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Week 3: The Urban Housing Market, Structures and Density.

- Hedonic Regression Analysis.
- Shadow “prices” versus marginal costs.
- Land value maximizing FAR.
- FAR and Urban Redevelopment.
- Land Use competition: Highest Price for Housing – versus – highest use for land

Urban Housing

- Great diversity from historical evolution, changes in technology and tastes.
- Multiple attributes to each house: size, baths, exterior material, style….location
- Consumers value each of these attributes with the normal law of micro-economics: diminishing marginal utility.
- Huge industry has evolved to applying statistical models to understand and predict diverse house prices:
  - Property Tax appraisals.
  - Automatic Valuation Services for lenders, brokers…

Hedonic Regression Analysis

1). Linear:

$$R = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots$$

X's are structural, location attributes

2). Log Linear:

$$R = e^{[\alpha + \beta 1X1 + \beta 2X2 + \beta 3X3 + \ldots]}$$

$$\ln(R) = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots$$

3). Log Log:

$$R = \alpha\, X_1^{\beta 1} X_2^{\beta 2} X_3^{\beta 3} \ldots$$

$$\ln(R) = \ln(\alpha) + \beta_1 \ln(X_1) + \beta_2 \ln(X_2) + \ldots$$

Dallas apartment rent Hedonic equation: 1998 (Log monthly rent)

Regression statistics	
Multiple R	0.90518672
R Square	0.819363
Adjusted R Square	0.81899567
Standard error	0.14378576
Observations	7885

ANOVA

	df	SS	MS	F	Significance F
Regression	16	737.8460495	46.11538	2230.561	0
Residual	7868	162.6657463	0.020674		
Total	7884	000.5117958			

	Coefficients	Standard error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0
Intercept	-0.57141659	0.176232118	-3.24241	0.00119	-0.9168784	-0.22595	-0.91688
#BED	-0.00076159	0.004946816	-0.15395	0.877649	-0.0104587	0.008935	-0.01046
#BATH	0.04799528	0.005624626	8.533063	1.69E-17	0.0369695	0.059021	0.03697
LnSQFT	0.6432852	0.012443205	51.69771	0	0.6188932	0.667677	0.618893
1/FAR	0.09504048	0.005839225	16.27621	1.31E-58	0.083594	0.106487	0.083594
LnAGE	-0.08762126	0.00195439	-44.8331	0	-0.0914524	-0.08379	-0.09145
LnPARK	0.09666656	0.00533756	18.11063	7.46E-72	0.0862035	0.10713	0.086204
#POOL	-0.03185748	0.001586528	-20.08	1.67E-87	-0.0349675	-0.02875	-0.03497
RCA	0.00732288	0.000715092	10.24048	1.86E-24	0.0059211	0.008725	0.005921
SEC	0.01631909	0.002140012	7.625699	2.71E-14	0.0121241	0.020514	0.012124
WD	0.00775154	0.002556777	3.031761	0.002439	0.0027396	0.012764	0.00274
APP	0.02115624	0.001660838	12.73829	8.35E-37	0.0179006	0.024412	0.017901
FP	0.0181616	0.004472787	4.060466	4.94E-05	0.0093937	0.026929	0.009394
DEN	0.02276466	0.006928009	3.285888	0.001021	0.0091839	0.036345	0.009184
INT	0.00872255	0.001784347	4.88837	1.04E-06	0.0052248	0.01222	0.005225
LnHome$	0.17170179	0.005361375	32.0257	1.2E-211	0.1611921	0.182212	0.161192
LnSAT	0.01175916	0.019835531	0.592833	0.55331	-0.0271238	0.050642	-0.02712

