Quick Review

- The user cost model in housing valuation
- Limitations of the user cost model

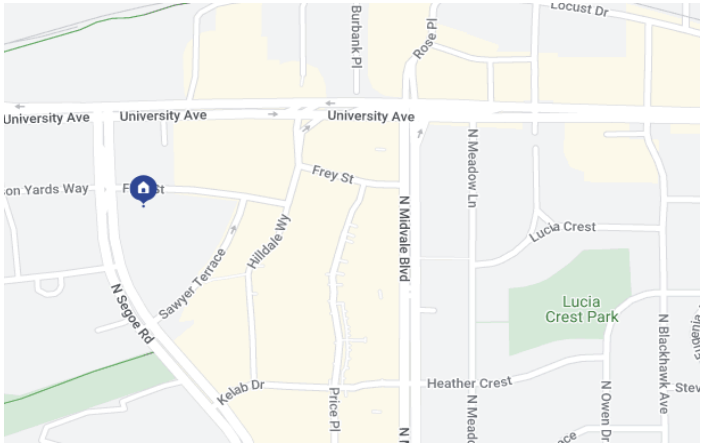
Housing Valuation II

RE420: URBAN AND REGIONAL ECONOMICS

Introduction

- Imagine you are considering to buy a home listed in Zillow
- How do we determine the listing price is appropriate?

< Weston Place, 625 N Segoe Rd, Madison, WI 53705 >



Two Different Approaches for Value

1. The User Cost Model
2. Hedonic Approach

Two Different Approaches for Value

1. The User Cost Model

2. **Hedonic Approach**

Hedonic Approach

Limitations of the User Cost Model

Hedonic Approach

Limitations of the User Cost Model

- Possible missing components in the user cost model
- Rent prices are not available for all properties
- Even if we know the rent price of a house, whether the rent price is fairly priced is still a question

Hedonic Approach

- Kain, J., Quigley, J. (1970). "Measuring the Value of Housing Quality," *Journal of the American Statistical Association* 65(330), 532-548.
- A dwelling is a bundle of attributes:
  - Floor space
  - Lot size
  - # Bedrooms
  - # Bathrooms
  - # Garages
  - Fireplace
  - …

Hedonic Approach

- When purchasing home, the buyers jointly purchase a wide variety of attributes, which influences the sale price
- Researchers found a number of variables that are relevant to the home purchase prices, such as:
  - Variables related to the quality of dwelling units (e.g., condition of floors, windows, walls, levels of housekeeping, etc.)
  - Variables related to the quality of the structure and parcel (e.g., condition of drives and walks, landscaping, structure exterior, etc.)
  - Variables related to the quality of adjacent properties (e.g., condition of structures, parcels, etc.)
  - Variables related to pertaining to the residential quality of specific aspects of the block face (e.g., condition of street, percent of nonresidential use, etc.)

Hedonic Approach

- E.g., Grether and Mieszkowski (1974):

$$House\ Value = 36 + 5.2 \times square\ footage + 0.89 \times lot\ size + 800 \times \#\ bathrooms + 580 \times family\ room + 830 \times fireplace + 790 \times one - car\ garage + 1{,}270 \times two - car\ garage - 5.2 \times average\ room\ size - 0.07 \times age \times square\ footage + additional\ attribute\ effect$$

Hedonic Approach

- E.g., Grether and Mieszkowski (1974):

$$House\ Value = 36 + 5.2 \times square\ footage + 0.89 \times lot\ size + 800 \times \#\ bathrooms + 580 \times family\ room + 830 \times fireplace + 790 \times one - car\ garage + 1{,}270 \times two - car\ garage - 5.2 \times average\ room\ size - 0.07 \times age \times square\ footage + additional\ attribute\ effect$$

  - A second bathroom is worth $800

Hedonic Approach

- E.g., Grether and Mieszkowski (1974):

$$House\ Value = 36 + 5.2 \times square\ footage + 0.89 \times lot\ size + 800 \times \#\ bathrooms + 580 \times family\ room + 830 \times fireplace + 790 \times one-car\ garage + 1{,}270 \times two-car\ garage - 5.2 \times average\ room\ size - 0.07 \times age \times square\ footage + additional\ attribute\ effect$$

