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Homing in on Tax Evasion: Homestead Fraud in the Florida Real Estate Market

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Abstract

Local Florida governments are primarily funded by *ad valorem* property tax revenues. State law provides preferential tax treatment to primary resident homeowners, as opposed to the owners of rental properties or winter homes. This "Homestead" exemption reduces the assessed taxable value of the property, and caps annual increases. By Florida statute, a home cannot legally be simultaneously Homesteaded and rented out long-term.

We combine January 2022 Trulia.com home rental data with county appraiser Homestead status data and find that larger rental homes are more likely to be Homesteaded. Our results suggest that Florida municipalities may be able to recoup needed funds, which could go towards education and other important priorities, by tightening Homestead tax rule enforcement. We also consider the possibility that income disparities may be exacerbated by Homestead fraud, and that the system lends itself to inherent fragility akin to the problems that precipitated the 2008 housing crash.

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Introduction

The state of Florida has robust legal protections, called "Homestead Acts," for the owner of a property that serves as his or her primary residence. For example, it cannot generally be seized in bankruptcy proceedings, and taxation is also limited. These benefits were specifically designated for the owners who live at the property more than half of the year and exclude second homes and investment or rental properties. A Homesteaded property can qualify for up to $50,000 in reduction of taxable value (a maximum exemption of $25,000 is imputed for the purposes of school district taxes). Moreover, once a Homestead exemption is in place, the taxable value cannot increase by more than 3% per annum or the CPI, whichever is less, regardless of how much the market value of the property may have risen.

This can be a significant boon to owners, especially during extended periods of housing price increases. However, there will be a temptation for owners who do not legally qualify to apply for a Homestead exemption anyway, or to fail to inform the county appraiser if their property no longer meets the criteria. For example, the exemption would be voided if the property was rented out for more than six months, or for more than 30 days in two consecutive years. The present analysis examines a specific type of Homestead fraud in Florida, quantifying it and determining its noncausal predictors. As far as we know, we are the first to quantitatively assess this type of fraud.

Homestead laws in Florida are broadly popular, and many proponents argue that individuals should be able to protect their primary home from seizure for failure to pay their debts. Furthermore, the intricacies of the Homestead Act help to make property taxes more progressive, especially in a state with volatile housing prices — see Ittig (1984) — for a now classic discussion of property taxation and its relation to home investment. As a result, the tax burden shifts to those who can afford to pay more (Ihlanfeldt and Rodgers, 2022). In contrast, opponents of the Homestead Act point to reductions in property taxes that impact the total amount of public funds available to help communities build and maintain roads, support education, and foster other local public goods (Kent 2021; Lav and Leachman 2018; Maher et al. 2017; Mishra et al. 2020). Opponents further note that fraudulent abuses of the Homestead Act may be responsible for increasing income disparities (Ihlanfeldt and Rodgers 2022; Lav and Leachman 2018). If wealthier individuals, who make up the majority of rental property owners, are more likely to commit this type of fraud, and unfairly claim tax benefits meant only for primary resident homeowners, then the regulatory structure would tacitly serve as a vehicle for exacerbating inequality.

Complicating matters even further, recent work on the causes of the Great Recession has determined that mortgage fraud was one of the main contributing factors. This fraud often presented itself in the form of individual investors overreporting their income, or misrepresenting themselves as buying a primary, rather than an investment, property. Many loan originators were found to have been complicit in misrepresenting the quality of borrowers (Garmaise, 2015; Griffin and Maturana, 2016). All of these components were likely important determinants of the housing crash and subsequent Great Recession of 2008 (Li, 2015). To this end, understanding how housing fraud in the form of Homestead abuse may introduce financial "contagion" hazards, in which home buyers not actually in a position to repay mortgage obligations can destabilize the entire system, may be repeating these patterns. It is in this framework that the present analysis makes its contribution. Specifically, employing the results of our analysis can help to mitigate the risk of future economic disasters.

Empirically, we employ data from a popular long-term rental website and combine it with information on whether these same listed rental/investment properties were simultaneously illegitimately claimed as a primary residence and Homesteaded. This allows us to quantify one type of potential Homestead financial fraud, which is claiming a primary residence while also treating that residence as an investment property. While this is not the only way that Homestead fraud can occur, our analysis is the first to numerically analyze this particular type of impropriety. Furthermore, we are the first to attempt to predict Homestead fraud based upon the characteristics of a house and its location.

We find that owners of larger rental properties — both in terms of square footage, number of bedrooms, and number of bathrooms — are in fact more likely to commit Homestead fraud, compared with the average homeowner. We also find a path for properties in “hotter” housing markets, in terms of increased demand, being more likely to be fraudulently Homesteaded. Our results support the conclusion that Homestead fraud is a significant problem, and that wealthier investors are more likely to abuse these tax laws. This is problematic both from the perspective of wealth redistribution, basic fairness, and the patterns that led to the Great Recession’s housing crash (Eapen and Eapen 1982).

The remainder of our analysis is structured as follows: Section II presents the background and motivation for our analysis, detailing both the structure of Homestead laws in Florida, the possible associated fraud that can occur, and some changes currently being proposed to amend the Homestead laws in Florida. We also discuss the implications of housing fraud from an historical perspective. Section III presents our data sources and methodology, explaining in particular how we quantitatively bound one type of potential Homestead fraud. We follow this explanation with the results of our analysis in section IV, and a discussion of their implications in section V.

Literature Review

B.1. Meaning of Florida’s Homestead Act

As part of the United States Federal Homestead Act of 1864, it was decided that individuals should not be subject to forced sale or seizure of their property in order to pay off debts. When the Federal act expired, some states chose to extend this principle and create their own Homestead Acts. Florida was one of these states, and in 1868, statutes were passed to afford Homestead protection to properties of 160 or fewer acres (Miller and Crosby, 1949).

Article X, Section 4 of the Florida constitution defines exactly what is meant by an owner Homesteading their property. This includes protection from bankruptcy seizure of a primary residence. This was later revised to also place limits on property taxation on the home. Due to differences in interpretation, Florida statute §196.061 provides more detail regarding the methods of applying the Homestead Act, and when it is allowable or appropriate to do so. Therefore, even though the majority of property tax revenues go to local municipalities, and the Homestead exemption applications get approved by county tax commissioners, the eligibility rules are uniform across the state. While the Homestead Act was initially meant to protect single family homes, this was later extended to also include condominiums. Conversely, recreational vehicles (RVs) and mobile homes were not officially covered, but are often exempted due to loopholes, including personal property exceptions (Baker, 2016).

