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Hedonic Pricing and Housing Price Indices

Central Bank of Malta

March 7, 2019

Air Malta Magazine, March 2019

Portomaso Apartment

3 220m² € 1,800,000

his fantastic Portomaso apartment is in a special designated rea. The complex is one of the most sought after addresses in alta. Walking distance to all amenities, shops, restaurants and each clubs. It also includes access to the prestigious Hilton otel, where use of the swimming pool and gym are permitted to sidents. B-MT-138

Mercury Tower - 25th floor

1 1 60m² € 550,000

An iconic landmark property that redefines luxury and contemporary urban living right in the heart of Malta's premiere entertainment district. This unique development is set to raise the bar for future high-end lifestyle living developments, a game-changer in its own right. B-MT-075

Mellieha Penthouse

2 120m² € 630,000

erally 10 steps from the crystal clear sea, this property is in a nique location. Beautiful views from this stunning Penthouse the popular tourist village of Mellieha. Next door is the well-own Db Hotel and the Blu Beach club with various restaurants nd bars. B-MT-140

Gozo Farmhouse

5 5 870m² € 2,200,000

This beautiful 400 year old farmhouse in Gharb, Gozo has become available for sale. Recently renovated, the farmhouse has a mix of traditional and modern designer finishes. In the small, historic village of Gharb, the farmhouse stands on its own with fantastic 180-degree views of the countryside and sea. B-MT-141

Air Malta Magazine, March 2019

The importance of housing indices

Housing often represents the single largest component of household wealth

New housing construction is closely tied to changes in the price of existing housing

Housing combined contribution to GDP estimated at 15-18% in US

Several approaches to developing price indices for housing

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Median House Price

Repeat sales (Case-Shiller)

Mix-adjustment or Stratification

Sales Price Appraisal Ratio (SPAR)

Hedonic Pricing

Several approaches to developing price indices for housing

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In the United States, no real government sponsored house price index. Census Bureau surveys to find median house price by census tract, zip code, city, county, state, …

Large, diverse housing market(s), multiple data collecting agencies across many jurisdictions, …

Several approaches to developing price indices for housing

***San Diego home sales hit lowest point since '07*, San Diego Union Tribune, January 30, 2019**

"San Diego County's median home price ended the year at $550,000, one of its lowest points of 2018, real estate tracker CoreLogic reported Wednesday."

Several approaches to developing price indices for housing

Use of median house price in developing a housing price index

Pros: Easy to construct, easy to understand, limited data requirements

Cons: Different sectors of market may be more active at different times in the business cycle, no allowances for changes in quality

Several approaches to developing price indices for housing

So fluctuations in quality over time can adversely impact the accuracy of these indices. One way to control for quality changes is looking at repeat sales.

Several approaches to developing price indices for housing

San Diego home price increases fall behind nation, California, San Diego Union Tribune, January 29, 2019

"San Diego home price gains continued to slow in November compared to most of the nation and California, said the S&P CoreLogic Case-Shiller Indices released Wednesday."

