AN ANALYSIS OF CONNECTICUT PROPERTY APPRAISAL ACCURACY: ANNEX

WESTERN CONNECTICUT COUNCIL OF GOVERNMENTS

1. Statistical Testing for Vertical Inequity

In property taxation, vertical equity refers to the consistent appraisal of homes with different values (as opposed to horizontal equity, the consistent appraisal of homes with similar values).[1] The analysis conducted in our main paper "An Analysis of Connecticut Appraisal Accuracy" suggests serious vertical inequity in the Connecticut property appraisal process. We now supplement this analysis with statistical testing.

There is no single, agreed-upon best statistical test for vertical inequity in property assessment, due to persistent disagreements about which variable is the predictor and what form of regression is most appropriate.[2] Figure 1 shows a simple plot of the data of the data used in the original analysis. It appears that a linear model is a good fit for the data, but—given the cluster of over 100000 points in the bottom-left corner—it is impossible to know what type of model is best.

We begin with the simple Paglin and Fogarty model, which assumes linearity of the data. The model[3] consists of a simple linear regression $AV = \beta_0 + \beta_1 SP$, where AV is the Appraised Value and SP is the Sale Price (here, a stand-in for market value). The null hypothesis is $\beta_0 = 0$, with inequity indicated by $\beta_0 > 0$. The results of the regression are given below.

Table 1. Regression Using Paglin and Fogarty Model

Variable	**Value**	**Std. Error**	**p-Value**
β_0	113616	1567.29	< 0.00000001
β_1	0.7386	0.001383	< 0.00000001
R^2	0.709		

One might suspect that the strength of the results is caused by a number of properties sold for $0, represented in Figure 1 by points on the y-axis. This is not the case. Removing all points along the x and y axes and redoing the regression returns results which are equally significant, with nearly identical values. The Paglin and Fogarty model thus suggests substantial vertical inequity.

[1] Birch, Sunderman, and Radetskiy. "Reducing Vertical and Horizontal Inequity in Property Tax Assessments." *Journal of Property Tax Assessment & Administration* 14, no. 2 (2017): 73-83.

[2] Sirmans, Diskin, and Friday. "Vertical Inequity in the Taxation of Real Property." *National Tax Journal* 48, no. 1 (1995): 71-84.

[3] Paglin and Fogarty. "Equity and the Property Tax: A New Conceptual Focus." *National Tax Journal* 25, no. 4 (1972): 557-565