B.2. Interpreting the Florida Homestead Act and Fraud

The Florida state statutes say that renting a property for more than six months of the year constitutes an “abandonment” that would cause the Homestead status to be revoked, and continuing to claim this exemption would be considered an act of fraud. The statute also states that renting out the property for fewer than 30 days each year is allowable and does not constitute an abandonment of the property. Neither does the one-time choice to rent the property for six months or less. However, repeatedly renting out the property for more than 30 days over consecutive years would also be considered abandonment.

Not only would the Homestead status be revoked for violations of the statute, but individuals would also be forced to both pay substantial property back-taxes and have a lien placed on said property (Baker, 2016). Our analysis examines exactly this type of potentially fraudulent behavior.

Through a series of court cases and legal challenges, it has also been determined that "temporarily" leaving a property and moving to another state is not considered to be an act of fraud if the individual plans to return — assuming the other rental limits were not exceeded. It was also decided that there is no minimum time that the property needs to be in one's possession in order to claim a Homestead, however, continuing to live elsewhere while Homesteading a property as a primary residence — such as living most of the time in a different state — would violate this act. Furthermore, every owner on the title to the home needs to reside on the property, with several cases of spouses living separately considered to be a violation of this law.

One crucial interpretation was that individuals cannot purposely place money into their primary home in order to shield it from impending bankruptcy, since this would constitute fraudulent conversion. Neither could individuals use funds illegally obtained, for example, from gambling etc., in order to pay for the house. If it was discovered that either of these happened, it could be grounds for voiding the Homestead status. However, the courts have generally tended towards "liberally construing the Homestead law," and have not moved towards penalizing individuals with Homestead infractions.

B.3. Current Legislation Regarding Florida Homesteading

Given the information in the previous sections, we can now understand how and why Florida has considered changes to the current Homestead Act. In particular, efforts are being made to both increase the amount that is excluded from taxation for lower-income homeowners, arguably a small fraction of those in the state (Troncoso, 2021), and to include additional exemptions for certain types of individuals, such as primary school teachers, law enforcement officers, and first responders (Rohrer, 2022). It has also been proposed to allow the state to periodically increase the amount of the Homestead exemption without a voter referendum (Troncoso, 2021). However, there has also been a countervailing trend of localities recently increasing efforts to search for Homestead infractions and prosecute them to the fullest extent of the law. Duval, Pinellas, and Sarasota counties are a few of the examples (Baker, 2016).

B.4. Housing Fraud and the Great Recession

Presenting an historical context, the literature places a great deal of the blame for the housing crash of 2008 and the resulting Great Recession at the feet of investors. Individuals who fraudulently pretended to occupy a house to retain better loan terms represented fully one-sixth of homes that defaulted during that time (Elul et al., 2021). This often occurred as a strategic default, presumably also due to high rates of leveraging, which had driven up home prices to unmanageable levels (Elul et al., 2021; Haughwout et al., 2011; Li, 2015). This home price inflation, akin to what we may be seeing in present times in Florida, was largely responsible for the housing bubble and the subsequent housing crash (Campbell 2013; Li, 2015).

Furthermore, not only did investors commonly lie about their situation, they also often misreported their income (Mian and Sufi, 2015) or collateral (Piskorski et al., 2015). This led to significant underrepresentation in the riskiness of loans, and this type of misreporting was also a reason for increased levels of default and, ultimately, the housing crash (Garmaise, 2015). Unfortunately, these falsehoods about investor quality were also perpetuated by originators, who only increased the problematic situation (Griffin and Maturana, 2016).

Materials and Methods

C.1. Data

We employed two main data sources for this analysis. First, on Jan. 12, 2022, we created a dataset consisting of all Florida rental units then listed on the website www.trulia.com. In addition to the full address of the listing, the Trulia data included the rental amount requested for the listing, the number of bedrooms, bathrooms, total square footage, and the number of days that the unit had been listed as of that date. Notice also that bedrooms, bathrooms and square footage are often provided in a range, so that we recoded these variables with the mean of that range. For example, a listing stating that it had two-four bedrooms would be recoded as having three bedrooms.

Data were drawn for the entire state, and then the city given for each listing was matched to the corresponding county. We next dropped any observation where the stated city/town/village/etc. was located across county lines — this corresponded to 22 cities and 192 observations. The dropped observations account for approximately 2% of both the cities in the possible match set and the observations in the Trulia listings set.

The counties with the largest number of rental units were retained. Specifically, out of Florida's 67 counties — and the 57 for which we had any listings — we limited our analysis to those with at least 400 rental listings at the time that we pulled the data from Trulia. This meant that our focus was on the following counties: Broward, Palm Beach, Miami-Dade, Hillsborough, Duval, Orange, Pinellas, Pasco, Collier, Lee, Polk, and Sarasota. In practice, we had a minimum of 420 rental units for Sarasota county, and up to a maximum of 1,359 rental unit listings for Hillsborough county. Additional detail is provided in Appendix table 1.

In terms of larger cities, the counties we chose for the analysis are located in South Florida (Miami-Dade, Broward, and Palm Beach), Orlando (Polk and Orange), Tampa (Hillsborough, Pasco, and Pinellas), Jacksonville (Duval), and the Southern West Coast (Sarasota, Collier, and Lee). These are also the most populous and considered to be the most attractive areas in Florida.

The second main source of data we used for our analysis came from each county's appraiser office. The county appraiser maintains a list of each residential address and its Homestead status. All of our counties of interest, other than Pinellas, included Homestead information for the listings in our Trulia dataset, and this was the data we retained. Because of the large task of matching data structures across counties, we employed two research assistants who individually looked up each of the more than 8,000 listings in our dataset to ascertain Homestead status. We also constructed a county-level measure of the average rate of rental-unit Homesteading.

In addition to the main data sources (Trulia and county appraiser's office), we also used geographically-linked information for each county, and ZIP code. Specifically, at the county level, we employed Census 2020 Small Area Income and Poverty Estimates (SAIPE) on the county's median income and poverty level. Also at the county level, we employed data from www.zillow.com, including the median single-family-home list price, the median days on the market for houses in that county, a location-based "hotness" rank and score from Zillow (as well as individual levels of demand and supply), and the Nielsen (hotness) ranking, to indicate how much real estate in that county is in transition. We also employed the same variables from Zillow data at the ZIP code level.