  - Having a family room is worth $580

Hedonic Approach

- E.g., Grether and Mieszkowski (1974):

$$House\ Value = 36 + 5.2 \times square\ footage + 0.89 \times lot\ size + 800 \times \#\ bathrooms + 580 \times family\ room + 830 \times fireplace + 790 \times one-car\ garage + 1{,}270 \times two-car\ garage - 5.2 \times average\ room\ size - 0.07 \times age \times square\ footage + additional\ attribute\ effect$$

  - Having a fireplace is worth $830

Hedonic Approach

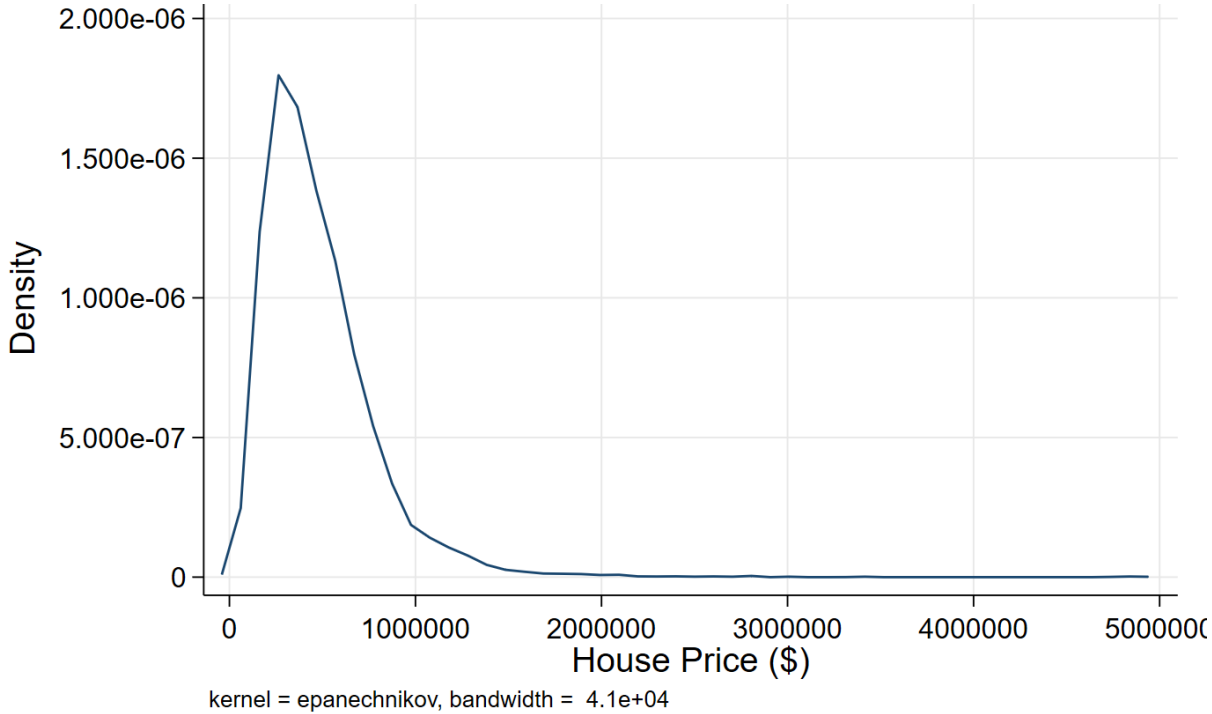
- E.g., Grether and Mieszkowski (1974):
  - Grether and Mieszkowski (1974) used housing transaction records during 1962-1969, when the home value were very low by today's standards
  - The average home value was $22,000