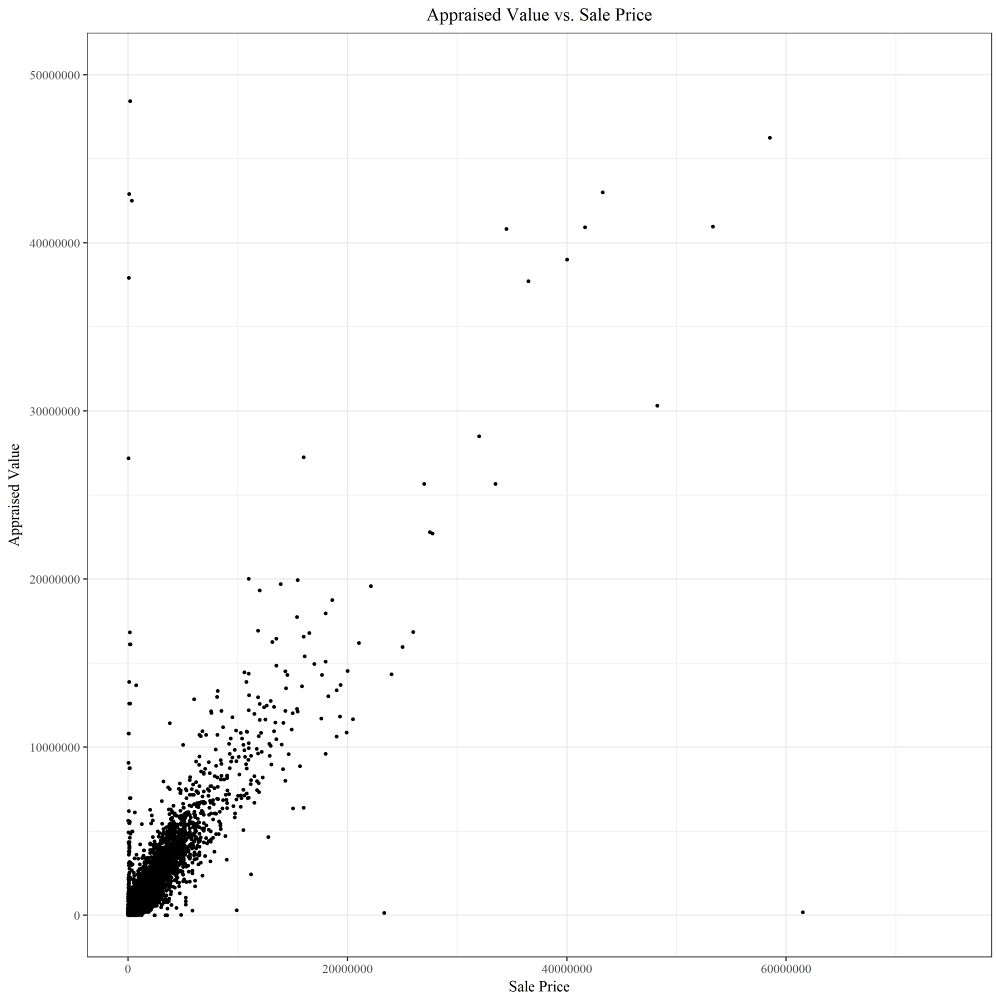

FIGURE 1

However, we cannot rule out the possibility of a non-linear relationship between the two variables. To account for this possibility, we turn to the Kochin and Parks model, of the form $\ln(SP) = \beta_0 + \beta_1 \ln(AV)$.[4] The null hypothesis is given by $\beta_1 = 1$, with inequity indicated by $\beta_1 < 1$. The results of regression using the Kochin and Parks model is given in Table 2.

TABLE 2. Regression Using Kochin and Parks Model

Variable	Value	Std. Error	p-Value
β_0	2.7120	0.02414	< 0.00000001
β_1	0.7744	0.00193	< 0.00000001
R^2	0.5791		

[4] Kochin and Parks. "Vertical Equity in Real Estate Assessment: A Fair Appraisal." *Economic Inquiry* 20, no. 4 (1982): 511-532.

The Kochin and Parks model appears to be a worse fit for the data compared to the Paglin and Fogarty model, but continues to suggest significant vertical inequity. Note that we have added 1 to every data point in order to retain points where either *AV* or *SP* is equal to 0. Removing these points instead gives very similar results.

Finally, we include the model advanced by the International Association of Assessing Officers (IAAO). The IAAO model is of the form $AV/SP = \beta_0 + \beta_1 SP$, with the null hypothesis $\beta_1 = 0$ and inequity indicated by $\beta_1 < 0$.[5] The results are summarized in Table 3; once again, the model concludes that substantial vertical inequity exists in the Connecticut property appraisal system.

TABLE 3. Regression Using IAAO Model

Variable	**Value**	**Std. Error**	**p-Value**
β_0	1.4784	0.02180	< 0.00000001
β_1	-1.39×10^{-7}	1.92×10^{-8}	< 0.00000001
R^2	0.000112		

The models we used in this analysis are not, by any means, an exhaustive list of all possible statistical tests for inequity. There exist many more, significantly more complex models for evaluating vertical equity in property appraisal. However, we believe that these three basic models are sufficient to give statistical weight to the conclusion we drew in our original paper: property appraisal in Connecticut suffers from widespread systemic vertical inequity favoring high-value properties at the expense of lower-valued ones.

2. EFFECTIVE MILL RATES

Using our data set, we are able to estimate how much incorrect appraisals affect the tax revenues of each town. From there, we can further estimate each town's effective mill rate (EMR), the mill rate that residents effectively pay on their true property value. The EMR can also be thought of as what each town would need to set its mill rate to if all property appraisals were completely accurate, assuming they wished to maintain constant tax revenues. In this sense, the EMR also suggests that many towns have an incentive to maintain inaccurate appraisals. Over-appraising properties is a far more politically tenable method of generating higher tax revenues than directly raising mill rates.

The following table lists each town, its 2016 mill rate, the estimated tax impact if property assessments were to become perfectly accurate (with no corresponding change in the mill rate), and the EMR. Compare this data with Appendix C of our main analysis. Notice that a few towns, despite a positive NAD (meaning that they typically over-appraisal properties), have a lower EMR than actual mill rate. This indicates that these towns aggressively under-appraise high-value properties and over-appraise all other properties, to the extent that perfectly accurate appraisals would actually increase overall tax receipts.