C.2. Methodology

We began our analysis with the assumption that longer term rentals (> six months) that were also Homesteaded presented the most likely possibilities for fraud. To this end, we first examined overall rates of Homesteading and breakdowns of the data, and then we determined how the previously enumerated variables in our dataset related with Homesteading. We chose to focus on the variables that showed statistically significant t-tests for difference of means by Homestead status.

After determining our preferred model structure, we employed a marginal Probit regression analysis to determine which variables related with Homesteading a rental property. While we do not claim a causal pathway, we believe it is crucial to determine the "independent" relationships between each of our variables of interest, and whether or not a property is Homesteaded. We also employed either (1) fixed effects for county or (2) a control for the county-level rate of Homesteading, and standard errors clustered at the county level. In either case, all standard errors were chosen as robust. Specifically, after identifying our variables that were individually statistically significantly related to Homesteading, we have, for individual rental unit *i* in county *c*:

$$Homestead_{i,c} = f\,(Baths_i, Beds_i, Sqft_i, DemandScore_c)$$

Where *Baths* are the number of bathrooms in the listing, *Beds* are the number of bedrooms, *Sqft* is the square footage of the listed property, and *DemandScore* is the (hotness) Demand level in the county.

As an aside, it would be virtually impossible to definitively ascertain if individuals are only renting out a portion of their property, and are not actually in violation of the Homestead statutes. Nevertheless, having a higher average bedrooms and bathrooms listed for rent for the Homesteaded properties makes this extremely unlikely.

Results

D.1. Summary Statistics

Table 1 displays the total number of rentals by county, as well as breaking this information out by whether the property was Homesteaded or not, meaning that we have an explicit "yes" or "no" from the county appraiser's office, and the specific reasons for missing data points. For example, we may have no listing for that property in the county appraiser's office data. We additionally provide the short-term listing rate at the county level.

To be precise, we construct the potential "Fraud" outcome as the number of Homesteaded properties relative to the total Homesteaded and non-Homesteaded properties in the county, excluding those with no listing. We also break out the number of missing observations as either not disclosing an actual address in the Trulia data or else not listing the given Trulia address in the county appraiser's data.

Table 1 shows us that potential instances of fraud vary substantially by county, with a low of approximately 4% in Hillsborough, and a high of 21% in Polk and Sarasota counties. Although Baker (2016) notes that there is differential enforcement in certain counties — e.g. Duval, Sarasota, and Pinellas — Sarasota still has some of the highest fraud rates in the state. While we cannot conclusively decide this without having data from before the increased investigation efforts, it may indicate that enforcement has not diminished fraud.

We also see that very little of the missing data is due to a non-disclosed address in the Trulia dataset. This accounts for only 1-3% of the data. In contrast, "not finding the data" in the county appraiser's office files accounts for a much larger 5-15% of the data. Finally, short-term listings do not constitute a large portion of the Trulia data in each county, with many counties hovering around 1-2%, and a maximum of just 7%.

Table 1. Homesteading Rentals by County

COUNTY	TOTAL	NON-H.S.	H.S.	Not Disclosed	Not Found	FRAUD	% short tm	% n.d	%n.f.
ALL	8163	6414	938	130	681	12.76%		1.59%	8.34%
HILLSBOROUGH	1298	1136	51	10	101	4.30%	2.00%	0.77%	7.78%
DUVAL	1230	990	140	7	93	12.39%	0.93%	0.57%	7.56%
MIAMI-DADE	1082	738	141	35	168	16.04%	6.82%	3.23%	15.53%
ORANGE	884	732	46	8	98	5.91%	0.41%	0.90%	11.09%
BROWARD	746	608	80	22	36	11.63%	7.30%	2.95%	4.83%
PALM BEACH	737	564	116	21	36	17.06%	4.08%	2.85%	4.88%
COLLIER	470	369	63	5	33	14.58%	7.67%	1.06%	7.02%
PASCO	465	343	70	4	48	16.95%	1.16%	0.86%	10.32%
LEE	445	338	70	7	30	17.16%	7.17%	1.57%	6.74%
POLK	404	298	80	7	19	21.16%	0.38%	1.73%	4.70%
SARASOTA	402	298	81	4	19	21.37%	7.50%	1.00%	4.73%

In summary, table 1 indicates that there is a large degree of potential fraud across counties, with only small fractions accounted for by "short term" rental listings. In terms of the effects of this fraud, if we assume an average tax rate of 2% on $50,000, over 938 potential fraud cases, this would represent about $938,000 in lost tax revenue. These results also provide evidence for the need to include county-level fixed effects to control for local variations. We note, as a caveat the higher than expected numbers of "not found" data points as potentially influencing results. We surmise that many of these missing data points are not, in fact, in the single-family-home category. It is also possible that mistakes in the Trulia address make it impossible to match the data to the county appraiser office files.

After determining overall rates of Homesteading in our data, table 2 examines whether housing characteristics vary based upon their Homesteading status. Specifically, we examine Trulia property characteristics in our dataset (Rent, # Bedrooms, # Bathrooms, Square Feet, Days Listed), as well as characteristics of the relevant county (Median Income, % in poverty, Nielsen ranking, Median List Price, Zillow Hotness Score and Rank, and Demand and Supply Scores). The p-values for difference of means t-tests by Homesteaded status indicate that Homesteaded and non-Homesteaded properties are significantly different in their individual characteristics of Rent, number of Bedrooms, number of Bathrooms, and Square footage. At the county-level, they are also different in terms of Median income, Median list price, Nielsen ranking, and Demand score.

Homesteaded properties appear to be somewhat larger, charge lower rent, have slightly more bathrooms, and slightly less bedrooms. They are in slightly poorer counties as measured by median income, and they are somewhat hotter as measured by the Nielsen ranking and the median list price — but not based on the demand score.