Several approaches to developing price indices for housing

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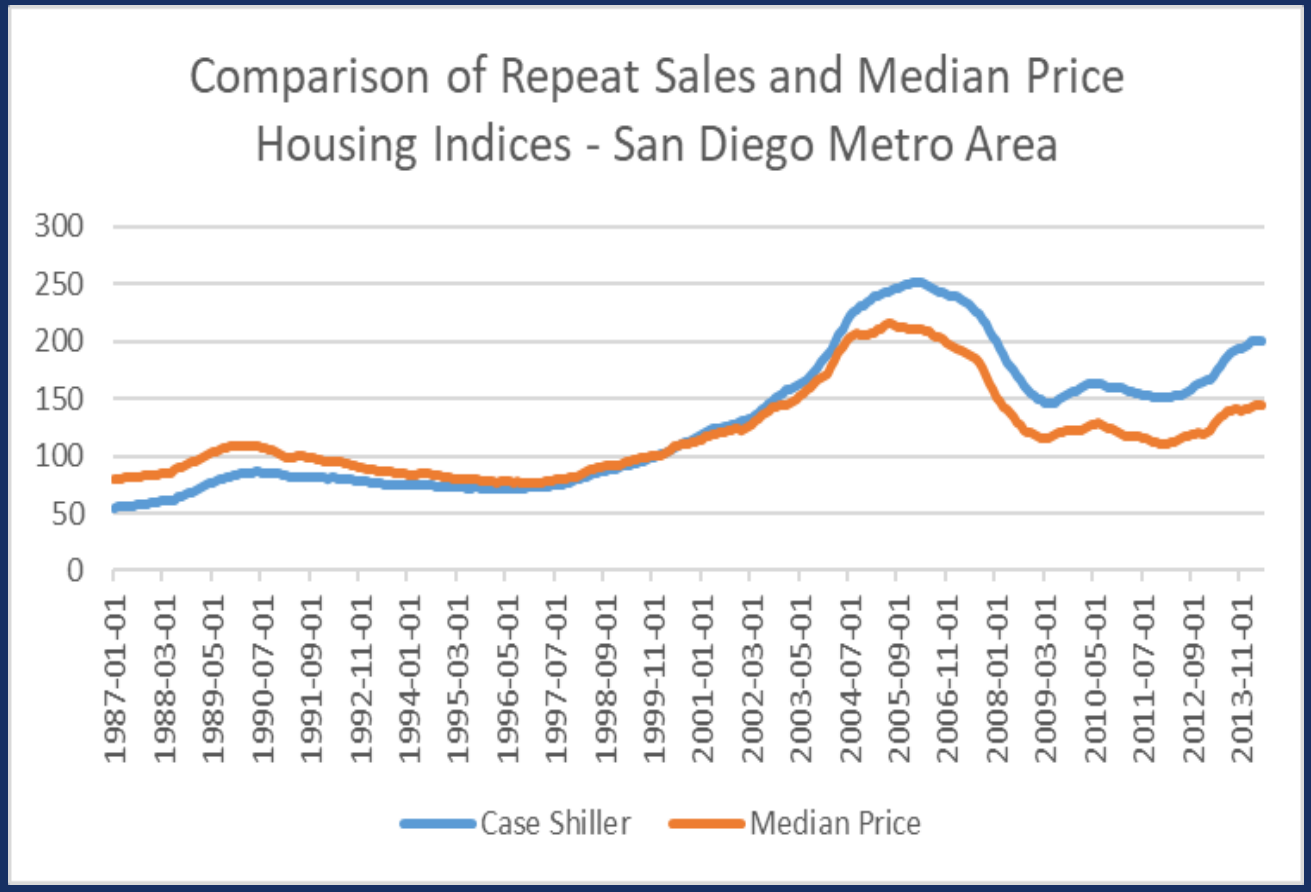
Repeat sales (Case-Shiller)

Measures the difference in prices of the same dwelling sold twice or more over some time period

Pros: Relatively easy to compute, limited data requirements

Cons: Need large number of observations to ensure sufficient repeat sales, dwellings resold may not reflect housing stock, assumes quality of repeat sales stays constant (no flipping)

Several approaches to developing price indices for housing



Several approaches to developing price indices for housing

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An alternative way of adjusting for quality would be to stratify the data. We could consider stratifying by geographic location, housing type, housing size and so forth. We would want to balance the number and degree of stratification with the availability of data. The different strata could then be used to develop a weighted housing price index, by first developing a price change for each strata, then aggregating across strata using the appropriate weights.

Several approaches to developing price indices for housing

Finally, we could consider the Sales Price Appraisal Ratio (SPAR) method. If appraisals are conducted relatively frequently, then each house sold in a period can be related to its appraised value at the beginning of the period. This can dramatically increase the size of the sample as well as the distribution of houses represented. However, it requires the availability of appraisals, it can miss new housing stock brought online after the most recent appraisal, and house specific quality is assumed to stay constant.

How can we determine the value of a house?