A Standard Hedonic Model

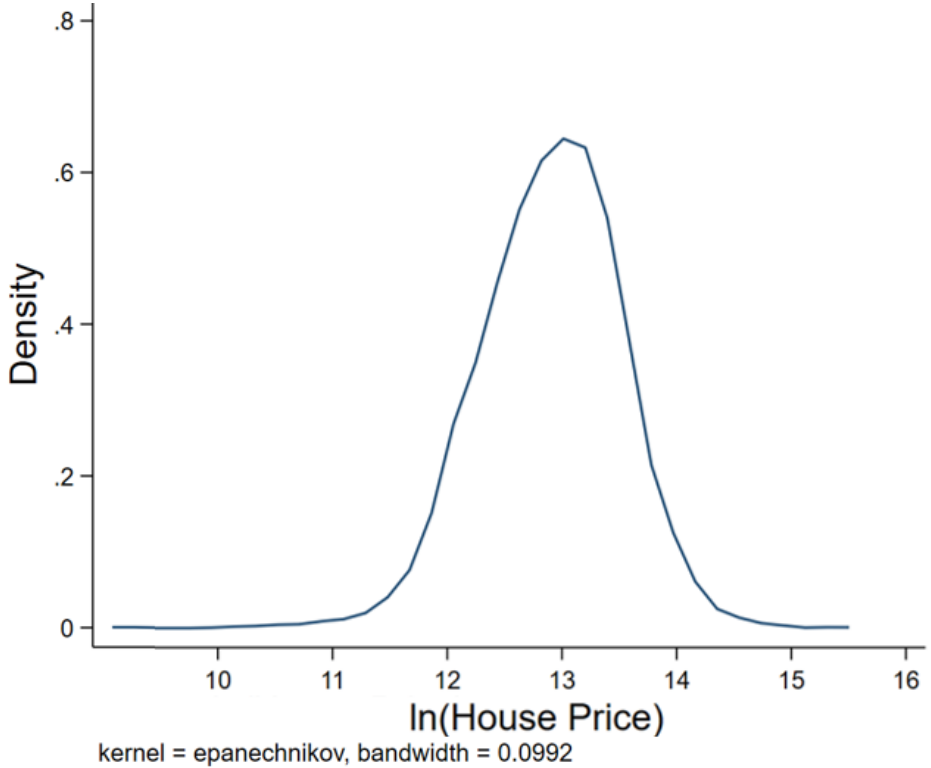
$$\ln P_{it} = \alpha + \beta_1 \ln X_{1i} + \beta_2 X_{2i} + \sum_{t=2}^{T} \gamma_t D_t + \varepsilon_{it} \quad (1)$$

- P_i is transaction price of property i, and is expressed in logarithmic form because the housing transactions prices are log-normally distributed;
- X_1 represents any continuously measured property, locational and neighborhood hedonic characteristics (e.g., lot size);
- X_2 represents any discretely measured property, locational and neighborhood hedonic characteristics (e.g., number of bedrooms, presence of garage);
- D_{it} is indicator variables (dummy) which take value of 1 if property i transacted during period t and 0 otherwise; notice one time period (typically the first period) is excluded;

House Price Distribution



ln(House Price) Distribution



A Standard Hedonic Model

$$\ln P_{it} = \alpha + \beta_1 \ln X_{1i} + \beta_2 X_{2i} + \sum_{t=2}^{T} \gamma_t D_t + \varepsilon_{it} \qquad (1)$$

- P_i is transaction price of property i, and is expressed in logarithmic form because the housing transactions prices are log-normally distributed;
- X_1 represents any continuously measured property, locational and neighborhood hedonic characteristics (e.g., lot size);
- X_2 represents any discretely measured property, locational and neighborhood hedonic characteristics (e.g., number of bedrooms, presence of garage);
- D_{it} is indicator variables (dummy) which take value of 1 if property i transacted during period t and 0 otherwise; notice one time period (typically the first period) is excluded;

Estimating Hedonic Model Using Stata

Set-up to run linear regression

1. Import housing transaction data
   - File > Import > Data to Excel spreadsheet (*.xls;*.xlsx)
   - Browse and select the file *housing transactions.xlsx.*
   - Check "Import first row as variable names" and OK
2. Create logarithms of price, landsqft, bldgsqft
   - gen ln_price = ln(price)
   - gen ln_landsqft = ln(landsqft)
   - gen ln_bldgsqft = ln(bldgsqft)
3. Create age_square
   - gen age_square = age*age
4. Create indicator variables for each year
   - tab year, gen(i_year)