Table 2. Average characteristics by Homestead status

	All	NON-H.S.	H.S.	No H.S. Info	p-value t-test
Rent	7921.44	8119.27	6318.59	8285.47	**
Bedrooms	2.79	2.80	2.91	2.53	**
Bathrooms	2.07	2.06	2.18	2.01	**
Square Feet	1596.10	1582.66	1751.81	1489.59	**
Days Listed	48.28	48.41	50.53	44.28	-
Median Income Cty.	63291.42	63442.63	62676.16	62806.53	**
Nielsen Rank	3367.51	3344.44	3604.54	3267.53	**
Median List Price	551293.90	542353.30	600005.70	564524.90	**
Demand Score	59.10	59.99	58.47	52.63	+
Hotness Rank	3872.03	3762.57	3840.67	4789.96	-
Hotness Score	62.57	63.24	62.94	56.73	-
Supply Score	66.05	66.49	67.41	60.81	-
% in Poverty	12.58	12.54	12.51	12.94	-

***Note**: p-values are provided for the difference of means t-test beween homesteaded and non-homesteaded properties. ** is significantly different at the 1% level, * is significantly different at the 5% level, and + is significantly different at the 10% level.*

Because we believe that county-level variation may be substantial, we repeat this analysis at the county level, with the goal being a determination of which factors consistently relate with Homesteading status. Results are displayed in Appendix table 2, where it is clear that the number of bedrooms, the number of bathrooms, and square footage, are the most consistently significant.

Taken together, our results provide both an indication that potential fraud in Homesteading may be substantial, as well as the fact that certain characteristics of homes do appear different with respect to their Homesteaded status. Regressions will next ascertain the independent strength of each of these relationships.

D.2. Regression Results

Tables 3 and 4 examine the relationship between several individual home characteristics and whether or not the property is Homesteaded. Specifically, table 3 examines each characteristic in a separate regression, while table 4 combines all of the characteristics into one regression. Regressions are alternately run with either clustered standard errors at the county level with a right-hand-side control for the county-level Homesteading rate, or, alternately, with county fixed effects.

Table 3. Marginal probits for fraud

Cluster S.E. & Rate	X	
Fixed Effects		X
Bathrooms	0.0219	0.0219
	[4.63]**	**[6.16]****
N	7040	7040
Bedrooms	0.0198	0.0166
	[5.16]**	[2.80]**
N	7067	7067
Square Feet	0.0000	0.0000
	[5.18]**	[5.83]**
N	6962	6962
Demand Score	0.0005	0.0000
	[2.26]*	[-0.37]
N		
	6971	6971

Note: *There are eight separate regressions listed above. Coefficients are provided with t-statistics in brackets beneath. ** is significant at the 1% level, * is significant at the 5% level, and + is significant at the 10% level.*

Table 4. Relationship with Fraud

Cluster S.E. & Rate	x	
Fixed Effects		x
Bathrooms	0.0014	-0.0011
	[0.11]	[-0.14]
Bedrooms	0.0079	0.0106
	[0.87]	[1.81]+
Square Feet	0.0000	0.0000
	[2.47]*	**[2.33]***
Demand Score	-0.0001	0.0004
	[-1.72]+	[1.58]
N	6578	6578

Note*: Coefficients are provided with t-statistics in brackets beneath. ** is significant at the 1% level, * is significant at the 5% level, and + is significant at the 10% level.*

From table 3, we see that individually, larger homes (with more bathrooms, more bedrooms, and more square footage) do positively correlate with Homestead status. Demand may also have a positive impact, with more "in demand" locations showing a higher rate of Homesteading. Table 4 further explores this question, and finds that square footage is the most important and significant factor in explaining the choice to Homestead. While the coefficients are small due to the units of measurement, we can say that an increase of a thousand square feet is related to an increase of the likelihood of Homesteading the property by about 2%. In particular, if we were to instead employ "square footage in thousands" then this truncation of effects would not be present and the positive relationship is further highlighted.

Discussion

The present analysis examined potential fraud associated with a homeowner claiming a Florida Homestead exemption, while simultaneously renting the property out in a long-term agreement, which is a situation prohibited by Florida statute. We found that larger properties, and possibly those in hotter housing market areas, are more likely to be involved in this fraud. While decidedly descriptive, our analysis is, as far as we know, the first to quantitatively estimate risk factors for this type of Florida Homestead fraud.

Our results are valuable for understanding the dynamics in the present housing boom. Our findings of fraud and potential investor overreach in the market point to the need for increased vigilance in Florida's housing market. It is also the case that the disproportionate and potentially inappropriate presence of wealthy investors in the ranks of Homesteaded properties shows the need for a discussion on income redistribution. If Homesteading is unintentionally being used as a vehicle for the wealthy to pay less than their fair share of the tax burden, then we would argue for increased education and legal enforcement. If, however, the fraud is intentional, we would argue for increased enforcement by municipalities to recoup their lost tax revenues, or even a reexamination of the Florida Homestead Act.

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Declaration of interest statement

The authors have no competing interests or funding to declare.

Data availability statement

Some portions of the data are available online through Zillow.com and the Census SAIPE data. Trulia.com and individual county appraiser websites in Florida were employed by the authors to construct the remainder of the data. Author-constructed data and code is available upon request.

References

Baker, A.J. (2016). Florida: Sun, Fun, and Sand or BackTaxes, Penalties, and Interest? *Real Estate Finance Journal*, Summer/Spring.

Campbell, P. (2013). Collateral Damage? Transforming Subprime Slum Dwellers into Homeowners. *Housing Studies*, 28(3), 453-472.

Eapen, A.T., & Eapen, A.N. (1982). Tenants and Homeowners Under Property Tax Relief. *Public Finance Quarterly*, 10(1), 67-93.

Elul, P., Payne, A., & Tilson, S. (2021). Owner-Occupancy Fraud and Mortgage Performance. Federal Reserve Bank of Philadelphia Working Paper No. 19-53.

Florida Constitution - Article X, Section 4. Homestead; exemptions. https://www.flsenate.gov/Laws/Constitution

Florida Statutes Section 196.061 - Rental Of Homestead To Constitute Abandonment. (Fla. Stat. § 196.061). https://www.flsenate.gov/Laws/Statutes/2020/0196.061

Garmaise, M. (2015). Borrower Misreporting and Loan Performance. *The Journal of Finance*, LXX(1), 449-484.

Griffin, J.M., & Maturana, G. (2016). Did Dubious Mortgage Origination Practices Distort House Prices? *The Review of Financial Studies*, 29(7), 1671-1708.

Haughwout, A., Donghoon, L., Joseph, T., & van der Klaauw, W. (2011). Real estate investors, the leverage cycle, and the housing market crisis. Staff Report, No. 514, Federal Reserve Bank of New York.

Ihlanfeldt, K., & Rodgers, L.P. (2022). Homestead Exemptions, Heterogeneous Assessment, And Property Tax Progressivity. *National Tax Journal*, 75(1), 7-31.