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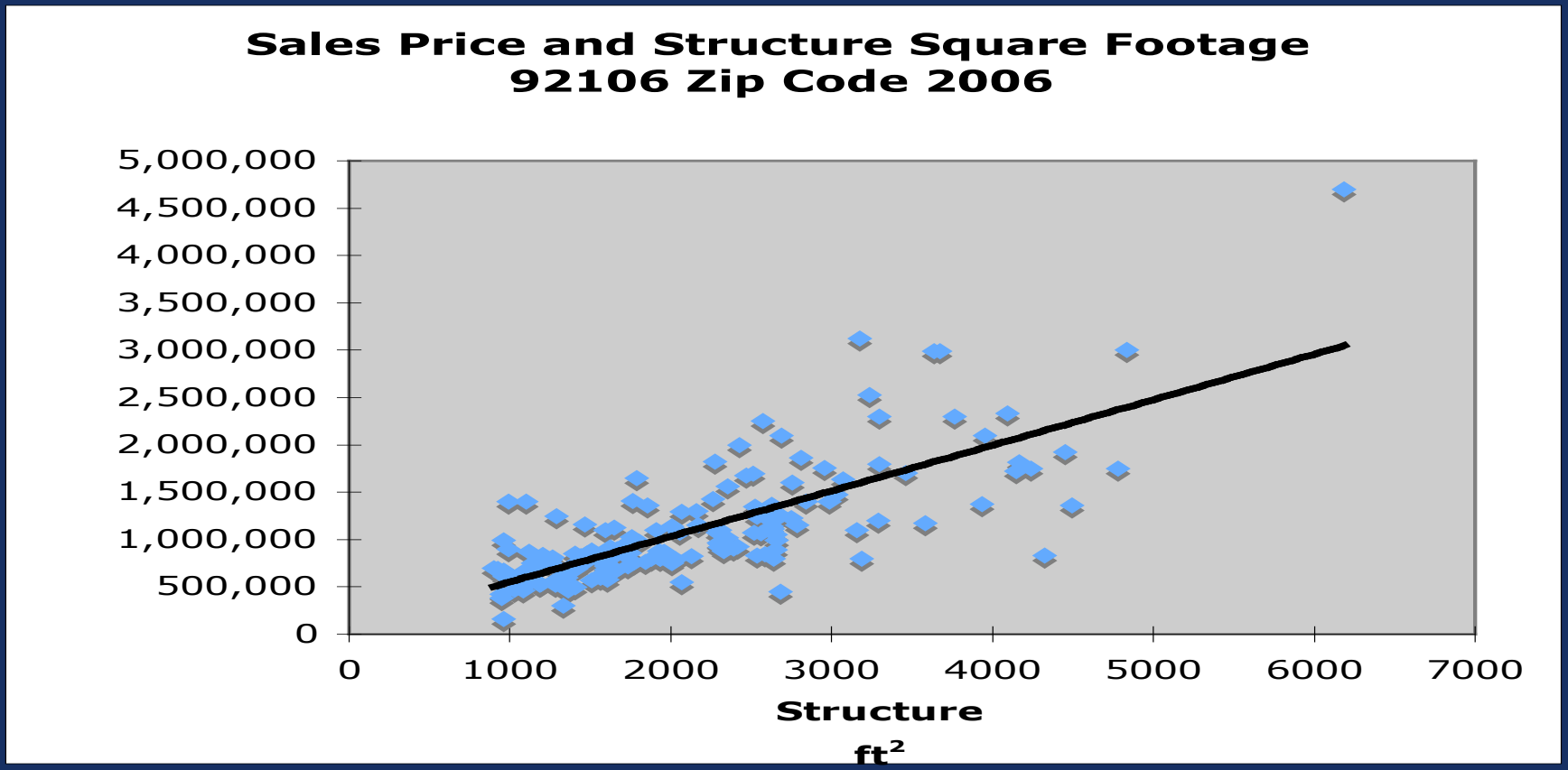
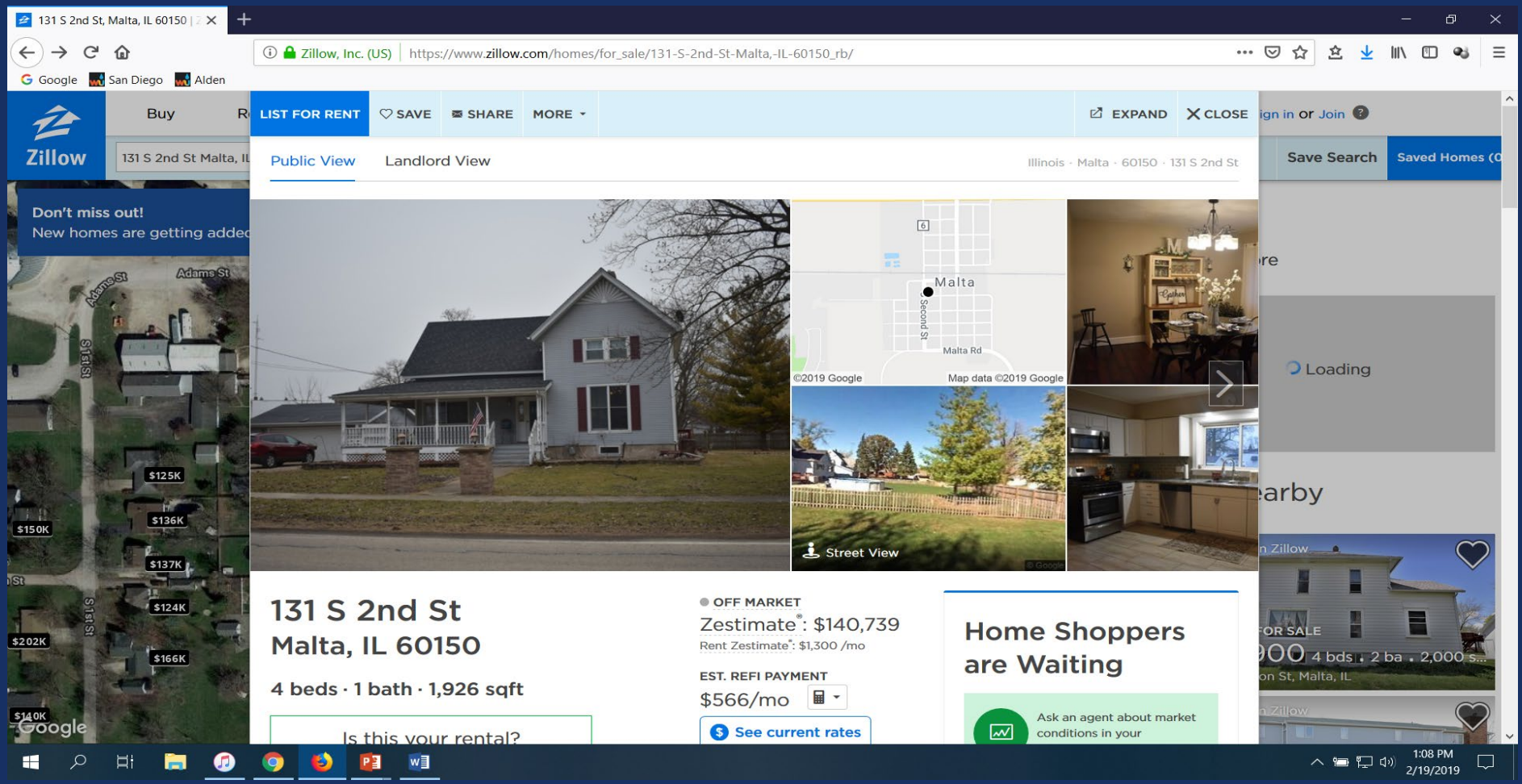
- Market prices – fair market value from an “arm’s length” transaction
- Rules of thumb – x$ per square foot (y€ per square meter)
- Appraisals – outside party (tax assessor or commercial appraiser)
- Zillow.com – Web based analysis
- Hedonic pricing analysis – more later