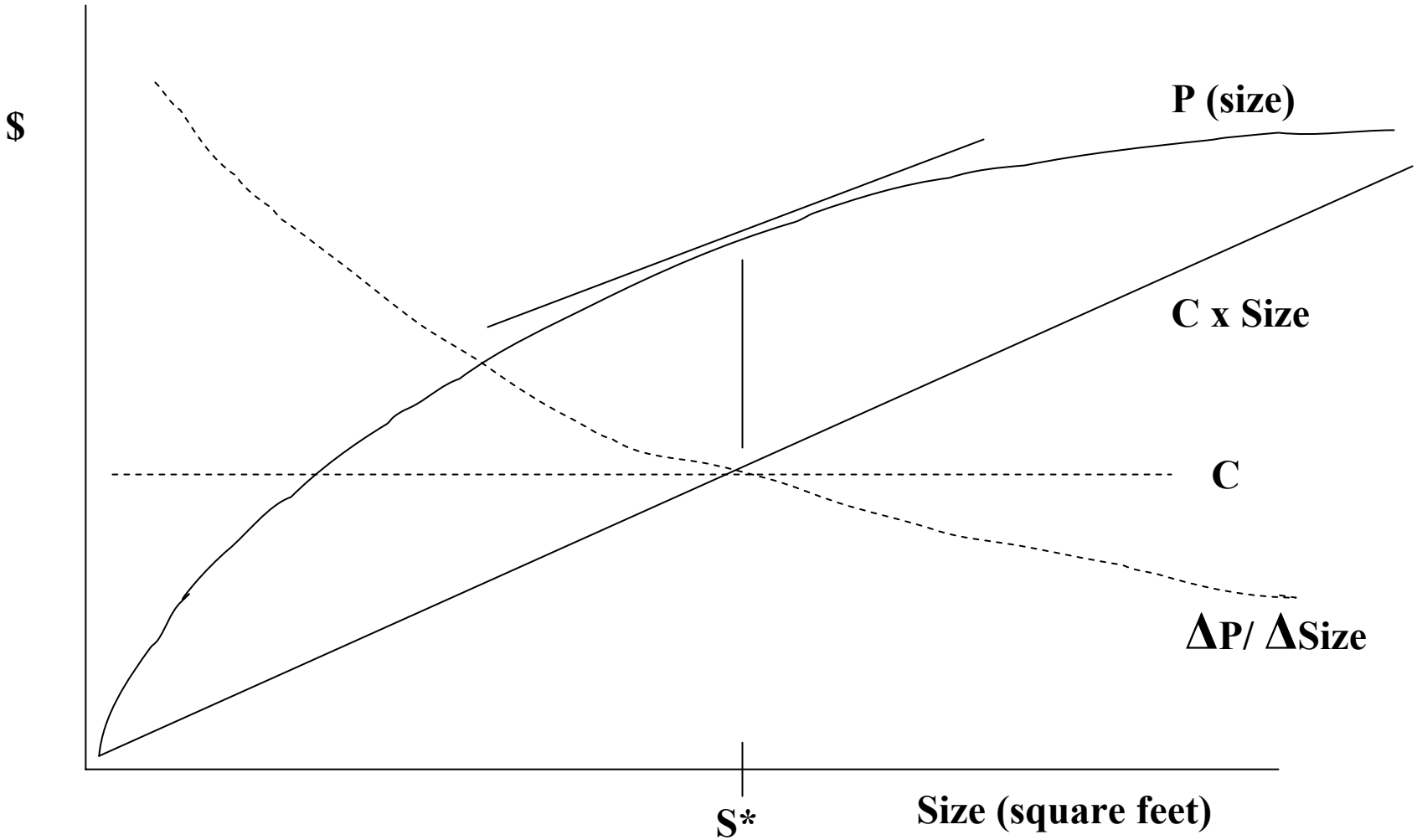
Log/Log; Verify White Settlement, Rockwall and Ft. Worth HOME$; all observations;

Figure by MIT OpenCourseWare.

Optimizing House Configuration

- Builders and developers compare the incremental value of additional house features against their incremental cost.
- Profit maximizing house: where the cost of an additional square foot, bath, fireplace falls to the marginal cost of construction.
- But what about land, lot size, density or FAR?
  - FAR: floor area ratio (ratio of floor to land area).
  - Density: units per acre.
  - Density x unit floor area = FAR
  - % of lot “open” = 1-(FAR/stories) (stories>FAR)

Optimizing House price (P) minus construction cost (C) as a function of square feet (see Dallas results)



FW Dodge data on projects tells the impact of FAR on Costs (see Dallas slide for rent impact)

Washington, DC Apartments					
Source	SS	df	M3	Number of obs =	7704
				F(44, 7659)	344.43
Model	1361.83364	44	30.9507646	Prob > F	0
Residual	688.245166	7659	.8986097	R-squared	0.6643
				Adj R-squared	0.6624
Total	2050.07881	7703	.26614031	Root M SE	0.29977