Ittig, P. (1984). Tax Subsidy of Home Ownership. *Journal of Public Policy*, 4(2), 103-110.

Kent, C. A. (2021). Property taxation and school finance in Pennsylvania. *Journal of Property Tax Assessment & Administration*, 18(2).

Lav, I.J., & Leachman, M. (2018). State Limits on Property Taxes Hamstring Local Services and Should Be Relaxed or Repealed: Michigan, Massachusetts, Oregon, and New York Reveal Range of Problems with Limits. Center on Budget and Policy Priorities Staff Paper, 1-23.

Li., W. (2015). Smart Money or Dumb Money: Investors' Role in the Housing Bubble. Philadelphia Federal Reserve Business Review, Q1, 21-26.

Maher, C.S., Stallmann, J.I.,…, & Park, S. (2017). The effects of tax and expenditure limits on state fiscal reserves. *Public Policy and Administration*, 32(2), 130-151.

Mian, A., & Sufi, A. (2015). Fraudulent Income Overstatement on Mortgage Applications during the Credit Expansion of 2002 to 2005. NBER Working Paper No. 20947.

Miller, G.J., & Crosby, H.B. (1949). Our Legal Chameleon, The Florida Homestead Exemption Part I-III. Florida Law Review, 2(1), 12-84.

Mishra, S., Mishra, A.K., Panda, P. (2020). What Ails Property Tax in India? Issues and Directions for Reforms. *Journal of Public Affairs*, 22(1), 1-11.

Piskorski, T., Seru, A., Witkin, J. (2015). Asset Quality Misrepresentation by Financial Intermediaries: Evidence from the RMBS Market. *The Journal of Finance*, LXX(6), 2635-2678.

Rohrer, G. January 31, 2022. Property tax break for first responders, teachers advances in House. Florida Politics online. https://floridapolitics.com/archives/491802-property-tax-break-for-first-responders-teachers-advances-in-house/

Troncoso, R. December 20, 2021. Jacksonville lawmaker pushes bigger Homestead exemption — but with a catch. WJCT News online. https://news.wjct.org/first-coast/2021-12-20/jacksonville-lawmaker-pushes-bigger-Homestead-exemption-

. **Appendix T1.** Number of Trulia listings

County	Count	County	Count
Hillsborough	1359	Marion	89
Duval	1296	Okaloosa	72
Miami-Dade	1121	Bay	66
Orange	926	Flagler	58
Broward	787	Nassau	51
Palm Beach	763	Monroe	43
Pinellas	634	Highlands	40
Pasco	491	Citrus	39
Collier	488	Santa Rosa	37
Lee	466	Walton	21
Polk	421	Hernando	15
Sarasota	420	Columbia	7
Osceola	393	Gulf	4
Brevard	374	Okeechobee	4
Seminole	327	Sumter	4
Clay	312	Wakulla	4
Volusia	284	Bradford	3
Lake	201	Hendry	3
St. Johns	188	Suwannee	2
Alachua	174	Desoto	1
Manatee	158	Hardee	1
Martin	146	Holmes	1
Indian River	124	Jackson	1
Leon	108	Levy	1
Charlotte	107	Madison	1
St. Lucie	98	Putnam	1
Escambia	96	Taylor	1

Appendix T2. County-specific variable T-Tests for Homestead vs. non-Homestead properties

	Broward	Collier	Duval	Hillsborough	Lee	Miami-Dade	Orange	Palm Beach	Pasco	Polk	Sarasota
Rent	-	-	-	-	-	-	-	-	-	-	-
Days Listed	-	-	-	+	-	-	-	+	-	*	-
Bedrooms	-	-	-	-	-	**	-	*	*	+	-
Bathrooms	**	-	-	-	-	*	-	*	-	-	-
Square Feet	+	-	-	-	-	**	**	**	-	*	-

Note: *P-values for differences in means as based on a t-test are shown. ** is significant at the 1% level, * is significant at the 5% level, and + is significant at the 10% level.*

Nonprofit Hospitals' Property Tax Benefits: Evidence from Indiana

BY ELIZABETH PLUMMER, PH.D., CPA, AND GE BAI, PH.D., CPA

Abstract

Policymakers are increasingly interested in quantifying nonprofit hospitals' tax benefits to assess whether hospitals' nonprofit status is justified. Property taxes that nonprofits would otherwise pay are among the more difficult tax benefit to quantify. This paper aims to educate stakeholders on the issues with estimating nonprofit hospitals' property tax benefits.

We focus on Indiana because of relative advantages in its property tax record system. We first use a statewide database that identifies tax-exempt hospital properties to estimate property tax savings for all nonprofit hospitals in the state. We then examine five counties to quantify property tax benefits for specific hospitals. Using statewide data, we estimate a total property tax savings of $75.3 million in 2020 for all nonprofit hospitals in Indiana. However, upon closer examination of the five selected counties, we find that the state's identification code for hospital properties fails to identify over 500 property accounts associated with the nonprofit hospitals. Allowing for these additional properties increases nonprofit hospitals' tax savings in these counties by about 71%. These results suggest that our statewide estimate most likely understates nonprofit hospitals' property tax benefits by a significant amount. If statewide estimates were comparably understated, property tax savings in 2020 for all nonprofit hospitals in Indiana would be closer to $128 million. We conclude with policy recommendations.

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Introduction

About 58% of community hospitals in the United States are non-government nonprofit hospitals (AHA 2022). Community hospitals provide short-term care to patients in medical and surgical units, and do not include federal, psychiatric, and long-term care hospitals. About 24% are investor-owned for-profit hospitals, and 19% are state and local government hospitals.

Nonprofit hospitals are exempt from paying federal and state income tax, federal unemployment tax, sales tax, and property tax, and enjoy other tax-related benefits such as the ability to issue tax-exempt bonds. Nonprofit hospitals also benefit from larger donation amounts than they would otherwise because donors receive a tax deduction. A hospital's nonprofit status is granted in exchange for the expectation the hospital will provide community benefit that equals or exceeds the value of tax benefits derived from its nonprofit status. However, few states (if any) have effective systems in place to audit or evaluate hospitals' community benefit, or to measure the value of nonprofit tax benefits. As a result, hospitals generally face no accountability for providing low levels of community benefit, or community benefit that is low relative to a hospital's (unquantified) tax benefits.

