Hedonic Models and their effect on Price Indices

Tony Liu
Methodologist
Methods and Quality Directorate

09 May 2024

Introduction

- Stratified Double Imputation Hedonic method for rental/house price indices:
  - Stratify properties into elementary aggregate groupings.
  - Use hedonic models to impute prices for properties in these, then calculate unweighted indices (elementary aggregates).
  - Aggregate elementary aggregates using weights

- Performance at elementary aggregate level key. Evaluate this with test/train approach.

Data

- Use large monthly dataset (~450,000 properties)

of English rental properties surveyed within last 14 months

- Dataset updated monthly, properties not re-surveyed within 14 months are dropped

Data

- Key Variables in dataset used by all models tested:
  - Floor Area (used log of floor area)
  - ACORN (socioeconomic status of neighbourhood)
  - Bedroom Count
  - LA Code (Local Authority Code) – data on location
  - Furnished Status
  - Property Type (flat, terraced house etc.)
  - Age

Data Matching

- Make test set of matched properties from this dataset
- Take 15-month window, matched pool are properties that remain in the monthly dataset over window
  - Matched properties are resurveyed at least once in window
  - Can calculate price relatives from real data for Matched pool
- Examine seven 15-month windows (Jan 2015-April 2016, Jan 2016-April 2017 and so on)

Test/Train Split

- Test set for a 15-month window: random sample of 50% of matched pool
- Train hedonic models using rest of matched pool + unmatched pool

- Compare hedonic price relatives and elementary aggregates against real values in test set
  - Out of sample test of double imputation hedonic method at elementary aggregate level

Data Analysis – Missing Variable Proxy

- Test set can only be matched properties (need real price relatives to test against)

- Missing variables correlated with matched/unmatched status => different inflation behaviour in two pools

- If training set is unmatched + matched data, imputing over matched only test set will get erroneous results matched only.

Data Analysis – Missing Variable Proxy

- Test for this: regional (nine regions in England) time dummy hedonic (using all key variables) on matched and unmatched pools separately

- Found significantly higher inflation rates in unmatched pool for all times and regions.

- Need to control for missing variables if unmatched data to be used.

Data Analysis – Missing Variable Proxy

- Missing variables highly correlated with matched/unmatched status, use matched/unmatched status as proxy

- Preliminary test:
  - Use dummy for unmatched/matched status in hedonic models
  - Perform test/train split
  - Calculate Jevons for entire test set using train set of matched and unmatched data

Data Analysis – Missing Variable Proxy

- Find low error in Jevons with this approach, compared with large errors without proxy
- Get similar errors to using matched data only in both test and train sets (a safe way of controlling for missing variables)
- Evidence that this approach is effective.