Ln(cost/sf)	Coef.	Std. Err.	t	P > t	[95% Conf.	Interval]
Area	-0.001407	.0000897	-15.69	0.000	-.0015827	-0.00123
Units	0.0011156	.0001058	10.55	0.000	.0009083	0.001323
Stories	0.0239439	.0021155	11.32	0.000	.0197969	0.028091
Steel	0.1064428	.0241704	4.40	0.000	.0590621	0.153823
Wood	0.0201084	.0081667	2.46	0.014	.0040995	0.036117
Concrete	0.01922123	.0233001	8.25	0.000	.1465378	0.237887
Other/Unk	0.0197511	.0125935	1.57	0.117	-.0049357	0.044438
1967	-1.704015	.048317	-35.27	0.000	-1.798729	-1.6093
1968	-1.668757	.0463638	-35.99	0.000	-1.759643	-1.57787
1969	-1.554727	.046054	-33.76	0.000	-1.645005	-1.46445
1970	-1.524854	.0528213	-28.87	0.000	-1.628398	-1.42131
1971	-1.479251	.040121	-36.87	0.000	-1.557899	-1.4006
1972	-1.434557	.0399378	-35.92	0.000	-1.512846	-1.35627
1973	-1.335804	.0434758	-30.73	0.000	-1.421029	-1.25058
1974	-1.271703	.049658	-25.61	0.000	-1.369047	-1.17436
1975	-1.149854	.0558866	-20.57	0.000	-1.259407	-1.0403

Figure by MIT OpenCourseWare.

Optimizing FAR

1). $P = \alpha - \beta F$

α = Price for all housing and location factors besides FAR

F = FAR

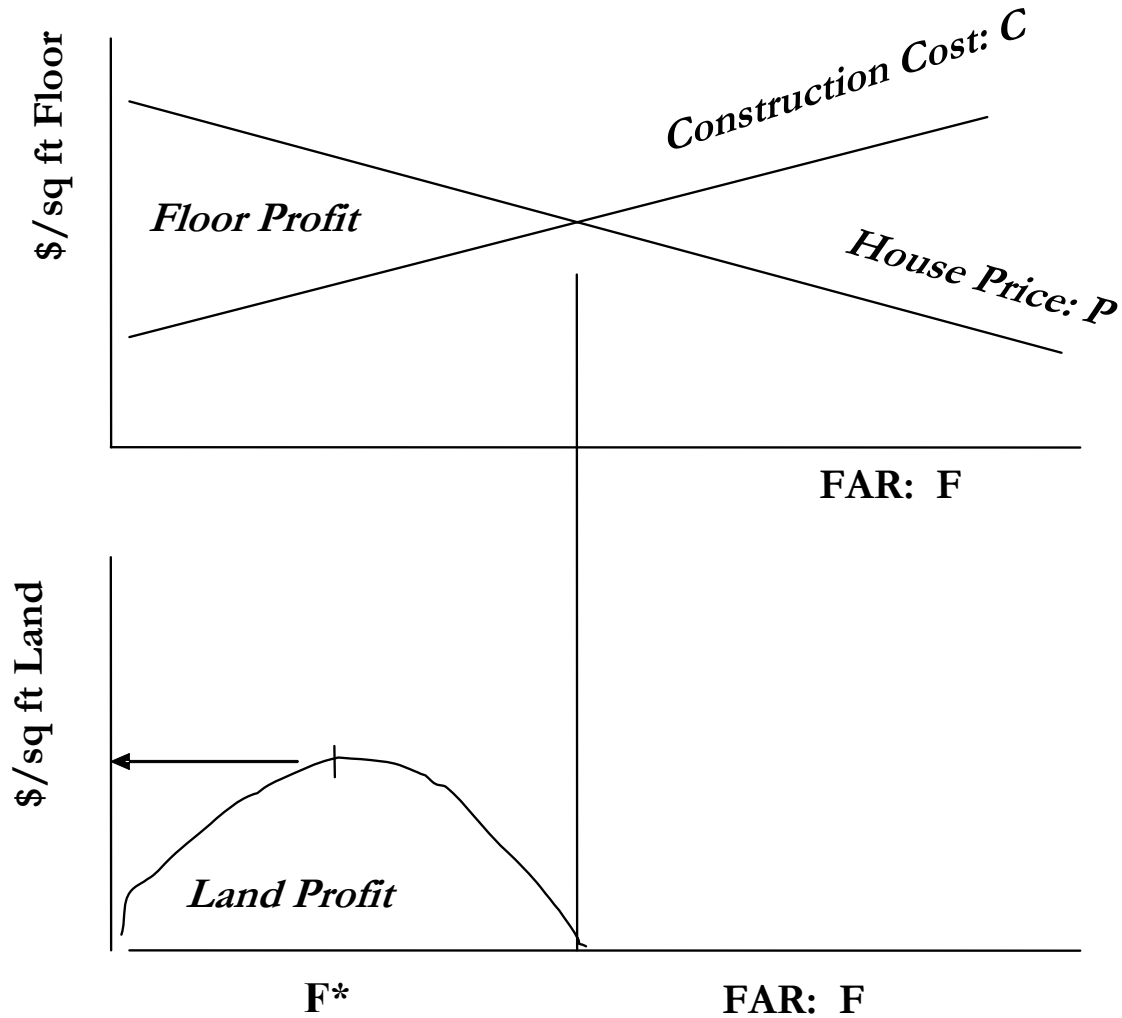
β = marginal impact of FAR on Price per square foot.

