Discussion of Broxterman, Larson, Yezer: "Characteristics of a Sufficient Statistic to Measure City Housing Prices"

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Paper Contributions

This paper shows that a transactions-based home price index will represent mean home price growth (as a Laspeyres index) only when either home price growth is constant across properties (implausible) or when transactions have weighted frequencies that match the characteristics of the entire housing stock (transacted or not). Next, the authors note that in a monocentric city with linear commuting costs in distance from downtown, constant appreciation rates as the urban boundary expands requires constant housing consumption with distance from downtown, which is unlikely.

Using both annual Census tract appreciation estimates from Contat and Larson (2024) (Figures 1 and 2) and coarser differences in appreciation rates between central cities and suburbs in American Housing Survey data (Tables 1 and 2), the paper shows both that appreciation rates and transaction frequencies vary with distance from downtown. The authors propose price indexes that average local (tract or central city versus suburb indicators) appreciation rates with weights proportional to housing units, rooms or value. Using Contat and Larson (2024) data, These three Laspeyres-consistent methods provide appreciation rate estimates that are visually indistinguishable at an annual frequency for Boston and Houston, but accumulate to mild differences over the three decades between 1990 and 2020.

These are important contributions. The paper provides a guide to assemble price indexes that are more likely representative of price growth (and hence asset wealth and rent paid) for all households in a metropolitan area than most indexes which rely on representativeness of the transacted stock. To have broader impact, the paper should address the following questions, described in more detail below. 1. Is it really clear in theory that rent growth should vary by location? 2. Why focus on price growth heterogeneity by location as opposed to, say, structure type or price point? 3. How are geographic areas with high weight but low transactions to be treated in index computation?

Is common growth across locations really implausible in theory?

In a standard dynamic monocentric city where commuting costs and the cost of developing a constant quality home at the urban fringe $b(t)$ are constant, homes appreciate by the amount by which fringe homes get worse: the product of commuting cost per unit of distance at the urban fringe times the expansion of the fringe. If boundary ($b(t)$) homes always cost k to rent, then the cost x of a home at distance r is

$$x = h(r)\left[k + \int_r^{b(t)} \frac{\theta}{h(z)} dz\right],$$

so

$$\frac{dx}{dt} = h(r)\theta \frac{\dot{b}}{h(b)},$$

and

$$\frac{\frac{dx}{dt}}{x} = \frac{\theta \frac{\dot{b}}{h(b)}}{h(r)\left[k + \theta \int_r^{b(t)} \frac{1}{h(z)} dz\right]}.$$

As the authors note, this will only be a constant if the denominator is constant in r, e.g. if the income elasticity of housing demand is zero and the price elasticity is minus one, an unlikely combination.

That we should not expect equal appreciation across locations given this result in a standard setting motivates the empirical analysis that shows non-constant appreciation across locations.

There is a plausible case, however, for constant appreciation across locations. Recognizing that commuting speeds likely slow down as congestion increases near the city center, concave commuting cost as a function of distance is a reasonable modeling alternative. In Cosman et al. (2017), rents per unit are derived in a special case as

$$\log x(r) = \log h(r) + \log k + \theta \log \frac{b}{r},$$

so

$$\frac{d\log x}{dt} = \theta \frac{\dot{b}}{b} x(r),$$

and appreciation is constant across locations and equal to the rate of expansion of the urban fringe times the elasticity of commute cost with respect to distance. An empirical question then is whether a constant elasticity of commuting cost with respect to distance is a notably poor approximation. If not, constant appreciation by distance (within product type) may be plausible.

Price and distance in Vancouver

Figure fig. 1 shows median rent per square foot of condo apartments by rounded kilometers distant from Downtown Vancouver sold in Greater Vancouver in 2015 (before the exodus of foreign buyers in response to empty homes and foreign buyer taxes) and 2023 against distance, up to 25 kilometers (roughly New Westminster). Data come from BC Assessment. Two patterns stand out. First, up to 10 kilometers distance, the gradient flattened dramatically between 2018 and 2023, violating equal appreciation. Second, a constant gradient in either levels or logs does not fit the data particularly well. In 2018, there is a pronounced flattening of the gradient at about 15 kilometers that is not as evident in 2023. Future work might explore whether constant appreciation is implausible based simply on distance gradients, or whether violations are primarily due to changes in demand conditions. For Vancouver, the latter is plausible as foreign buyers may have been an important clientele for luxury condos (see, e.g. Pavlov et al. (2024)).