Estimating Hedonic Model Using Stata

Running linear regression

1. Model 1: Age, Age^2, Bedrooms, Bathrooms, Centair, Fireplace, log(Bldgsqft)
2. Model 2: Age, Age^2, Bedrooms, Bathrooms, Centair, Fireplace, Garage1, Garage2, log(Landsqft), log(Bldgsqft)
3. Model 3: Age, Age^2, Bedrooms, Bathrooms, Centair, Fireplace, Garage1, Garage2, log(Landsqft), log(Bldgsqft), and Year Dummies (i_year2 - i_year17)

Estimating Hedonic Model Using Stata

- Model 1 Results

```
. reg ln_price age age_sq bedrooms bathrooms centair fireplace ln_bldgsqft
```

Source	SS	df	MS	Number of obs	=	4,905
				F(7, 4897)	=	842.05
Model	1026.85963	7	146.694232	Prob > F	=	0.0000
Residual	853.114596	4,897	.17421168	R-squared	=	0.5462
				Adj R-squared	=	0.5456
Total	1879.97422	4,904	.383355265	Root MSE	=	.41739

ln_price	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
age	.0091476	.0011283	8.11	0.000	.0069356	.0113595
age_sq	-.0000369	7.32e-06	-5.04	0.000	-.0000512	-.0000225
bedrooms	-.0125885	.0106274	-1.18	0.236	-.0334229	.0082459
bathrooms	.0811261	.0131337	6.18	0.000	.0553783	.106874
centair	.0677522	.0145667	4.65	0.000	.0391949	.0963096
fireplace	.273851	.0142485	19.22	0.000	.2459175	.3017845
ln_bldgsqft	.7527097	.0304127	24.75	0.000	.6930871	.8123323
_cons	6.613615	.1998897	33.09	0.000	6.221742	7.005488

Estimating Hedonic Model Using Stata

- Model 2 Results
  - Do more bedrooms reduce the housing value? Multicollinearity.

```
. reg ln_price age age_sq bedrooms bathrooms centair fireplace garage1 garage2 ln_landsqft ln_bldgsqft
```

Source	SS	df	MS	Number of obs	=	4,905
				F(10, 4894)	=	657.76
Model	1077.94319	10	107.794319	Prob > F	=	0.0000
Residual	802.031028	4,894	.163880472	R-squared	=	0.5734
				Adj R-squared	=	0.5725
Total	1879.97422	4,904	.383355265	Root MSE	=	.40482

ln_price	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
age	.0061594	.0011118	5.54	0.000	.0039798	.008339
age_sq	-.0000212	7.18e-06	-2.96	0.003	-.0000353	-7.16e-06
bedrooms	-.0215125	.0103288	-2.08	0.037	-.0417615	-.0012635
bathrooms	.0723319	.0127651	5.67	0.000	.0473067	.0973572
centair	.063527	.0141349	4.49	0.000	.0358162	.0912377
fireplace	.2249499	.0142307	15.81	0.000	.1970514	.2528484
garage1	.0832416	.0169442	4.91	0.000	.0500235	.1164598
garage2	.1034306	.016112	6.42	0.000	.0718438	.1350173
ln_landsqft	.2222428	.0159847	13.90	0.000	.1909056	.25358
ln_bldgsqft	.6542621	.0300247	21.79	0.000	.5954002	.7131241
_cons	5.545046	.214156	25.89	0.000	5.125204	5.964888

Estimating Hedonic Model Using Stata

- Model 3 Results

```
. reg ln_price age age_sq bedrooms bathrooms centair fireplace garage1 garage2 ln_landsqft ln_bldgsqft i_year2 i_year3 i_year4 i_year5 i_year6
> i_year7 i_year8 i_year9 i_year10 i_year11 i_year12 i_year13 i_year14 i_year15 i_year16 i_year17
```