2). $C = \mu + \tau F$

μ = "baseline" cost of "stick" SFU construction

τ = marginal impact of FAR on cost per square foot

If each unit of floor are is unprofitable then so is land – regardless of FAR. As FAR approaches zero, land profit is zero no matter how profitable floor area.



3). $p = F[P - C] = F[\alpha - \mu] - F^2[\beta + \tau]$

4). $\partial p/\partial F = [\alpha - \mu] - 2F[\beta + \tau] = 0$, or

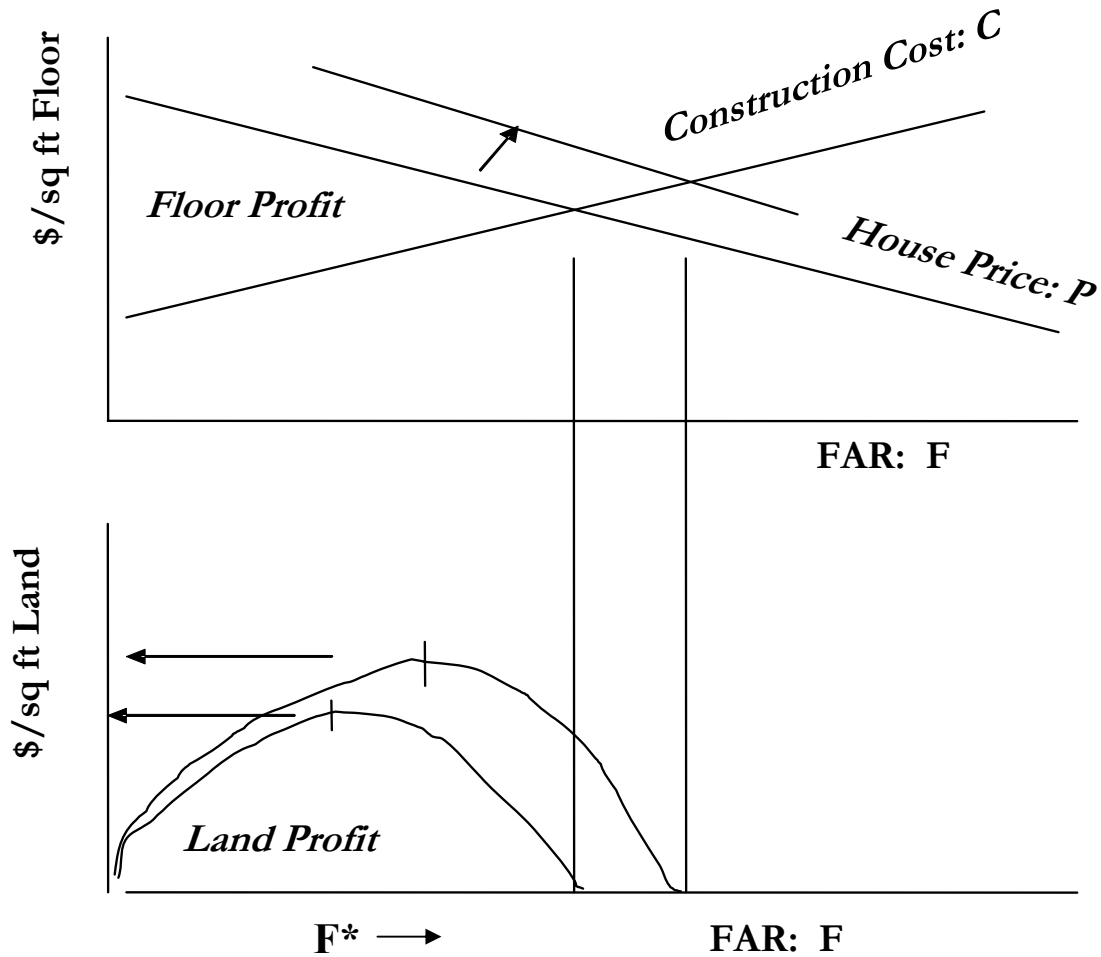
$F^* = [\alpha - \mu] / 2[\beta + \tau]$, and