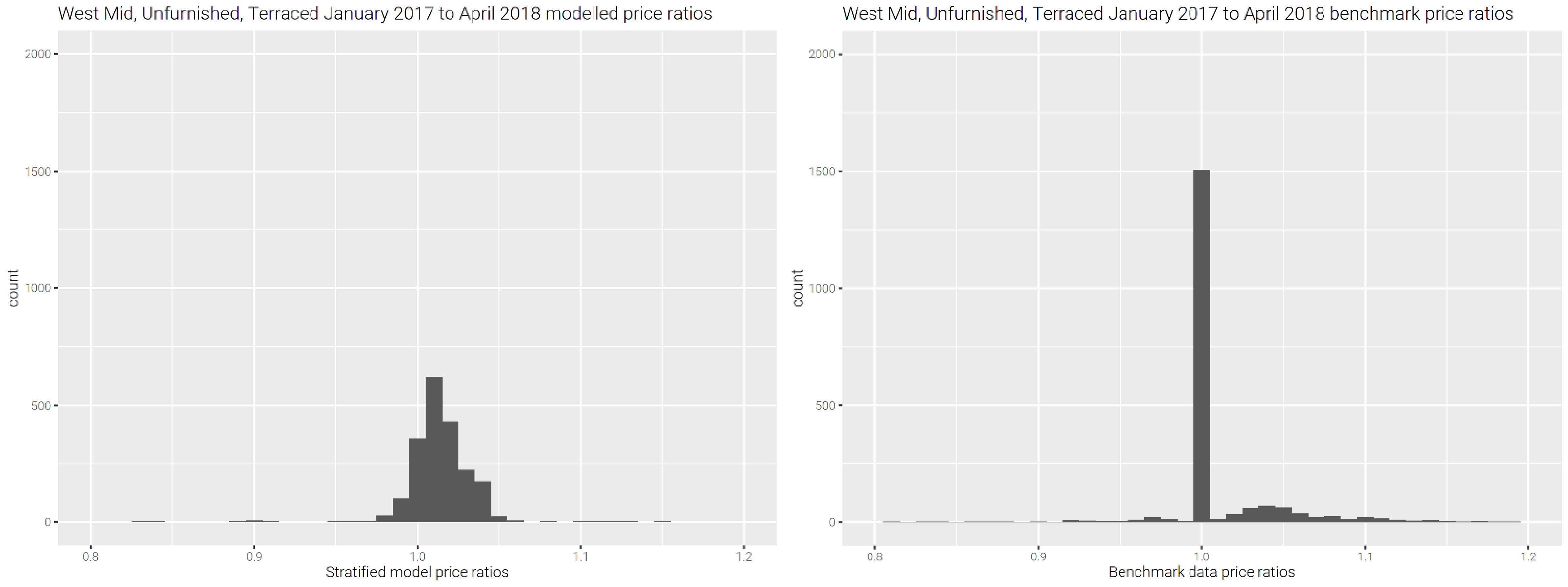
Final Method

- Generate 10 test/train sets per 15-month window. Take average for each elementary aggregate grouping and window.

- Test 3 hedonic models:
  - (Simple) Countrywide OLS models with key variables
  - Stratified OLS models (at LA code level and region) with same variables

Results – Price Relatives

- All models tested are not accurate at predicting price relatives at property level
- Spike at 1 => contract stickiness in matched pool?



Results – Price Relatives

- Real data price relatives show higher dispersion than hedonic price relatives (results for all England)

PR standard deviation, data	PR standard deviation, Basic Model	PR standard deviation, LA Stratified Model	PR standard deviation, Region Stratified Model
0.0488	0.0280	0.0450	0.0338

- Stratified regressions have more degrees of freedom, likely better at replicating higher price relative dispersion in matched data

Results – Elementary Aggregates (Jevons)

- Look at elementary aggregate groupings of:
  - Region/furnished status/property type
  - LA/furnished status/property type (finer)

- Define error as difference between hedonic index and real index
- Only include groupings and time windows with test sets with >499 properties for regional level grouping, >49 for finer scheme

Results – Elementary Aggregates (Jevons)

- Despite inaccuracies at property level, Jevons elementary aggregates have low average error.
  - All three models show negligible bias.
- True for both elementary aggregate grouping schemes

Jevons error - basic model (regional grouping)	Jevons error - LA stratified model (regional grouping)	Jevons error – regionally stratified model (regional grouping)
0.000290	0.000494	0.000287

Jevons error - basic model (finer LA level grouping)	Jevons error - LA stratified model (finer LA level grouping)	Jevons error – regionally stratified model (finer LA level grouping)
-0.000164	-0.000114	-0.000100

Results – Elementary Aggregates (Jevons)

- Error spread increases with finer groupings.
- Spread of errors (error standard deviation) tighter for stratified regression specifications