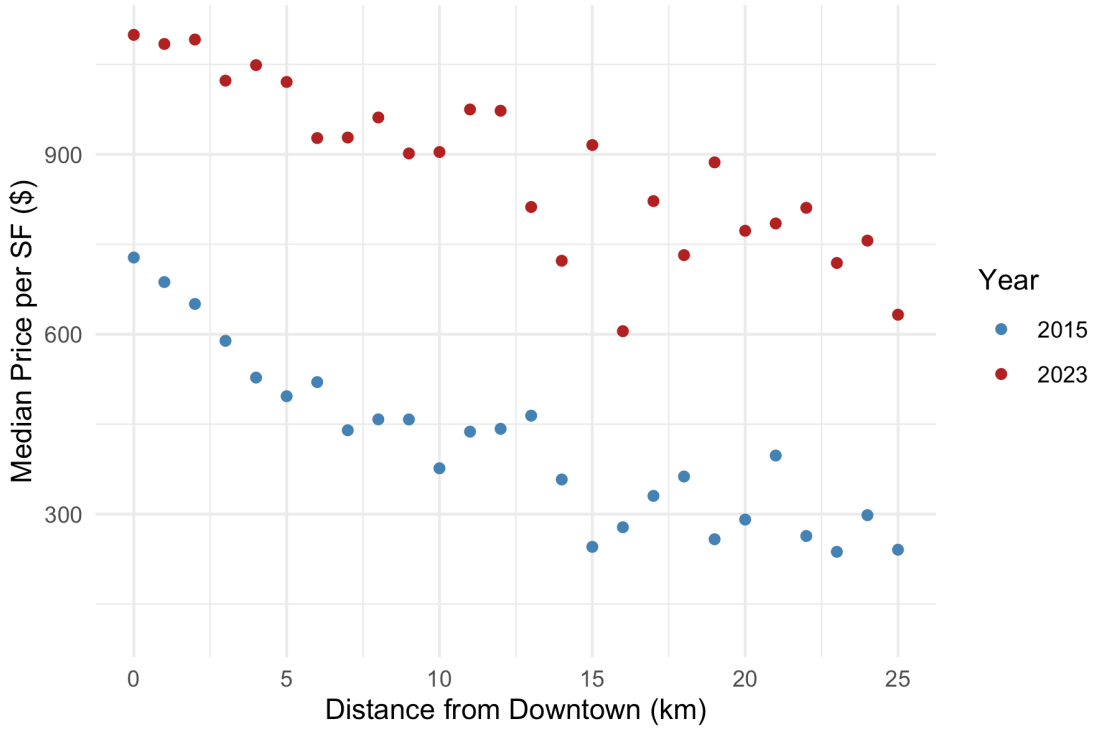

Figure 1: Median condo price per square foot for condo sales in Greater Vancouver, 2015 and 2023. Data from BC Assessment

Is distance to downtown the right dimension of heterogeneity?

Even if constant elasticity of commuting costs with respect to distance is implausible, other sources of differences between transacted properties and the full stock may deserve as much or more focus in constructing and weighting sub-indexes.

Pairwise Correlations in Greater Vancouver and the Fraser Valley

Available evidence suggests that price point and property type may be more important sources of variation in appreciation than correlations as much as location within markets

Table tbl. 1 shows correlations in 1-year price changes among single family and condo properties in Greater Vancouver and Fraser Valley markets, with the latter inclusive of the large suburb of

Surrey as well as more exurban and rural locations. The correlations between the two markets' single family (.82) and condo (.70) are on average greater than cross-type correlations for within Greater Vancouver (.71) and the Fraser Valley (also .71). Over the 2014-2024 decade, Fraser Valley condos appreciated at an annual rate of 10.7%, versus 5.9% for Greater Vancouver single family homes. The intermediately priced Greater Vancouver condos and Fraser Value single family homes had intermediate appreciation rates. For Greater Vancouver, then, it would be important to ensure condos and single family homes be weighted relative to their population shares at all locations. And it appears that separate indexes would be appropriate for most analysis.

Table 1: Correlations among property types in 1-year price changes, data from Canadian Real Estate Association HPI for apartments (condos) and single-family homes for Greater Vancouver and Fraser Valley real estate markets

	VanSingle	VanCondo	FVSingle	FVCondo
VanSingle	1.00	0.71	0.82	0.54
VanCondo	0.71	1.00	0.71	0.70
FVSingle	0.82	0.71	1.00	0.71
FVCondo	0.54	0.70	0.71	1.00

Evidence from the boom and bust of the 2000s: Heterogeneity Driven by Subprime Propensity

Landvoigt et al. (n.d.) show that price appreciation was highly correlated with price point in Greater San Diego between 2000 and 2005, there is a spatial pattern to price point, but they argue that the important similarity was changes in credit conditions favoring appreciation at the low end of the quality and wealth spectra.