$p^* = [\alpha - \mu]^2 / 4[\beta + \tau]$

5). How do prices and FAR vary by:

- Location
- Other factors that shift the parameters

At "better" locations, the price of housing at any FAR is higher. This yields a substitution of capital for land and the optimal FAR rises – helping to offset rise in Prices.



Boston Back Bay Condominium Example

- From 1984 regression: R = 222 – 1.48F, for new 2-bed, 2-bath with parking on Beacon hill. (178-1.48F for end of Commonwealth Ave.
- Construction costs: C = 100+2F
- F* = 17.5, p* = 46 million per acre (43,560 square feet)
- At F of 4.0, 2-bed, 2-bath existing land has value of 18.8 million (40% as much!)

“Optimal” Urban Design

- **What if you are building a ski resort? Or Designing a “new town”, or a Resort?**
- **Determine how much your clientele discounts FAR.**
- **Determine how much your clientele is willing to pay for access to the “urban Center”: ski lifts, beach, town center.**
- **At each location from the center figure the optimal FAR and residual land value.**
- **Develop accordingly. What do Ski resort FAR patterns look like?**

How does actual land use “evolve”?

- **Real City Development evolves gradually: from the center outward – always on vacant land at the edge.**
- **At each time period, there is a “shadow” value for interior land that is already built upon.**
- **When does that “shadow” value exceed the entire value of the existing structures?**
- **Fires, disasters create vacant land – shaping development**
- **Where does redevelopment happen?**