As healthcare costs rise and governments look for additional revenue sources, nonprofit hospitals in the U.S. have come under increased scrutiny from federal and state legislators and policymakers (Bai et al. 2020; Bai et al. 2021; Zare et al. 2022). In Pennsylvania, a state court ruled that nonprofit hospitals providing insufficient charity care were not tax-exempt charities, and must begin paying millions in annual property taxes (Kennedy and Johnson 2022). In January 2020, Indiana state legislators introduced Indiana Senate Bill 232, which would have eliminated the property tax exemption for property owned by an Indiana nonprofit corporation and used in the operation of a hospital (Frissel, 2020). The legislation stalled.

Nationwide, the size and growing magnitude of nonprofit hospitals' tax benefits raise questions on whether these hospitals' community benefit is large enough to justify their nonprofit status. Prior research estimates the total value of nonprofit hospitals' tax benefits in 2011 was $24.6 billion (Rosenbaum et al. 2015). This estimate includes federal, state, and local tax savings combined, with property tax savings representing $4.3 billion (17.5%) of the total. A recent study estimates that the value of non-profit hospitals' *federal* tax benefits in 2019 was $12.4 billion (Ernst & Young 2022).

Another study estimates that nonprofit hospitals' property tax savings represents about 22% of the total tax benefits (Herring et al. 2018). Both studies estimate nonprofit hospitals' property tax savings by multiplying hospital revenues with the average property tax-to-revenue ratio of for-profit hospitals in the same state. We are aware of no study that uses actual property tax data to estimate nonprofit hospitals' property tax savings.

The purpose of this paper is to focus on nonprofit hospitals' tax benefits attributable to their forgone property taxes. Our overall goal is to provide federal, state and local policymakers with an overview of the issues and challenges in estimating nonprofit hospitals' property tax benefits, and inform future studies that attempt to quantify nonprofits' property tax benefits. Improved estimations of tax benefits can help policymakers better assess whether nonprofits' justify their tax-exempt status.

For myriad reasons, property taxes that nonprofits would otherwise pay are among the more difficult tax benefit to quantify. Accordingly, we focus on one state – Indiana – that has a property tax record system with two features that allow better and more manageable estimates of property tax savings. First, property tax assessors in Indiana provide assessed values for nonprofit hospitals' tax-exempt properties. This feature eliminates the need to estimate assessed values. Second, parcel-specific property tax data for all counties in Indiana is posted on the state's website, and all county data is formatted the same. This feature makes obtaining and working with the data significantly more manageable than is generally the case.

We use two different empirical approaches. In our first approach (Approach 1), we estimate nonprofit hospitals' property tax savings for all counties in Indiana using the state's identifier for hospital properties with tax exemptions. Using this approach, we estimate a total property tax savings of $75.3 million in 2020 for all nonprofit hospitals in Indiana. In our second approach (Approach 2), we focus on nonprofit hospitals in five counties, searching each county's tax roll for hospital-owned properties using hospital name and/or address. This approach accomplishes two objectives: (1) it allows us to estimate property taxes forgone for *specific* nonprofit hospitals, and (2) it allows us to identify problems with using the state's code for identifying hospitals. Specifically, Approach 1 fails to capture hospital-owned tax-exempt property coded as something other than "Hospital," and thus understates nonprofit hospitals' tax savings. We find this to be a significant issue for our five selected counties, where Approach 1 underestimates property tax savings for 2021 by 71% for our five counties combined. If statewide estimates were comparably understated, property tax savings in 2020 for all nonprofit hospitals in Indiana would be closer to $128 million.

Our paper proceeds as follows. The next section discusses property taxation in Indiana, followed by a discussion of the data. We then present our statewide estimate of tax savings for nonprofit hospitals in Indiana using Approach 1, followed by our estimate of tax savings for nonprofit hospitals in five selected counties using Approach 2 and compare that with estimates made using Approach 1. We conclude with policy suggestions

Indiana property taxation

In Indiana, property taxes are levied by local governments on real property (land and buildings) and business tangible personal property (e.g., business equipment; furniture; billboards). Inventories, supplies, vehicles subject to excise tax, and intangible property (e.g., software) are exempt.

Taxing Jurisdictions

In Indiana, taxing units are political subdivisions with the power to tax. Examples of taxing units include counties, cities/towns, townships, schools, libraries, and various special districts (e.g., airports, fire districts). In Indiana, taxing districts correspond to geographic areas and are created for property tax bill purposes. A taxing district is composed of multiple unique taxing units. The DLGF sums the certified tax rates for overlapping units in a geographic area to create a taxing district rate, and this taxing district rate is the rate that appears on each tax bill. A taxing unit may span multiple taxing districts, but each parcel exists in only a single taxing district.

Tax Caps

Taxing districts in Indiana are subject to tax caps. These caps are administered through a "circuit breaker credit," which is an amount that ensures a taxpayer does not pay more than the statutory maximum percentage on a property's gross assessed value. The taxing districts' property tax cap thresholds are: 1% for residential homestead properties; 2% for long-term care property, agricultural land, residential property, and some tangible property; and 3% for nonresidential real property, personal property, and select tangible property. If a taxing district's rate exceeds the relevant percentage, the most the district can actually assess is 1%, 2% or 3%, depending on property type (DLGF 2121). The 3% tax cap is the one most applicable for hospital properties, although some hospital property is subject to the 2% cap.

Property Tax Assessment and Administration

In Indiana, property tax reporting and assessment is at the county level. County assessors are responsible for annually assessing real property at its "market-value-in-use" as of January 1, whereas Indiana's personal property tax system is a self-assessment system. Business taxpayers, both for-profit and nonprofit, must annually file a return reporting all their tangible personal property and its true tax value as of January 1. 'True tax value' is determined under the rules of the Department of Local Government Finance (DLGF) per Ind. Code §6-1.1-31-7(d), and does not mean fair market value. The assessor then transfers all real and personal property tax data to the county auditor. The auditor applies deductions, exemptions, and other valuation adjustments to the relevant properties, and then sends these values (i.e., certified net assessed values) to the DLGF. After review and statistical analysis, DLGF makes adjustments where necessary, approves counties' property tax assessments, and determines local governments' property tax rates by dividing each local unit's approved budget amount by the unit's total assessed value (DLGF 2022a).