The relationship between price and square footage



Zillow.com
Malta, IL Pop 2010 - 1164
Pop 2000 - 969



Hedonic Pricing Analysis

Sales Price	# of bedrooms	# of bathrooms	Lot ft2
$500,000	3	1	5000
$520,000	3	2	5000
$525,000	3	1	5500
$460,000	2	1	5000

How much is a bedroom worth?
Bathroom? Lot size per square foot?

Hedonic Pricing Analysis

Sherwin Rosen, Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition, *Journal of Political Economy*, Vol. 82, No. 1 (Jan. - Feb., 1974), pp. 34-55

Cited by over 11,000 peer-reviewed academic articles

Hedonic Pricing Analysis

Impact of Homeowners Association Fees on Condominium Prices, Co-authored with Vivek Sah and Steve Conroy. **Journal of Housing Research**, 27(1), pp. 79-91, 2018.

Cash and Distressed House Sales Price Discounts: Dual Sample Selection Spatial Interdependence Approaches, Co-authored with Alan Tidwell, Andres Jauregui, and Vivek Sah, **Journal of Real Estate Finance and Economics,** 56(1), 101-139, 2018.

Estimating School Proximity Effects on Housing Prices: the Importance of Robust Spatial Controls in Hedonic Estimations, Co-authored with Vivek Sah and Steve Conroy. **Journal of Real Estate Finance and Economics**, 53(1), 50-76, 2016.

Short Sale Spillovers: Are Short Sales Like Foreclosures? Co-authored with Stephen Conroy and Dirk Yandell. **Journal of Business Management and Applied Economics**, 3(4), 2014.

The Value of a Floor: Valuing Floor Level in High-Rise Condominiums in San Diego, Coauthored with Steve Conroy and Jon Sandy. **International Journal of Housing Markets and Analysis**, 6(2), 197-208, 2013.

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Estimating the Value of the Historical Designation Externality. **International Journal of Housing Markets and Analysis**, *1*(3), 288-295, 2008.