Actual Urban FAR Gradients

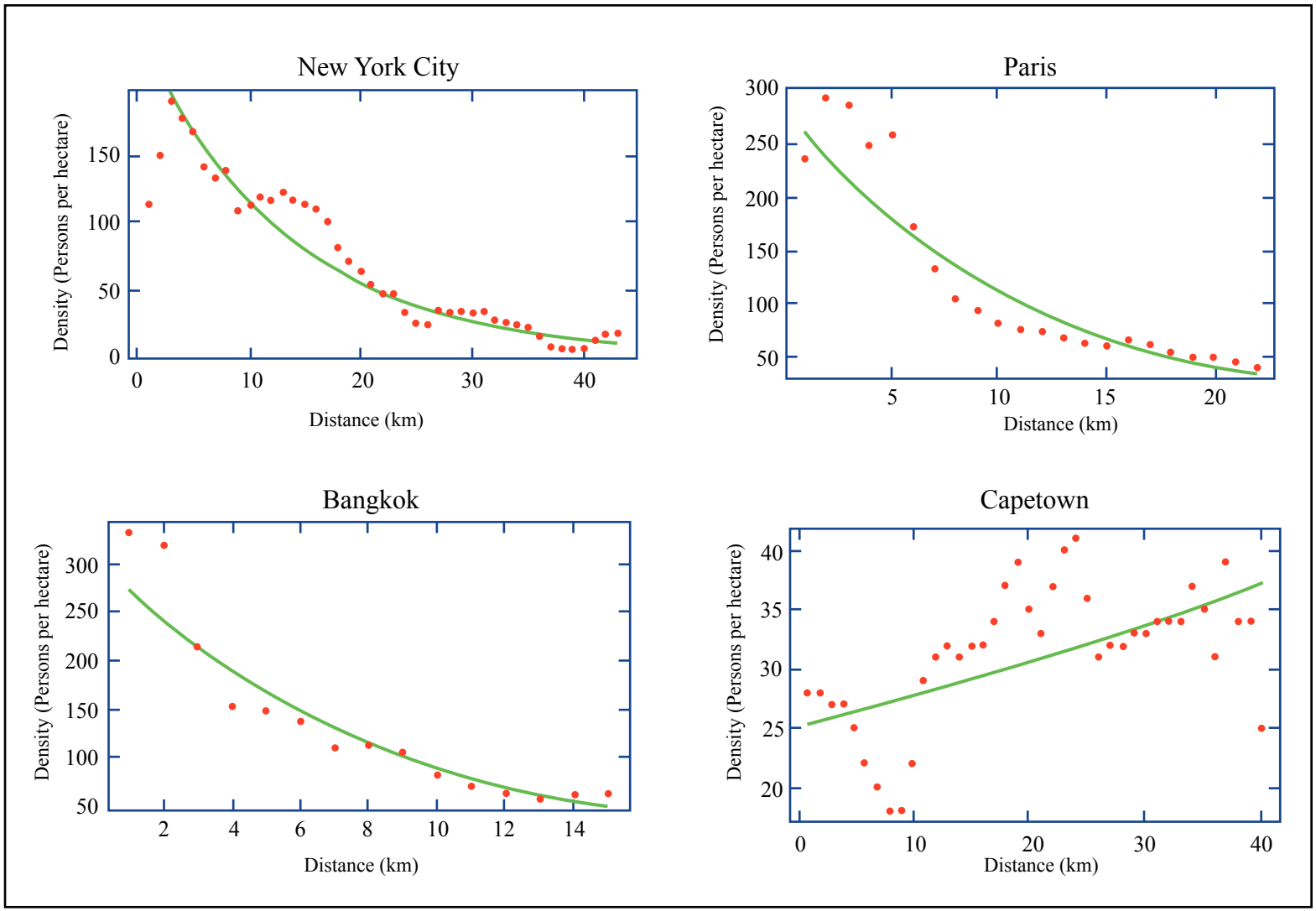
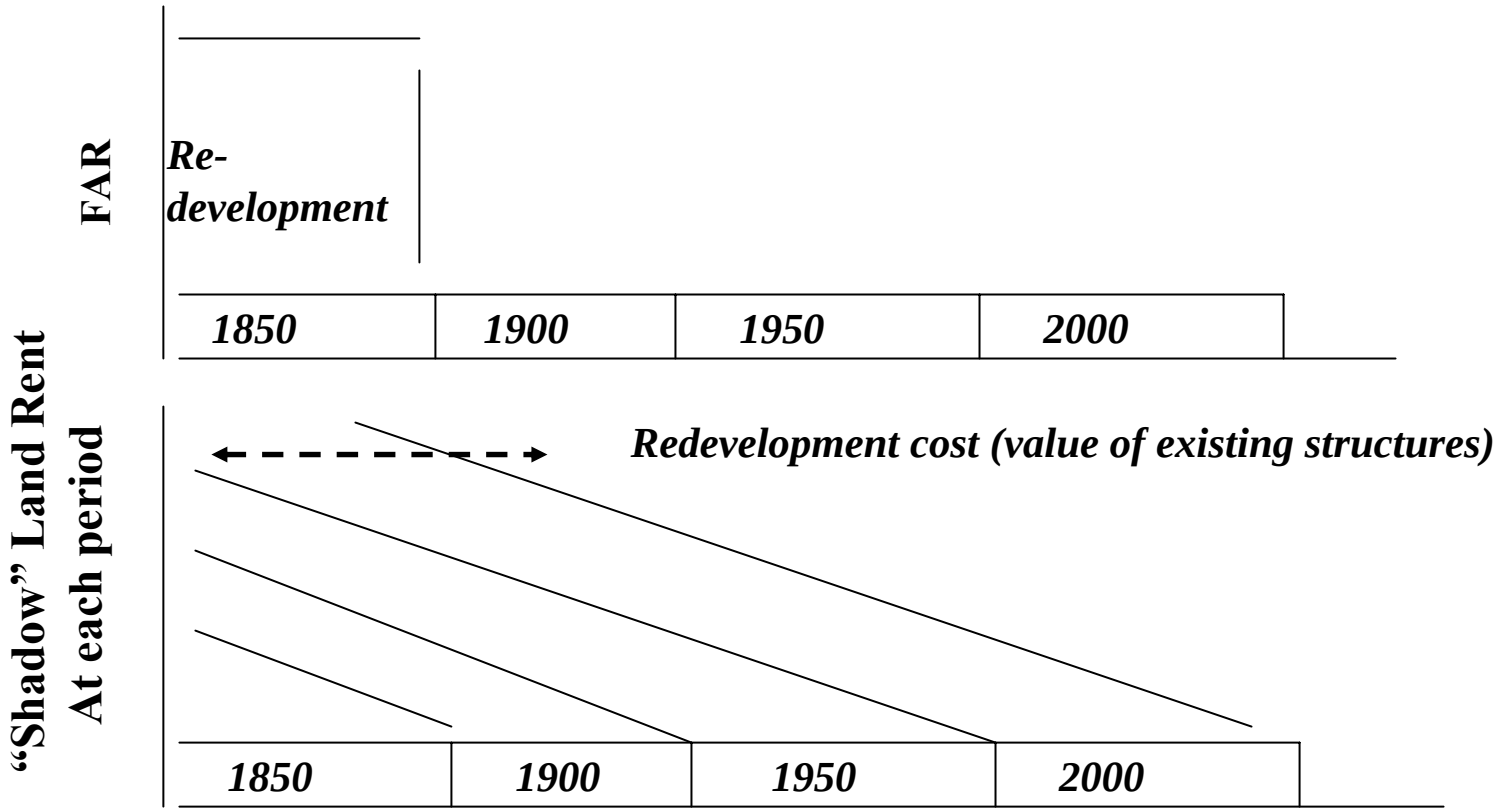