Source	SS	df	MS	Number of obs	=	4,905
				F(26, 4878)	=	308.32
Model	1168.76466	26	44.952487	Prob > F	=	0.0000
Residual	711.20956	4,878	.145799418	R-squared	=	0.6217
				Adj R-squared	=	0.6197
Total	1879.97422	4,904	.383355265	Root MSE	=	.38184

ln_price	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
age	.0052777	.0010512	5.02	0.000	.003217	.0073385
age_sq	-.0000172	6.79e-06	-2.53	0.011	-.0000305	-3.89e-06
bedrooms	-.0217251	.0097563	-2.23	0.026	-.0408518	-.0025984
bathrooms	.0712853	.0120658	5.91	0.000	.047631	.0949396
centair	.0559059	.0133955	4.17	0.000	.0296447	.0821671
fireplace	.2311303	.0134517	17.18	0.000	.204759	.2575017
garage1	.0855076	.0160298	5.33	0.000	.0540819	.1169332
garage2	.103643	.015224	6.81	0.000	.073797	.133489
ln_landsqft	.2240198	.0150943	14.84	0.000	.1944282	.2536114
ln_bldgsqft	.6584156	.0283941	23.19	0.000	.6027504	.7140809
i_year2	.047372	.0289969	1.63	0.102	-.0094749	.1042189
i_year3	.1722712	.0280525	6.14	0.000	.1172757	.2272668
i_year4	.236422	.0277317	8.53	0.000	.1820555	.2907886
i_year5	.2888367	.0282932	10.21	0.000	.2333694	.344304
i_year6	.4036855	.0288176	14.01	0.000	.34719	.460181
i_year7	.474108	.0299043	15.85	0.000	.4154822	.5327339
i_year8	.4642035	.0321114	14.46	0.000	.4012507	.5271564
i_year9	.3755582	.0343425	10.94	0.000	.3082315	.4428849
i_year10	.221729	.0357797	6.20	0.000	.1515846	.2918733
i_year11	.1763287	.0339424	5.19	0.000	.1097863	.2428712
i_year12	.1144668	.0355145	3.22	0.001	.0448424	.1840912
i_year13	.0723015	.0327919	2.20	0.028	.0080145	.1365884
i_year14	.2171321	.03166	6.86	0.000	.1550643	.2791999
i_year15	.2604176	.0321901	8.09	0.000	.1973105	.3235248
i_year16	.3018166	.0311502	9.69	0.000	.2407481	.3628851
i_year17	.3019244	.0310974	9.71	0.000	.2409595	.3628893
_cons	5.298103	.2032612	26.07	0.000	4.899619	5.696586

Estimating Hedonic Model Using Stata

- From the estimated coefficients from Model 1, we can write the hedonic price equation as:

$$\ln(Price) = 6.61361 + 0.00914 \times Age - 0.00003 \times Age^2 - 0.0125 \times Bedrooms + 0.0811 \times Bathrooms + 0.0677 \times CentAir + 0.2738 \times Fireplace + 0.7527 \times \ln(bldgsqft)$$

- Then, what is the price of a house with the following characteristics?
  - 20-year-old
  - 3 bedroom & 3 bathroom
  - w/ central air conditioning & fireplace
  - 3,000 building sqft

Estimating Hedonic Model Using Stata

$$\ln(Price) = 6.61361 + 0.00914 \times 20 - 0.00003 \times 20^2 - 0.0126 \times 3 + 0.0811 \times 3 + 0.0677 \times 1 + 0.2738 \times 1 + 0.7527 \times \ln(3000) = \mathbf{13.35549}$$

$$\therefore Price = \exp(13.35549) = \mathbf{\$631,272.9}$$

Limitation of Hedonic Model

1. Never be able to completely and exhaustively know which variables affect housing values
2. Even if we know all the relevant variables, it is almost impossible to collect all these hedonic characteristics data
3. Hedonic function is changing over time
   - E.g., proximity to water (lake, river, ocean) typically increases the housing value, but recently, due to the increasing flood risk, proximity to water no longer increases the property value

Video Clip

Housing Markets Don’t Efficiently Factor in Flood Risk (2:20)

Key Takeaways

- Understand the concept of the hedonic model in housing valuation
- Understand the actual estimation of the hedonic model using Stata
- Understand the limitation of the hedonic pricing model
- Optional Readings:
  - Jan K. Brueckner, *Lectures on Urban Economics.* Chapter 6
  - Kain, J., Quigley, J. (1970). "Measuring the Value of Housing Quality," Journal of the American Statistical Association 65(330), 532-548.