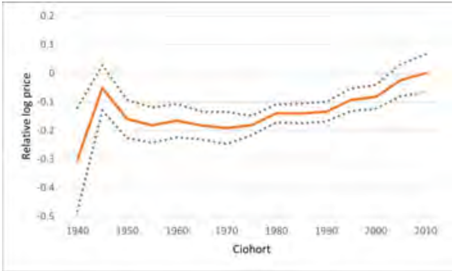
US Residential Property Prices

US housing prices

- Zillow ZTRAXX single family housing
- Sample period: 1994-2019
- Three Pennsylvania cities
  - Philadelphia-Camden-Wilmington (653,369 transactions)
  - Pittsburgh (115,914 transactions)
  - Allentown-Bethlehem-Easton (45,573 transactions)
- Billy Joel (1982) "Allentown"
  "Well we're living here in Allentown. And they're closing all the factories down. Out in Bethlehem they're killing time, filling out forms, standing in line..."
- Variables: floor area, lot size, fireplace, Number of baths, direction from CBD, distance to CBD

Philadelphia housing prices





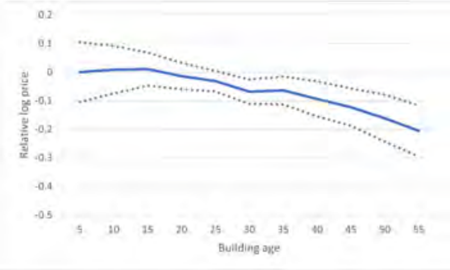
Physical and economic depreciation (5–45 years)

- Physical: 0.3%/year
- Obsolescence: 0.4%/year
- Economic: 0.7%/year

Cohort effects

- Obsolescence has been accelerating since 1980s.

Pittsburgh housing prices



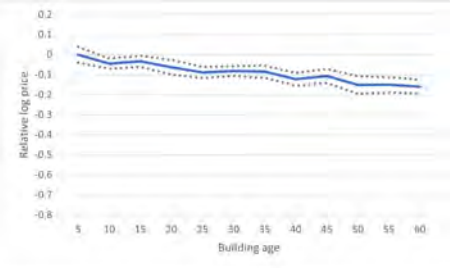
Physical and economic depreciation (5–45 years)

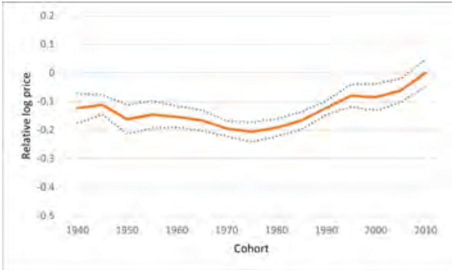
- Physical: 0.5%/year
- Obsolescence: 0.5%/year
- Economic: 1.0%/year

Cohort effects

- Obsolescence has been accelerating since 1980s.

Allentown-Bethlehem housing prices





Physical and economic depreciation (5–45 years)

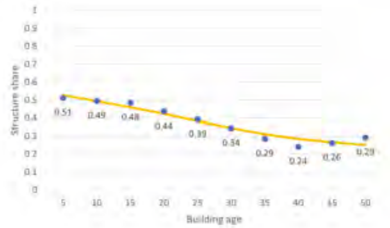
- Physical: 0.3%/year
- Obsolescence: 0.5%/year
- Economic: 0.8%/year

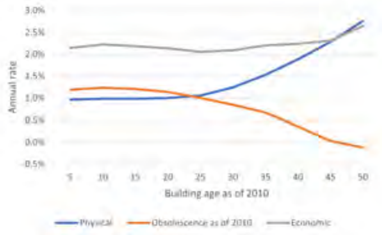
Cohort effects

- Obsolescence has been accelerating since 1980s.

Structure value depreciation (Philadelphia housing)

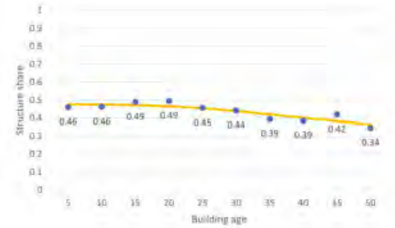
Structure value share is 0.24–0.51
Structure physical deterioration: 1.0 to 2.8% per year
Structure obsolescence: -0.1 to 1.2% per year
Structure economic depreciation: 2.1 to 2.6% per year

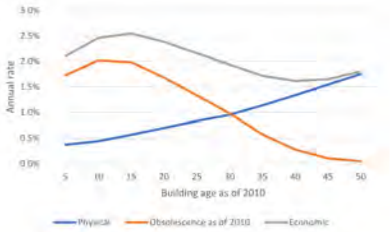




Structure value depreciation (Pittsburgh housing)