Historic Designation and Residential Property Values. Co-authored with Jon Sandy and Charles Tu. **International Review of Real Estate**, *11*(1), 83-95, 2008.

Hedonic Pricing Analysis

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The value of a house can be thought of as the sum of the values of its attributes

Attributes can be structure specific, neighborhood specific, or reflect market conditions

Examples of structure specific attributes

Examples of neighborhood specific attributes

Examples of market conditions

Hedonic Pricing Analysis

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$$\ln P_i =$$

$$\alpha_i + \sum_{j=1}^{J} \beta_j \text{Property}_{ij} +$$

$$\sum_{k=1}^{k} \beta_k \text{Neighborhood}_{ik} + \sum_{m=1}^{M} \beta_m \text{Market}_{im} + \varepsilon_i$$

Possible econometric issues associated with hedonic pricing

Heteroskedasticity – Large variance in housing prices and some explanatory variables (house size, lot size, distances, … can lead to heteroskedasticity

Possible econometric issues associated with hedonic pricing

Multicolinearity – Total square footage of the structure, the number of rooms, the number of bathrooms, and the number of bedrooms are likely to be highly collinear

Possible econometric issues associated with hedonic pricing

Spatial autocorrelation – No matter how well neighborhood effects are modelled, there is still a possibility that there are unobserved neighborhood effects that get incorporated into the error term, leading to spatial autocorrelation

Solutions to possible econometric issues associated with hedonic pricing

Heteroskedasticity – Log-linear form is most frequently employed

Multicolinearity – Often not concerned with coefficient values and p-values of structural characteristics

Spatial Autocorrelation – Two-stage generalized least squares using a proximity matrix based on latitude and longitude

Current research – House Orientation and Housing Values

San Diego bumps off Los Angeles as the number 1 spot in the nation for solar installations.
The San Diego Union-Tribune, April 4, 2017

Current research – House Orientation and Housing Values

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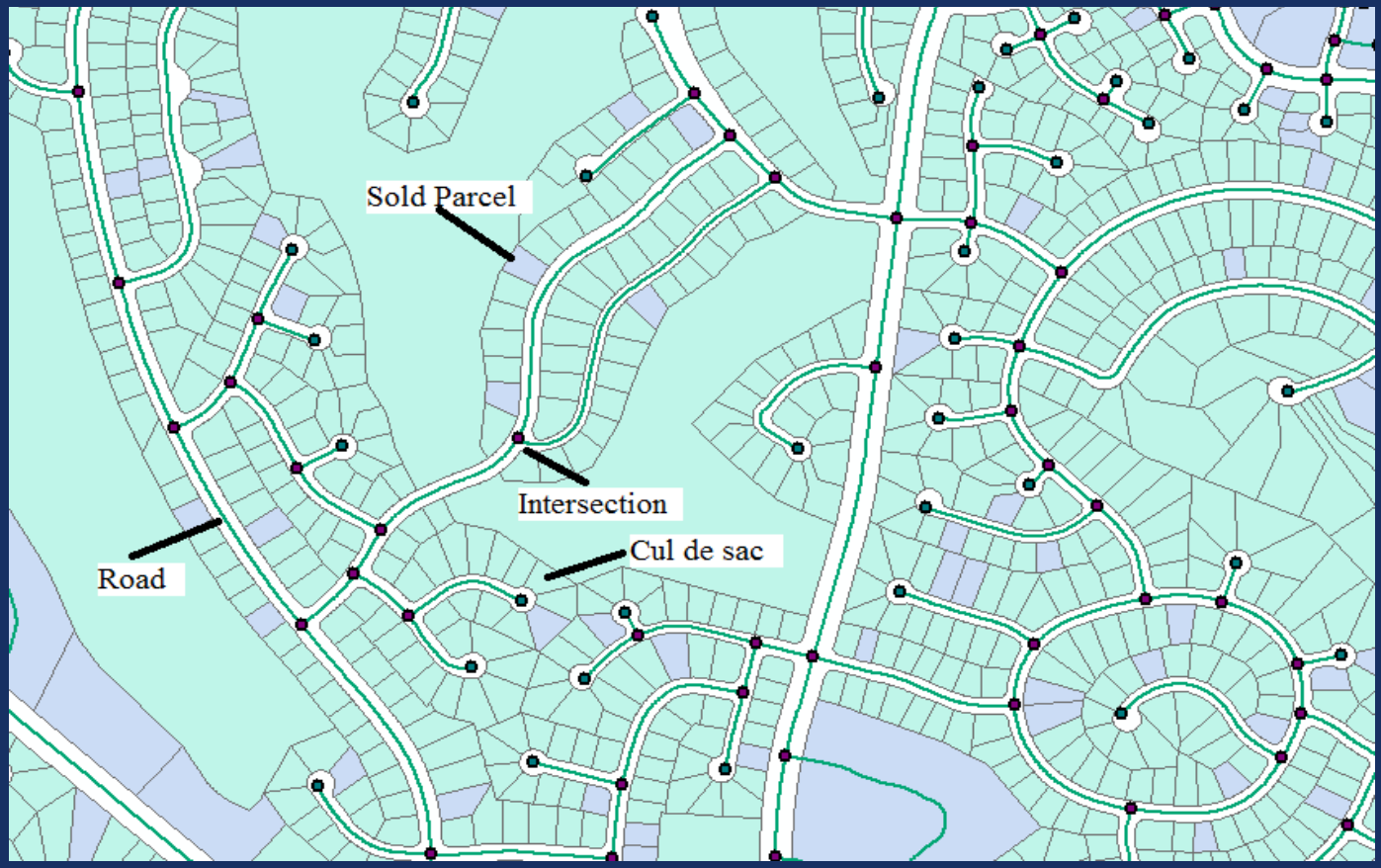