Figure fig. 2 below, taken from Davidoff (2017) plots Zip Codes, with the horizontal axis representing population minority share based on the 2000 Census and the vertical axis representing the amplitude of the 2000s price cycle (log peak level squared divided by pre-and-post levels). The red points are in "flyover" metropolitan areas, the blue on the Northeast US "Acela Corridor" or Pacific Coast, and the green are in the "Sand States" of Arizona, Florida,Nevada and non-Coastal California. Given the link between minority share and non-prime lending share and the seemingly high penetration of subprime lending in the Sand States, this is further evidence that the most intense geographic variation in price growth was driven by changing credit conditions.

Weighting choices

The authors propose that an index weight subindexes, e.g. at the Census Tract level, based on the share of housing units, value, or rooms in each geography. Figure 3 shows that the choice of basis for weighting has almost no effect at high frequencies and small cumulative effects over three decades. The discussion above suggests that subindexes should certainly include property type and price point, and might aggregate up to broader locations to preserve sample size.

Ignoring heterogeneity in rooms, value, and units, under the authors proposed weighting scheme, transactions will have weight inversely proportion to transaction activity in their sub-geography. This could add unwanted variance to the index if there are cells with small numbers of observations. An interesting exercise the authors might want to perform would be to consider optimal borrowing across subindexes. To the extent that the model is right in that distance from downtown is a key determinant of relative price growth, the authors might draw on the literature on optimal bandwidth size and shape for kernel estimators. A "rectangular'' with sharp boundaries at a tract boundary being the optimal choice seems like a knife-edge case. To the

extent that submarkets consist of both property type or price point and location, the multi-dimensional bandwidth problem becomes both more complex but also likely more important as there may be a large number of cells with small numbers of transactions over any period. Intertemporal smoothing might also be part of an optimal index in that case.