Structure value share is 0.34–0.49
Structure physical deterioration: 0.4 to 1.8% per year
Structure obsolescence: 0.1 to 2.0% per year
Structure economic depreciation: 1.6 to 2.6% per year





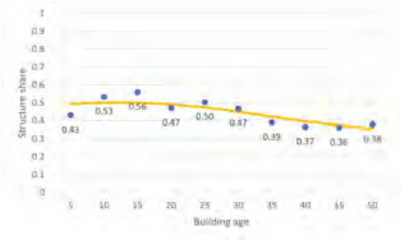
Structure value depreciation (Allentown-Bethlehem housing)

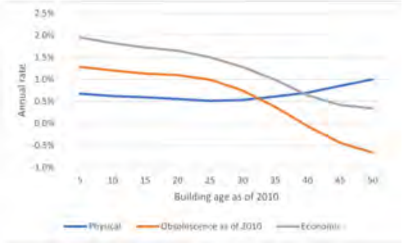
Structure value share is 0.36–0.56

Structure physical deterioration: 0.5 to 1.0% per year

Structure obsolescence: -0.7 to 1.3% per year

Structure economic depreciation: 0.3 to 2.0% per year





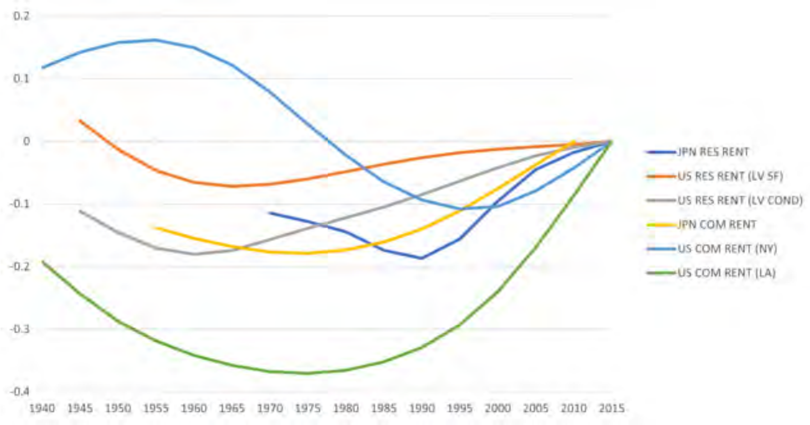
Navigation

Summary of depreciation rates

	Prices		Rents	
	Residential	Office	Residential	Office
Japan (Tokyo)	(SF)		(MF)	
Property	3.1%	5.3%	1.7%	1.6%
(largest at)	5 yrs	5 yrs	20 yrs	15 yrs
Structure	5.8%	10.8%	4.8%	N/A
USA	(Philly-SF)	(NY)	(LV-SF)	(NY)
Property	1.1%	1.4%	1.8%	1.0%
(largest at)	5 yrs	5 yrs	5 yrs	5 yrs
Structure	2.1%	2.7%	N/A	N/A

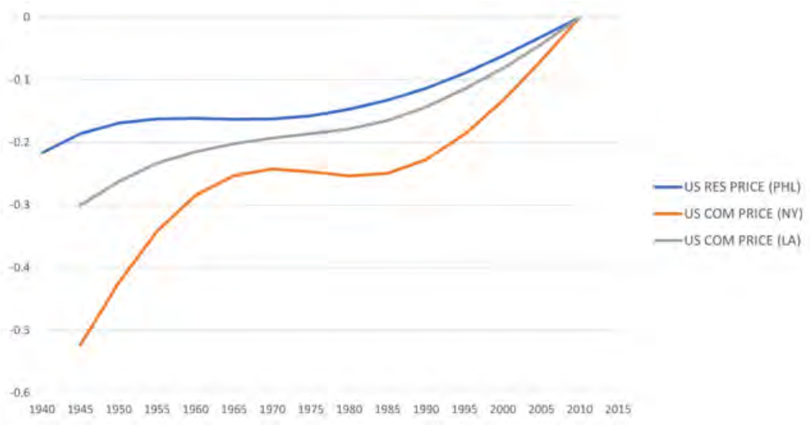
- Property rent depreciation is similar across markets
- Structure depreciation is larger than property depreciation where land is significant
- Price depreciation is larger than rent depreciation in Japan, suggesting a short economic life

Summary of cohort effects on rents



- Lower rents for past cohorts (obsolescence)
- The bottom year varies by market
  - JPN Res at 1990 vs US Res at 1960
  - JPM Com at 1975 vs LA Com at 1975 and NY Com at 1995