Figure by MIT OpenCourseWare, adapted from Bertaud, Alain, and Stephen Malpezzi. "The Spatial Distribution of Population in 48 World Cities: Implications for Economies in Transition."

The spatial Pattern of Economic Redevelopment



Economic Redevelopment

6). The sunk cost of existing structures generates a barrier to the smooth adjustment of FAR.

7). Rarely do we see incremental FAR increases. Rather old uses are destroyed and replace with new. Redevelopment "waves" in NY, Boston

8). Existing "older" structures:

$$P_0 = \alpha_0 - \beta F_0$$

δ = demolition cost per square foot

F_0 = FAR of existing use

$p_0 = F_0 [\alpha_0 - \beta F_0]$:land acquisition cost

9). $p^* - p_0 > \delta F_0$ implies

$F^*(\alpha - \beta F^*) - F_0(\alpha_0 - \beta F_0) > \delta F_0 + F^*(\mu + \tau F^*)$

"increase in value of land and capital" > "demolition plus development cost"

Most likely if $\alpha > \alpha_0$ (existing capital deteriorated)

$F^* > F_0$ (new use much more dense)

See: [Rosenthal and Helsley].

Boston Back Bay Condominium Example (continued)

- Assume that historic properties have 75% of the structure value versus new. Hence the value of 1 acre of 4-story brownstones is:

  4 x [166.5-1.48x4] x 43560 = 27m

- Thus even with significant demolition costs the current historic stock might be ready for "market demolition". Zoning?
- Ocean Front in LA? Mid Ring Tokyo?
- The lower existing FAR – the less the opportunity cost of redevelopment.

Land Use competition between groups

10). $P_i = \alpha - k_i d - \beta_i F$

d = distance from desirable location

F = FAR

i = 1,2 (different household types)

$k_1 > k_2$, $\beta_1 > \beta_2$

i.e. 1's value location more and mind FAR more (value lot size more).

11). $\partial P_i / \partial d = - k_i$ hence P_1 steeper than P_2

(previous lecture on location of groups)

11). $p_i = \max_F: F[\alpha - k_i d - \beta_i F - (\mu + \tau F)]$

$$F_i^* = [\alpha - k_i d - \mu] / 2[\beta_i + \tau] ,$$

$$p_i^* = [\alpha - k_i d - \mu] F_i^* / 2$$

since $\beta_1 > \beta_2$, $F_1^* < F_2^*$

12). $\partial p^*_i / \partial d = - k_i F_i^*$

Even though P_1 is steeper than P_2 it could be the case that p^*_1 is less steep than p^*_2

Group 1 is willing to pay the most for houses near the center, but group 2 is willing to pay the most for central land (it is the most profitable group to develop central land for).