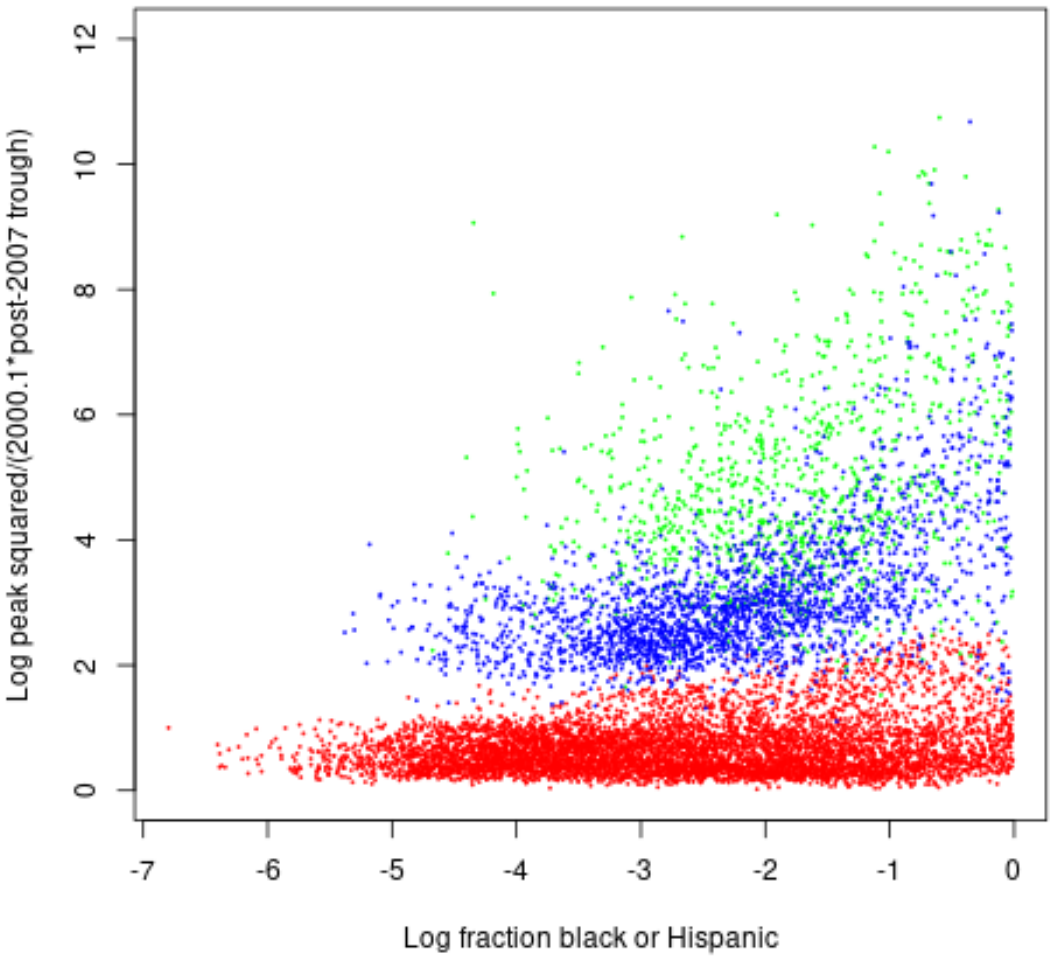

Figure 2: Zillow Zip code price peak squared divided by product of 2000 and 2012 levels against minority share (from Davidoff (2017))

Other issues: index use and data sources

It would be useful in this paper to see cases in which a poor choice of index construction leads to a bad decision in an important context. Realtors and assessors certainly recognize differences across submarkets, and do not assume equal appreciation throughout a metropolitan area. It seems plausible, though, that mortgage-backed securities packages assumed constant growth and volatility parameters within markets. Hurst et al. (2016) note that while US GSEs price loans almost free of geographical information, the private market does not. But whether loans are priced within markets based on appropriate indexes or subindexes is potentially interesting. A candidate case in which transaction-based indexes might are commonly used and yield estimates unrepresentative of the overall stock are consumer price indexes, but that may be a feature not a bug, in that for consumers looking for housing, the transacted stock may be more relevant.

This paper uses American Housing Survey data to show the importance of proper weighting of urban and suburban submarkets (Tables 1 and 2), but their quantitative results on the effect on the metropolitan index are likely affected by significant measurement error that arises in the AHS from some combination of owner assessed values and small samples. A glance at FHFA data versus estimates of appreciation from AHS show some stark differences. For example, the authors find 13% annual appreciation using AHS for metro Atlanta, but FHFA indicates roughly 7% annual growth between 2015 and 2019. This seems like too large a gap to be explained just by aggregation weights. Other metropolitan areas' appreciation rates appear more plausibly measured by AHS.

Summary

This paper provides important guidance for home price index construction. Transacted properties may fail to be representative of the overall housing stock for several reasons. Price indexes for larger markets can be important for exercises such as measuring home equity or average rents paid, and thus should be representative of the whole housing stock, not just the transacted stock. Ensuring that index weights are not biased towards the transacted stock can be accomplished, as the authors suggest, by weighting cells not by transactions, but rather units, rooms, or value.

Two remaining challenges for implementation of the proposed weighting scheme are how to treat property type and price point heterogeneity, and whether to borrow or smooth from neighboring cells in computing weighted sub-indexes. With finer data than AHS, it would be useful to show the relative contributions of location, property type and price point to appreciation heterogeneity. To the extent that location is relatively unimportant, it may be preferable to keep subindex geography relatively broad, e.g. to the county or municipal level.

References

Contat, Justin, and William D. Larson. 2024. "A Flexible Method of Housing Price Index Construction Using Repeat-Sales Aggregates." *Real Estate Economics* 52: 1551–83.

Cosman, Jacob, Thomas Davidoff, and Joseph Williams. 2017. *Housing Appreciation and Marginal Land Supply in Monocentric Cities with Topography*. University of British Columbia.

Davidoff, Thomas. 2017. “A Review of Volume 5 of the Handbook of Regional and Urban Economics, Parts III and IV.” *Journal of Regional Science* 57 (5): 713–30.

Hurst, Erik, Benjamin J. Keys, Amit Seru, and Joseph Vavra. 2016. “Regional Redistribution Through the US Mortgage Market.” *American Economic Review* 106 (10): 2982–3028.

Landvoigt, Tim, Monika Piazzesi, and Martin Schneider. n.d. “The Housing Market(s) of San Diego.” *American Economic Review* 105 (4): 1371–407.

Pavlov, Andrey, Tsur Somerville, and Jake Wetzel. 2024. “Foreign Buyer Taxes and Housing Affordability.” *Real Estate Economics* 52 (3).