Summary of cohort effects on prices



- Smaller obsolescence for residential than for offices
- Rapid obsolescence for New York offices since 1990

Depreciation and Housing Service Production

Depreciation creates variation in production factors

- For a newly developed house, housing services h_0 are produced with the optimized mix of land and structure.
  - $h_0 = f(L^*, S^*)$
- Effective structure decreases as structure depreciates at age u.
  - $h_u = f(L^*, E_u S^*)$
- If housing services is a linear transformation of housing asset, asset data can be used ($H_u = ah_u, a \in \mathbb{R}_+$).
  Caveat: Need a more careful analysis of transformation

We observe only property value

$$V_{t,u} = P_t^H H_u = P_t^H \left[\alpha (E_u S)^{\frac{\theta-1}{\theta}} + (1-\alpha) L^{\frac{\theta-1}{\theta}} \right]^{\frac{\eta\theta}{\theta-1}},$$

P_t^H: Unit price **(latent variable)**

H_u: Effective quantity of property **(latent variable)**

S: Quantity of structure (floor s.f.)

E_u: Effectiveness of structure at age u

- Depreciation: $d \ln E_u / du < 0$

L: Quantity of homogeneous land (lot s.f.)

α: Relative weight on the effective structure

θ: Elasticity of substitution between structure and land

η: Returns to scale

Value shares provide information about production function

Suppose the seller solves:

$$\max_{S,L} \Pi \equiv V_{t,u}(S,L) - P_t^{ES} E_u S - P_t^L L,$$

where P_t^{ES} and P_t^L are shadow prices in the internal factor markets (factors $E_u S$ and L are inelastically supplied for seasoned assets).

By FOCs:

$$\frac{P_t^{ES} E_u S}{V_{t,u}} (\equiv s_{t,u}) = \eta \left[\frac{\alpha \left(E_u S\right)^{\left(1-\frac{1}{\theta}\right)}}{\alpha \left(E_u S\right)^{\left(1-\frac{1}{\theta}\right)} + (1-\alpha) L^{\left(1-\frac{1}{\theta}\right)}} \right],$$

$$\frac{P_t^L L}{V_{t,u}} (\equiv l_{t,u}) = \eta \left[\frac{(1-\alpha) L^{\left(1-\frac{1}{\theta}\right)}}{\alpha \left(E_u S\right)^{\left(1-\frac{1}{\theta}\right)} + (1-\alpha) L^{\left(1-\frac{1}{\theta}\right)}} \right].$$

Results

Result 1

$$s_{t,u} + l_{t,u} = \eta \text{ (Returns to scale)}$$

$$\text{CRS if } s_{t,u} + l_{t,u} = 1 \text{ and } \Pi_{t,u} = 0,$$

$$\text{DRS if } s_{t,u} + l_{t,u} < 1 \text{ and } \Pi_{t,u} > 0,$$

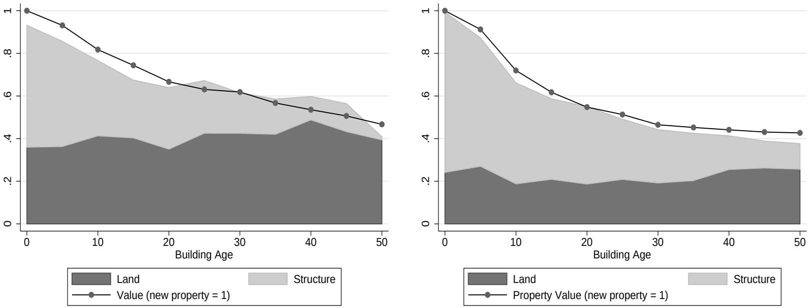
$$\text{IRS if } s_{t,u} + l_{t,u} > 1 \text{ and } \Pi_{t,u} < 0,$$

Result 2

$$\frac{\partial s_{t,u}}{\partial u} = \frac{(1-\theta)\,\delta_u s_{t,u} l_{t,u}}{\theta\eta}$$

The value share of structure is decreasing if $(1-\theta)\delta_u < 0$.