[5] Justin Carter. "Methods for Determining Vertical Inequity in Mass Appraisal." *Fair and Equitable* (2016).

Town	Mill Rate	Revenue Impact	EMR
Andover	30.72	-7.66%	33.27
Ansonia	37.52	-14.18%	43.72
Ashford	32.96	-6.85%	35.38
Avon	28.80	-5.19%	30.38
Barkhamsted	27.72	-6.63%	29.69
Beacon Falls	33.40	+0.11%	33.36
Berlin	30.35	-2.93%	31.27
Bethany	35.04	-3.02%	36.13
Bethel	32.18	+2.28%	31.46
Bethlehem	22.96	-7.81%	24.90
Bloomfield	36.00	-4.97%	37.88
Bolton	36.77	-3.78%	38.22
Bozrah	27.00	-12.71%	30.93
Branford	26.93	-1.38%	27.31
Bridgeport	42.20	-41.72%	72.41
Bridgewater	17.25	-14.14%	20.09
Bristol	34.61	-6.65%	37.08
Brookfield	25.70	+2.61%	25.05
Brooklyn	23.43	-5.54%	24.80
Burlington	31.10	-3.55%	32.24
Canaan	23.50	-11.01%	26.41
Canterbury	21.65	-18.45%	26.55
Canton	29.19	-4.21%	30.47
Chaplin	35.05	-21.57%	44.69
Cheshire	30.69	+0.57%	30.52
Chester	25.32	-8.47%	27.66
Clinton	26.77	-5.69%	28.39
Colchester	30.76	-0.91%	31.04
Colebrook	27.80	-27.90%	38.56

Columbia	27.13	+3.04%	26.33
Cornwall	15.13	-13.08%	17.41
Coventry	31.20	-10.06%	34.69
Cromwell	31.38	+6.39%	29.50
Danbury	28.26	+11.59%	25.32
Darien	15.35	+2.30%	15.01
Deep River	26.28	-6.74%	28.18
Derby	35.74	-14.37%	41.74
Durham	33.74	-9.74%	37.38
Eastford	30.40	-6.63%	32.56
East Granby	28.68	-8.18%	31.23
East Haddam	27.78	-4.24%	29.01
East Hampton	45.86	-12.50%	52.41
East Hartford	31.55	-8.08%	34.32
East Haven	24.71	-0.61%	24.86
East Lyme	30.31	-1.27%	30.70
Easton	25.11	-7.01%	27.00
East Windsor	30.38	-0.97%	30.68
Ellington	30.50	-9.66%	33.76
Enfield	29.89	-6.48%	31.96
Essex	21.08	-3.34%	21.81
Fairfield	24.79	+1.64%	24.39
Farmington	25.10	+5.17%	23.87
Franklin	24.72	-9.58%	27.34
Glastonbury	36.10	+3.28%	34.95
Goshen	19.10	-8.07%	20.78
Granby	36.22	-1.33%	36.71
Greenwich	11.27	+10.11%	10.24
Griswold	26.57	-11.73%	30.10
Groton	20.95	-6.66%	22.44
Guilford	28.24	-8.67%	30.92

Haddam	31.20	-13.04%	35.88
Hamden	40.87	-22.37%	52.65
Hampton	30.51	-9.66%	33.77
Hartford	74.29	-36.01%	116.09
Hartland	25.50	-6.59%	27.30
Harwinton	27.30	-4.50%	28.59
Hebron	36.00	-5.55%	38.12
Kent	17.86	-8.87%	19.60
Killingly	27.31	-17.11%	32.95
Killingworth	25.23	-1.59%	25.64
Lebanon	28.70	+9.47%	26.22
Ledyard	30.40	-9.31%	33.52
Lisbon	19.50	-2.68%	20.04
Litchfield	26.20	-0.42%	26.31
Lyme	17.75	-18.62%	21.81
Madison	25.76	-6.91%	27.67
Manchester	39.40	-5.80%	41.82
Mansfield	29.87	+6.94%	27.93
Marlborough	32.89	-2.06%	33.58
Meriden	36.63	-10.02%	40.71
Middlebury	30.12	+7.18%	28.10
Middlefield	33.67	-0.87%	33.97
Middletown	32.60	-6.67%	34.93
Milford	27.88	-3.71%	28.95
Monroe	34.35	-4.74%	36.06
Montville	30.09	-6.16%	32.06
Morris	25.92	-8.49%	28.32
Naugatuck	45.57	+25.25%	36.38
New Britain	49.00	-11.30%	55.24
New Canaan	15.99	-3.28%	16.53
New Fairfield	28.53	-6.95%	30.66