Current research – House Orientation and Housing Values

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Table 2 Descriptive Statistics of the Data Set (n = 26,749)

	Mean	Std. Deviation	Minimum	Maximum
Sale Amount	$750,588	$595,252	$200,000	$7,000,000
Lot Size (ft^2)	17,067	28,488	2,500	298,822
Age	51.4	18.7	1	114
Living Area (ft^2)	1933	1109	500	21392
Baths	2.34	1.11	1	14
Beds	3.45	1.11	0	14
Pool	0.195	0.396	0	1
Cul-de-sac	0.253	0.435	0	1
Intersection	0.103	0.303	0	1
Distance to Ocean	37977	31996	67	294787
Distance to Downtown	77986	54899	1461	319779
Distance to Open Space	16309	26728	12	223860

Current research – House Orientation and Housing Values

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	Mean	Std. Deviation	Minimum	Maximum
Distance to Freeway	7218	11587	74	171154
Distance to Park	2728	3324	0	62948
Distance to Elementary	3184	3243	146	59987
CAASPP Score	2436	45	2288	2555
South	0.150	0.357	0	1
East	0.175	0.380	0	1
North	0.154	0.361	0	1
West	0.183	0.387	0	1
Northeast	0.081	0.273	0	1
Northwest	0.087	0.282	0	1
Southeast	0.084	0.277	0	1
Southwest	0.086	0.281	0	1

Current research – House Orientation and Housing Values

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	OLS		2SGLS	
Variables	Coefficient	t-statistic	Coefficient	t-statistic
Log of Lot Size	0.025***	9.43	0.022***	9.22
Age	-0.005***	-14.3	-0.002***	-5.61
Age squared	0.000***	23.07	0.000***	11.52
Log of Living Area	0.560***	81.46	0.475***	79.49
Baths	0.087***	33.49	0.073***	32.82
Bedrooms	-0.039***	-19.8	-0.024***	-14.37
Pool	0.086***	20.96	0.081***	22.91
Cul-de-sac	0.004	1.05	-0.000	-0.04
Intersection	0.010**	1.96	0.005	0.194

Current research – House Orientation and Housing Values

Log Dist to Coast	-0.179***	-105.03	-0.078***	-40.86
Log Dist Downtown	0.072***	20.28	-0.050***	-15.14
Log Dist Open Space	-0.033***	-27.49	-0.003**	-2.02
Log Dist Freeway	0.012***	7.88	0.002*	1.62
Log Dist Park	0.004**	2.84	-0.006**	-3.11
Log Dist Elementary	0.034***	13.18	0.013***	5.98
Log CAASPP	6.170***	61.76	2.867***	30.83