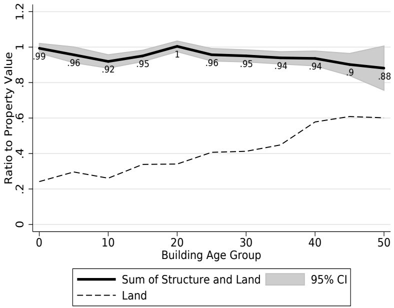
Decomposition of Property Value (Residential, Japan)



(a) Tokyo (b) Outside Tokyo

Results by Age (Residential, Japan)

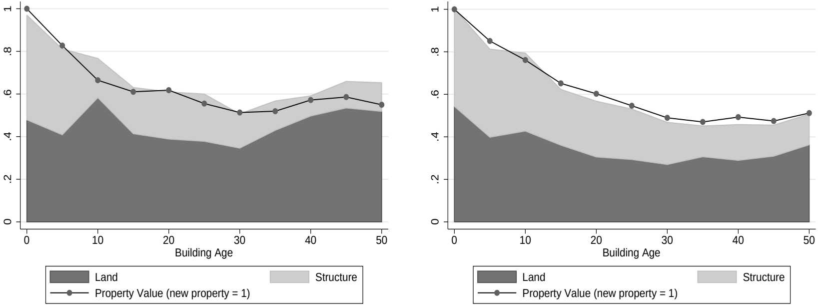
(a) Tokyo



(b) Outside Tokyo

Finding 1: $s_{t,u} + l_{t,u} = \eta \approx 1$ (constant returns)
Finding 2: $\frac{\partial s_{t,u}}{\partial u} < 0 \Rightarrow \theta > 1$ (gross substitutes)
Finding 3: Value share of land is larger for old properties in a larger city

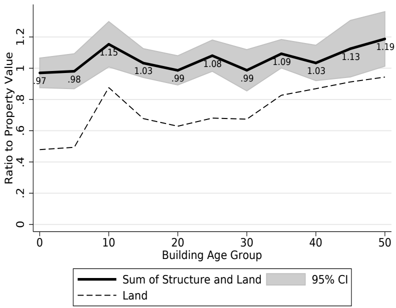
Decomposition of Property Value (Commercial, Japan)



(a) Tokyo

(b) Outside Tokyo

Results by Age (Commercial, Japan)

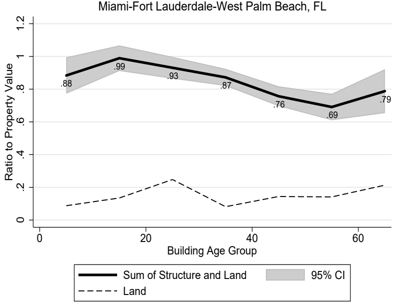


(a) Tokyo

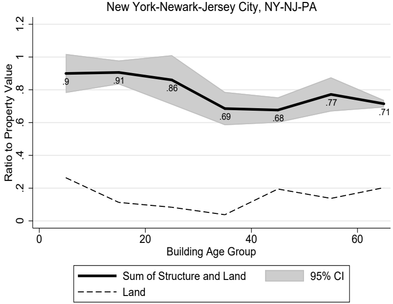
(b) Outside Tokyo

Finding 1: $s_{t,u} + l_{t,u} = \eta \approx 1$ (constant returns)
Finding 2: $\frac{\partial s_{t,u}}{\partial u} < 0 \Rightarrow \theta > 1$ (gross substitutes)
Finding 3: Land value share is larger for commercial real estate than housing

Results by Age (Apartment, Supply-Inelastic US Cities)



(c) Miami

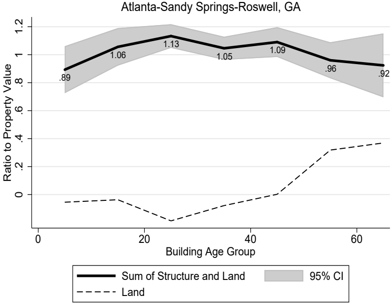


(d) New York

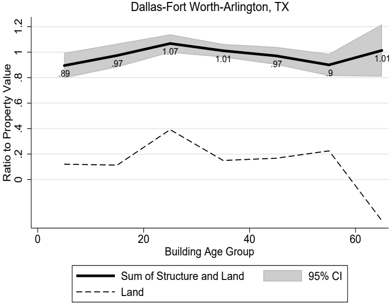
Finding 1: $s_{t,u} + l_{t,u} = \eta < 1$ (decreasing returns) for older properties

Finding 2: Land value share is very small

Results by Age (Apartment, Supply-Elastic US Cities)



(a) Atlanta



(b) Dallas

Finding 1: $s_{t,u} + l_{t,u} = \eta \approx 1$ (constant returns)

Finding 2: Land value share is very small

Summary

Depreciation sounds dismal but is important and interesting.

In particular, functional obsolescence of capital provides insights into past technological progress.

Depreciation rates vary significantly by market due to different technological environments.

Real estate depreciation also gives additional insight into real estate service production.

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