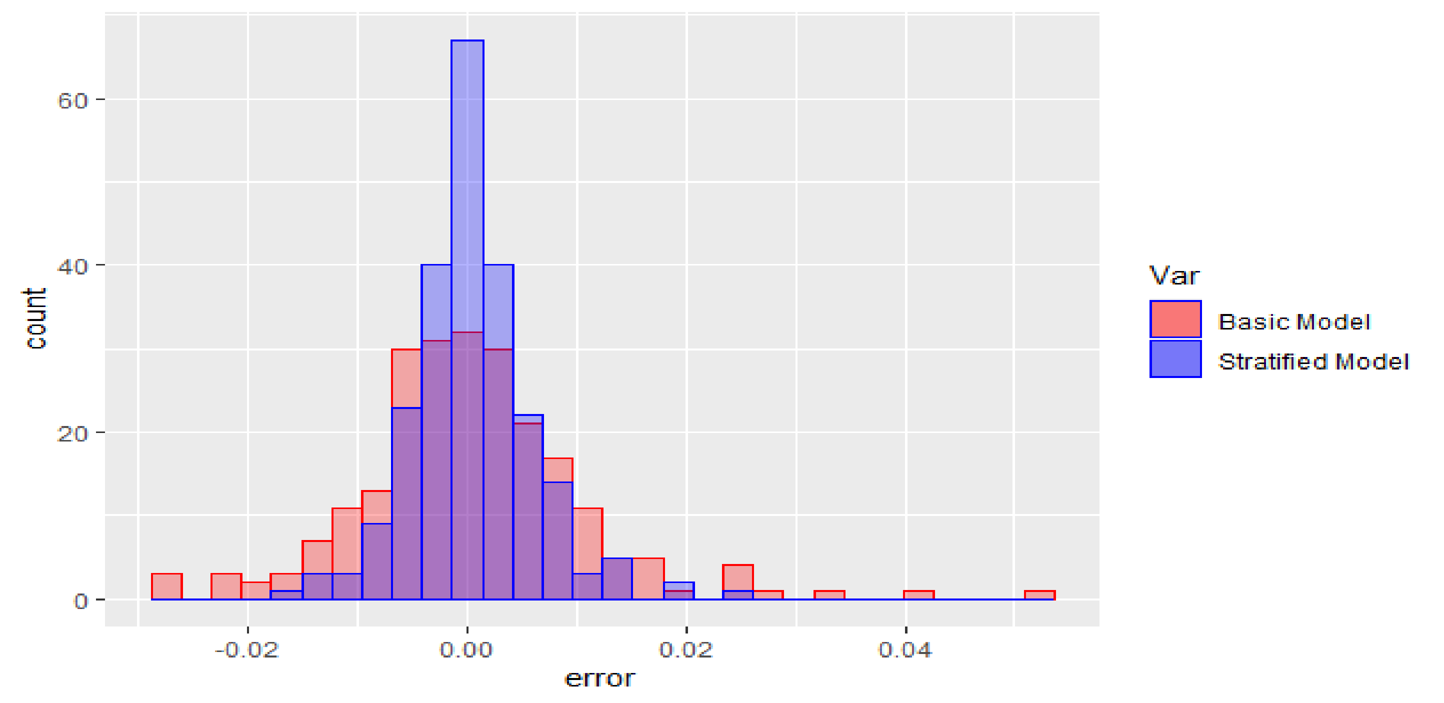
Jevons error standard deviation -basic model (regional grouping)	Jevons error standard deviation - LA stratified model (regional grouping)	Jevons error standard deviation - regionally stratified model (regional grouping)
0.0103	0.00552	0.006407

Jevons error standard deviation - basic model (LA level grouping)	Jevons error standard deviation - LA stratified model (LA level grouping)	Jevons error standard deviation - regionally stratified model (LA level grouping)
0.0211	0.0122	0.0169

- For LA stratified model, error spread is ~ half of basic model. Larger tightening of spread for finer grouping.

Results – Elementary Aggregates (Jevons)

- Error distribution of all elementary aggregates and periods for regional grouping scheme, comparing two models:



- Stratified specs have more degrees of freedom, can replicate finer details in price movements?

Results – Elementary Aggregates (Carli)

- At regional level grouping scheme, performance largely similar to Jevons
- At LA (finer) level grouping scheme, bias significantly larger, especially for simpler regression specs. Spread similar to Jevons.

Carli error, finer (LA level) grouping – basic model	Carli error, finer grouping (LA level) – LA stratified model	Carli error, finer grouping (LA level) – regionally stratified model
-0.00106	-0.000490	-0.000800

Carli error standard deviation, finer grouping (LA level) - basic model	Carli error standard deviation, finer grouping (LA level) – LA stratified model	Carli error standard deviation, finer grouping (LA level) – regionally stratified model
0.0212	0.0123	0.0170

Results – Elementary Aggregates (Carli)

- Much larger bias in Carli index with finer elementary aggregate scheme.
- Linked to simpler hedonic models not replicating price relative dispersion (Carli is sensitive to this).

- Carli is harder for hedonic models to calculate correctly under finer grouping schemes – so worse as a choice of index formula.

Caveats

- Results might not extend to unmatched pool
- Need to evaluate imputation accuracy over unmatched pool, so need to consider:
  - Effectiveness of proxy
  - What the missing variables are

- Numerical results for error spreads will also be different (tighter) if we have missing variables.

Conclusions

- Testing on set of matched pairs, double imputation hedonic model
  - Poor at predicting price relatives for individual properties
  - But shows low bias for Jevons elementary aggregates (so indices aggregated from these will tend to have low bias)
  - More stratified regression specs give tighter error spreads, effect larger for finer elementary aggregate groupings
  - Carli elementary aggregates show greater bias with finer groupings, hedonic methods seem better at predicting Jevons.

- Preliminary work though – some important caveats.

Any Questions?

- Thanks for Listening!