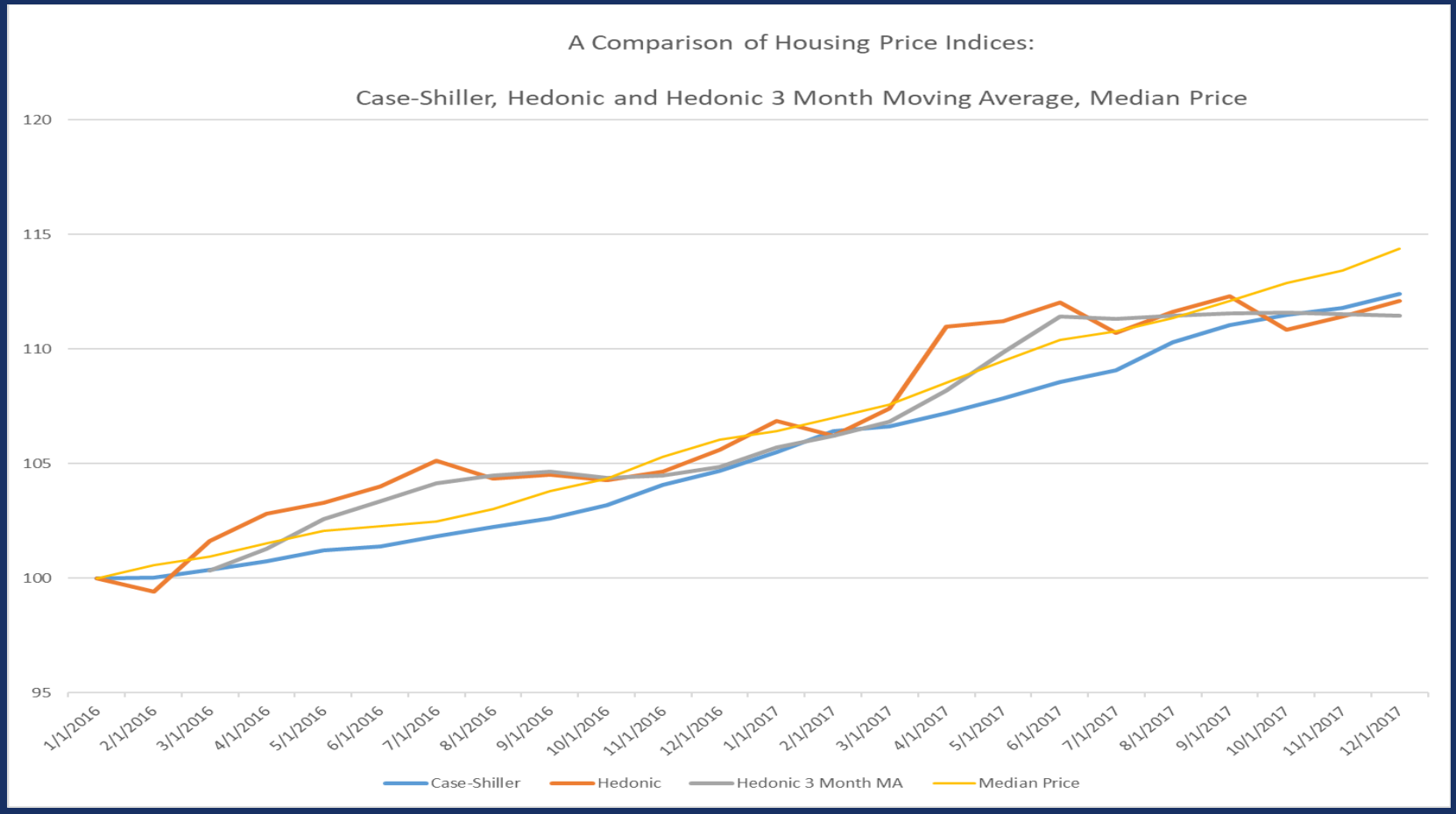
Current research – House Orientation and Housing Values

East	0.013**	2.76	0.011**	3.02
North	-0.003	-0.73	-0.001	-0.2
West	0.017***	3.11	0.013**	2.92
Northeast	0.010	1.55	-0.001	-0.03
Northwest	0.012**	1.97	0.013**	2.6
Southeast	0.007	1.06	0.008	1.44
Southwest	0.004	0.39	-0.005	-0.81

Current research – House Orientation and Housing Values

	Coefficient	t-stat	Coefficient	t-stat
2nd Quarter	0.024	3.81	0.022	4.05
3rd Quarter	0.036	5.85	0.031	5.78
4th Quarter	0.039	6.06	0.041	7.36
5th Quarter	0.055	8.15	0.054	9.33
6th Quarter	0.100	16.2	0.094	17.79
7th Quarter	0.110	17.63	0.109	20.43
8th Quarter	0.098	15.25	0.096	17.54

Comparison of Repeat Sales, Median Price and Hedonic Time Dummy Price Indices



Pros and Cons of Time Dummy Method

Pros: relatively easy to estimate and interpret, best for limited time frame (either by design or because of data limitations)

Cons: assumes shadow prices of structural and locational variables time invariant, estimates of index subject to change as additional time periods added

Variants on the Hedonic Dummy Approach

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Rolling Time Dummy Method

Hedonic Imputation Method

Average Characteristics Method

Repricing Method

Rolling Time Dummy Method

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The data is divided into overlapping subsets by time, and the hedonic model is repeatedly estimated with dummy variables for the shorter lengths of time.