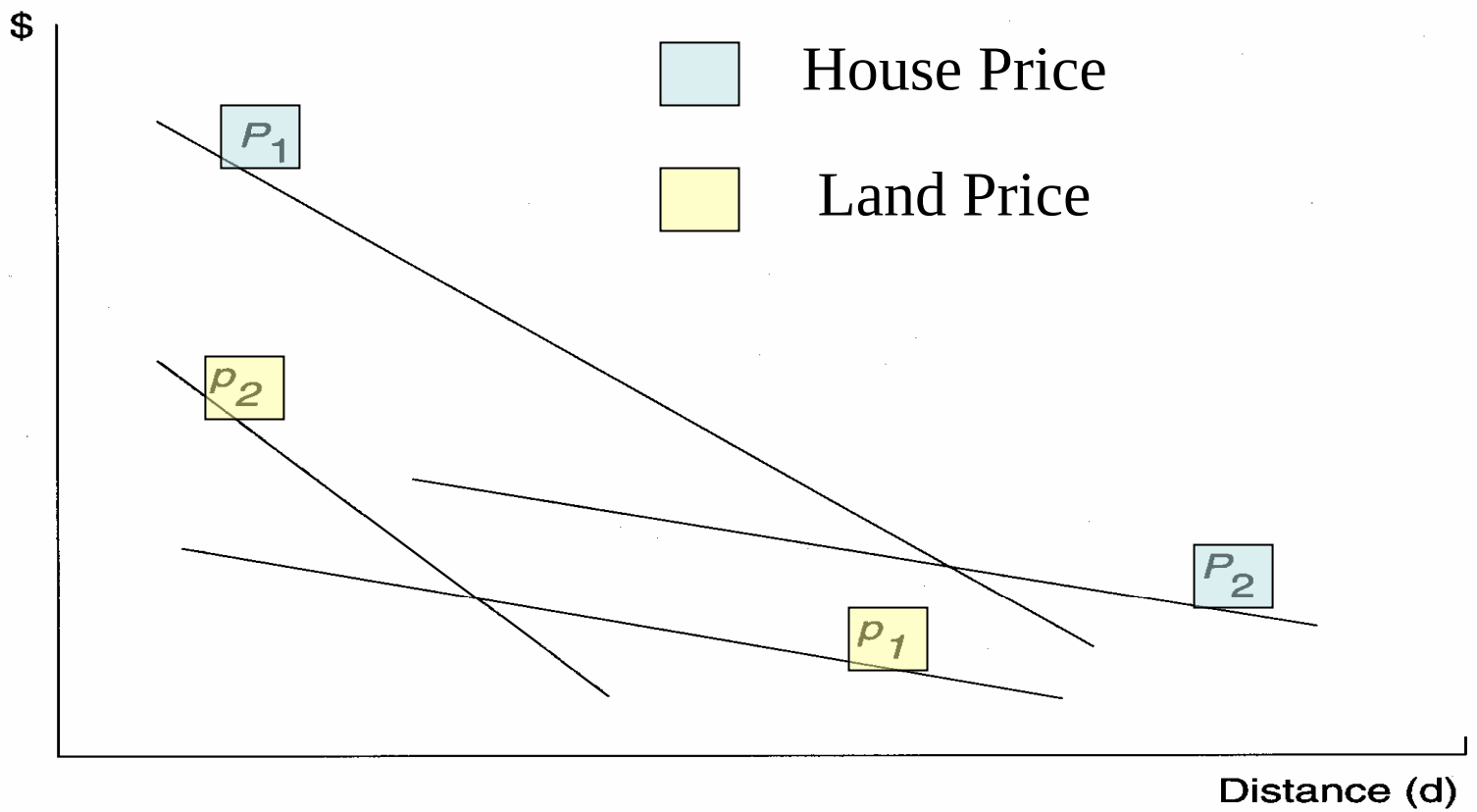


FIGURE 4.11 House and land price bids for two household types.

Examples of location and land bidding between groups

- Miami Waterfront has high rise condos populated by elderly who are never on the beach. Those on the beach (younger families) live inland!
- Why would wealthy families live in the center of Paris or Rome, but at the edge of Boston or Atlanta (with a few exceptions)?

NY Land Residuals: Highest Use? (2004 Data)

Location	Office				Condo			
	F	*P*	*C*	*p*	*F*	*P*	*C*	*p*
Downtown	20	220	250	(-)	6	524	350	1050
Midtown	20	376	250	2500	20	594	350	4800
Conn	4	225	150	300	2	350	200	300
NNJ	4	180	150	120	2	242	200	84

Sales data from the Internet, Costs from RS Means, 2004.