Key Features of Indiana's Property Tax System

There are two features of Indiana's property tax system that make it ideal for our study. First, unlike appraisal districts in many states, property tax assessors in Indiana provide assessed values for properties owned by nonprofit taxpayers. In some states, nonprofit properties will not be on the property tax rolls at all, or they will be on the rolls but at a value other than the assessed value (e.g., zero or the property's original cost). Administratively, this may make sense if there will be no property tax owed (i.e., the property is 100% tax exempt regardless of market value) and assessments are costly. However, if the tax rolls do not provide assessed values for nonprofit properties, it is difficult to provide reliable estimates of nonprofits' property tax benefits for more than just a handful of properties. Fortunately, Indiana's tax rolls provide assessed values for nonprofit hospitals—enabling a more reliable analysis since value estimation is unnecessary. There is a caveat, however. Property tax assessors may exert less effort in valuing nonprofit taxpayers' properties since there are no tax revenues at stake. For the same reason, nonprofit taxpayers may also be less careful in rendering values for their personal property. Nevertheless, the tax rolls' assessed values are the best data available for estimating nonprofits' tax benefits in this analysis.

The second feature of Indiana's property tax system that makes our study possible is that DLGF posts bulk datasets containing parcel-specific property tax data for all counties on the state's Gateway platform (Indiana Gateway 2022a), and data for all counties is reported in the same format. These datasets can be downloaded free of charge. DLGF also posts parcel-specific property tax data separately by county. These data can be searched by owner name, street address, and/or property type (DLGF 2022c). This centralized reporting of property tax information is unusual and allows for a significantly more manageable and careful analysis. From our research experience, almost all property tax assessment data in other states must be obtained by going separately to each individual county's website. This assumes, of course, that the county makes their data publicly-available, which is often not the case for smaller counties. Furthermore, data formats generally differ across counties, even within a single state, and only large appraisal districts generally provide bulk datasets that can be downloaded. If there is no bulk dataset, one must search for individual properties by owner name and/or address. Accordingly, most property tax studies are generally limited to a single appraisal district, severely limiting the ability to provide a comprehensive analysis encompassing more districts and states.

Property Taxation of Indiana Hospitals

In Indiana, for-profit hospitals must pay property tax on all real property and all tangible furniture, fixtures, and equipment (FF&E) that they own, except for inventory and supplies. Taxable FF&E includes medical equipment, computer systems, furniture, medical gas lines, wheelchairs, beds, drapes, curtains, and additional equipment added to an ambulance. Software is not taxable. The base vehicle of an ambulance is not taxable (i.e., it is taxed via excise tax) but any add-ons are taxable. For-profit hospitals receive no special exemptions. There is an option to obtain a property tax abatement. However, abatements are a political avenue and must be negotiated between a specific taxpayer and the local government.

A nonprofit hospital's property tax benefit is the property tax that they do not have to pay because of their nonprofit status. To estimate property tax forgone, we estimate the property tax benefit for each property owned by a nonprofit hospital, where property tax benefit is equal to the property's gross assessed value times the applicable taxing district's tax rate.

Data and Sample

Data used for the statewide analysis includes the "Tax Bill" and "Adjustments" datasets for "All Counties – 2020 pay 2021" (Indiana Gateway 2022). These data are for the 2020 assessment year, with taxes payable in 2021, and were the most recent year available for 'all counties' when we performed our analysis. The tax bill data contains parcel-specific information for all assessed properties in the state. The adjustments file includes information for all properties in the state that receive a credit, exemption, or deduction related to their property taxes. We merge the two files using the *property ID* variable. The adjustments file has an *Adjustment Code* variable that denotes whether a property's adjustment is related to a hospital (code=31). However, to the extent nonprofit hospitals own property that is not coded as "hospital," this will understate their property tax benefits. We discover this to be a significant issue when we use our second approach – searching individual county tax rolls using hospital name and/or address. In the final step of our analysis below, we compare the two approaches for our five selected counties and find the tax savings under the second approach is significantly greater. This leads us to question the validity of the first approach, which simply relies on the state's hospital coding. Nevertheless, the first approach provides a useful starting point for our analysis and clearly demonstrates issues involved with using governmental property tax data.

There is an additional limitation of using the state's hospital identifier variable. While it allows us to estimate the tax benefit for all nonprofit hospitals in a county combined, we cannot estimate the total tax benefit for a *specific* hospital because there is no way to identify multiple properties owned by one taxpayer. Different property accounts are not linked together with any type of owner ID variable. To identify all properties owned by a single taxpayer, one must search by name and/or address.

To demonstrate how one would undertake estimating property taxes for a single nonprofit hospital, we estimate the forgone property taxes for all nonprofit hospitals in five Indiana counties: Allen, Bartholomew, Marion, Monroe, and Tippecanoe. We selected these five counties based on their representing the largest footprint of Employers' Forum of Indiana's (EFI) employer members. For each of the five counties, we searched by hospital name and/or address. This allows for the most comprehensive search of hospital-owned property. We used the 2021 assessment year, with taxes payable in 2022, as this was the most recent county-specific data at the time of our analysis (DLGF 2022c).

Indiana – Statewide results

Table 1 provides 2020 property tax information for the entire state of Indiana. There are over 4 million real and personal property accounts across all 92 counties combined. The total gross assessed property value is $572.7 billion, and the total net assessed value is $374.7 billion. Property taxes collected by all taxing districts combined totaled about $8.1 billion for the 2020 assessment year.

Table 1. Property Taxes in Indiana

	# of bills	Total Gross Assessed Value	Total Net Assessed Value	Total Property Tax Collected
All real and personal property tax bills in state	4,024,098	$ 572,683,461,394	$ 374,715,848,786	$ 8,078,348,676

Table 2. Indiana Non-profit Hospitals, 2020 property tax savings by county

The data in this table is obtained by identifying nonprofit hospital properties using Adjustment Code "Hospital=31" in the "Adjustments" database.