Allows for changing shadow prices, eliminates revising past estimates of price changes, however more data intensive both in terms of sales per time period and total time span of data set.

Rolling Time Dummy Method

Suppose you have five years of data. Rather than one regression with dummy variables for each of the 19 quarters, you might run a series of regressions each containing five quarters of data along with four quarterly dummy variables. You can then use the series of fourth and fifth quarter dummy variable coefficients to link price changes together.

Hedonic Imputation Method

The hedonic imputation method starts with separate regressions for each time period (if possible). This allows for the generation of different imputed prices for all characteristics for each time period. Then, for each house sold in period t, an imputed price can be generated for what that house would have sold for in period t+1, using valuations from the regression from time period t+1 (single imputation).

Hedonic Imputation Method

Double imputation would require the pricing of each house sold in time period t both using time period t's shadow prices as well as time period t+1's shadow prices.

By using the imputed prices in time t rather than the actual sales prices, this process results in more stable results when considering omitted variables whose impact remains stable over time.

Hedonic Imputation Method

The ratio of the two prices for each house sold in period t forms the basis for the overall price change.

A Laspeyres type price index can be developed by looking at the geometric mean for houses sold in time period t, while a Paasche-type index could be formed by using houses sold in period t+1, and imputing the price for time t.

Hedonic Imputation Method

For instance, a Laspeyres-type index would look like:

$$\frac{P_{t+1}}{P_t} = exp\left[\frac{1}{n(t)}\sum_{h=1}^{n(t)}\sum_{c=1}^{C}\left(\hat{b}_{t+1,c} - \hat{b}_{t,c}\right)x_{t,h,c}\right]$$

Hedonic Imputation Method

You can also take the average of the two computational methods to treat both periods symmetrically (Fisher Index).

Finally, you can use the arithmetic mean rather than the geometric mean when averaging over all houses sold.

Average Characteristic Method

Similar to hedonic imputation method, but rather than imputing prices for all houses sold, you impute prices for the "average" house sold in the time period.

$$\frac{P_{t+1}}{P_t} = \frac{\hat{p}_{t+1,h}(\hat{X}_t)}{\hat{p}_{t,h}(\hat{X}_t)} = exp\left[\sum_{c=1}^{C}(\hat{b}_{t+1,c} - \hat{b}_{t,c})x_{t,c}\right]$$

Average Characteristic Method

The average characteristic method and the hedonic imputation method will generate equivalent results under certain conditions.

The two requirements are that the models are being estimated using a log-linear specification, and locational effects are modelled using dummy variables rather than distances and/or latitude and longitude.

If these assumption hold, the two methods are equivalent, and the average characteristic method is computationally easier.

Repricing Method

The repricing method is a form of the average characteristics method where changes in the quality of the average house is incorporated into the index. The change in quality can be computed as follows:

$$\frac{Q_{t+1}}{Q_t} = \frac{exp(\sum_{c=1}^{C} \hat{b}_{0,c} \bar{X}_{t+1,c})}{exp(\sum_{c=1}^{C} \hat{b}_{0,c} \bar{X}_{t,c})}$$

Repricing Method

Since this quality measure controls for differences in houses across time periods, the price increase can just be modelled as the geometric mean (unadjusted) price increase divided by the quality adjustment.

$$\frac{P_{t+1}}{P_t} = \frac{\left[\prod_{h=1}^{n(t+1)} p_{t+1,h}\right]}{\left[\prod_{h=1}^{n(t)} p_{t,h}\right]} \frac{exp(\sum_{c=1}^{C} \hat{b}_{0,c} \bar{X}_{t,c})}{exp(\sum_{c=1}^{C} \hat{b}_{0,c} \bar{X}_{t+1,c})}$$

In summary: Several approaches to developing price indices for housing

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- Median House Price
- Repeat sales (Case-Shiller)
- Mix-adjustment or Stratification
- Sales Price Appraisal Ratio (SPAR)
- Hedonic Pricing
  - Time Dummy Method
  - Rolling Time Dummy Method
  - Hedonic Imputation Method
  - Average Characteristic Method
  - Repricing Method

Questions?

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Thank you for your attention