New Hartford	29.04	-10.07%	32.29
New Haven	41.55	+4.04%	39.94
Newington	39.49	-18.58%	48.50
New London	26.75	-6.00%	28.46
New Milford	35.80	+2.00%	35.10
Newtown	33.07	-4.21%	34.52
Norfolk	21.95	-12.20%	25.00
North Branford	31.08	-4.62%	32.58
North Canaan	27.50	-21.29%	34.94
North Haven	29.42	-6.47%	31.45
North Stonington	26.10	-10.67%	29.22
Norwalk	24.92	-2.75%	25.62
Norwich	40.90	-17.72%	49.71
Old Lyme	20.62	-17.51%	25.00
Old Saybrook	18.81	-12.89%	21.59
Orange	31.40	+6.22%	29.56
Oxford	24.96	+0.51%	24.83
Plainfield	28.36	-12.15%	32.28
Plainville	31.83	+0.82%	31.57
Plymouth	35.43	-15.92%	42.14
Pomfret	24.24	-13.98%	28.18
Portland	32.34	-6.02%	34.41
Preston	23.00	-21.53%	29.31
Prospect	29.23	+3.71%	28.18
Putnam	16.42	-19.64%	20.43
Redding	28.91	-10.99%	32.48
Ridgefield	26.01	+3.21%	25.20
Rocky Hill	29.70	-1.90%	30.28
Roxbury	13.70	-13.18%	15.78
Salem	31.70	-6.02%	33.73
Salisbury	10.70	+0.41%	10.66

Scotland	35.75	-13.14%	41.16
Seymour	34.59	-10.43%	38.62
Sharon	13.70	-7.48%	14.81
Shelton	22.31	+2.11%	21.85
Sherman	20.04	-6.85%	21.51
Simsbury	37.12	+2.93%	36.06
Somers	23.37	-2.22%	23.90
Southbury	36.54	-1.73%	37.18
Southington	28.40	+0.01%	28.40
South Windsor	29.14	+1.52%	28.70
Sprague	31.00	-9.54%	34.27
Stafford	33.37	-8.33%	36.40
Stamford	25.43	-7.97%	27.63
Sterling	31.60	-17.46%	38.29
Stonington	21.32	-5.20%	22.49
Stratford	36.98	-8.11%	40.24
Suffield	27.78	-5.29%	29.33
Thomaston	33.63	-7.93%	36.53
Thompson	24.80	-9.48%	27.40
Tolland	33.36	-3.92%	34.72
Torrington	45.75	-21.57%	58.33
Trumbull	32.87	+1.81%	32.28
Union	29.60	-11.36%	33.39
Vernon	36.91	-3.10%	38.09
Voluntown	26.61	-12.36%	30.36
Wallingford	27.47	-7.52%	29.71
Warren	14.20	+55.42%	9.14
Washington	13.75	+11.27%	12.36
Waterbury	58.22	-25.28%	77.92
Waterford	25.83	-8.08%	28.10
Watertown	30.10	-9.36%	33.21

Westbrook	38.31	+9.48%	34.99
West Hartford	31.25	-27.78%	43.27
West Haven	22.51	-4.03%	23.46
Weston	28.67	-5.41%	30.31
Westport	18.09	+11.24%	16.26
Wethersfield	38.19	-5.34%	40.35
Willington	27.34	-7.96%	29.71
Wilton	26.83	+2.80%	26.10
Winchester	32.70	-14.78%	38.37
Windham	34.35	-13.03%	39.49
Windsor	30.92	-2.07%	31.57
Windsor Locks	26.79	+1.61%	26.37
Wolcott	28.08	-12.64%	32.14
Woodbridge	37.66	-6.62%	40.33
Woodbury	26.07	-14.33%	30.43
Woodstock	23.36	-3.61%	24.23