ID	County	# of hospital properties identified	Total Exemption Amount	Property Tax Savings from Exemptions	Total county property tax collections	Tax savings as % of county taxes
1	Adams	13	$ 14,500,138	$ 333,395	$ 32,052,476	1.04%
2	**Allen**	**65**	**432,631,054**	**8,455,649**	**405,676,896**	**2.08%**
3	**Bartholomew**	**22**	**66,826,040**	**1,792,543**	**122,090,251**	**1.47%**
5	Blackford	5	4,869,150	146,075	11,663,046	1.25%
6	Boone	1	8,032,900	240,987	137,316,879	0.18%
8	Carroll	3	2,182,920	49,337	17,415,590	0.28%
9	Cass	36	17,067,820	505,100	29,684,680	1.70%
10	Clark	3	3,442,110	103,263	140,402,952	0.07%
11	Clay	4	5,655,980	139,199	14,335,311	0.97%
13	Crawford	1	61,600	1,848	8,163,598	0.02%
15	Dearborn	48	6,322,350	158,972	56,026,705	0.28%
17	DeKalb	15	27,546,010	708,434	49,555,111	1.43%
18	Delaware	11	37,400,650	1,121,991	93,327,613	1.20%
19	Dubois	41	67,090,170	1,652,760	52,282,441	3.16%
20	Elkhart	58	46,986,340	1,398,439	281,201,297	0.50%
21	Fayette	8	13,668,935	410,068	16,872,501	2.43%
22	Floyd	5	9,738,400	162,982	74,618,654	0.22%
23	Fountain	2	727,200	17,643	15,774,535	0.11%
24	Franklin	6	10,901,070	239,713	17,379,704	1.38%
26	Gibson	25	10,719,860	317,698	56,368,399	0.56%
27	Grant	59	67,119,401	1,997,487	58,773,278	3.40%
28	Greene	4	231,900	5,684	22,736,570	0.03%
29	Hamilton	2	6,727,520	152,535	634,144,060	0.02%
32	Hendricks	35	91,859,930	2,623,348	256,657,941	1.02%
33	Henry	20	13,469,640	398,503	37,719,116	1.06%
34	Howard	26	65,203,363	1,956,101	105,872,555	1.85%
35	Huntington	12	50,191,810	1,505,754	36,619,203	4.11%
36	Jackson	57	62,666,870	1,550,081	42,205,469	3.67%
37	Jasper	4	545,640	9,905	29,705,032	0.03%
38	Jay	5	6,006,700	180,201	23,080,874	0.78%
41	Johnson	11	36,060,281	779,382	180,883,772	0.43%
44	LaGrange	3	65,160	1,622	31,662,992	0.01%
45	Lake	43	594,936,398	16,303,441	683,741,217	2.38%
46	LaPorte	16	26,171,962	513,305	135,631,773	0.38%

47	Lawrence	27	21,946,400	636,771	35,903,956	1.77%
48	Madison	71	48,036,198	1,429,377	118,334,689	1.21%
49	**Marion**	**105**	**367,647,370**	**9,663,819**	**1,351,575,288**	**0.72%**
53	**Monroe**	**48**	**107,106,680**	**2,188,133**	**161,179,892**	**1.36%**
54	Montgomery	15	4,417,000	130,817	45,803,849	0.29%
55	Morgan	10	56,277,058	1,196,501	42,449,444	2.82%
56	Newton	6	467,980	11,907	19,602,681	0.06%
57	Noble	19	24,243,100	641,555	48,264,615	1.33%
60	Owen	4	89,980	2,301	15,773,738	0.01%
63	Pike	3	635,500	17,760	15,354,708	0.12%
64	Porter	19	21,955,953	590,921	234,365,687	0.25%
67	Putnam	2	583,800	15,159	32,313,331	0.05%
68	Randolph	28	12,779,350	376,616	23,489,232	1.60%
69	Ripley	17	6,175,910	125,223	23,139,289	0.54%
70	Rush	1	587,000	17,610	18,499,192	0.10%
72	Scott	3	460,860	11,597	19,045,354	0.06%
73	Shelby	3	20,700	322	53,980,981	0.00%
74	Spencer	6	567,770	13,504	27,616,259	0.05%
76	Steuben	8	18,666,130	386,568	40,568,210	0.95%
77	Sullivan	1	203,600	4,489	22,140,186	0.02%
79	**Tippecanoe**	**7**	**7,305,730**	**125,073**	**211,106,753**	**0.06%**
80	Tupton	2	10,743,208	322,296	18,674,792	1.73%
83	Vermillion	8	10,545,750	315,468	18,574,232	1.70%
84	Vigo	147	92,516,500	2,550,924	111,255,014	2.29%
86	Warren	10	3,090,360	76,707	10,082,387	0.76%
88	Washington	8	809,280	23,838	22,581,327	0.11%
89	Wayne	45	257,451,460	7,692,396	67,186,191	11.45%
91	White	5	14,554,686	377,912	29,918,947	1.26%
92	Whitley	21	15,803,520	398,122	35,823,023	1.11%
Total		1,318	$ 2,913,316,105	$ 75,277,133	$ 6,786,245,737	1.11%
Real property accounts			893 (67.8%)			
Personal property accounts			425 (32.3%)			
Total property accounts			1,318 (100%)			

Notes:
- Counties in bold are one of the five selected counties examined in detail.
- There are 29 counties with no hospital properties in the exemptions database.
- Total property tax savings before applying 2% and 3% caps is $ 89,217,419. If hospitals did not have a nonprofit property tax exemption, this additional $14 million of property value would still be non-taxable because of the 2% and 3% caps.

Table 2 provides property tax information for each of the 63 counties that had accounts identified as hospital properties with a tax exemption. Twenty-nine (29) counties had no nonprofit hospital accounts in the adjustments dataset. Across the entire state, there were 1318 accounts related to nonprofit hospitals: 67.8% were real estate accounts and 32.3% were personal property accounts. In total, a little over $2.9 billion of property value was exempt in 2020 because of the nonprofit hospital exemption, resulting in a total property tax savings of $75.3 million for all nonprofit hospitals combined.

The last column provides the tax savings as a percentage of total tax collections for each county. On average, property tax collections would have been about 1.11% higher if nonprofit hospitals' property were not exempt, but the percentage varies greatly across counties. Lake County's taxing districts lost the most in tax revenues ($16.3 million), but this represented only 2.38% of their tax collections. In contrast, property tax revenues in Wayne County would have been 11.45% higher if its districts had collected $7.7 million of property tax revenues lost to nonprofit hospitals.

It is worth noting that our statewide estimates of nonprofit hospitals' tax savings are very similar to estimates reported in an article discussing Indiana's Senate Bill 232, a bill which would limit tax exemptions for nonprofit hospitals. Frissel (2020) refers to estimates by the Indiana Legislative Services Agency, which estimated nonprofit hospitals received $2.6 billion of property exemptions for 2019, and $78 million of forgone property taxes for 2021. These compare with our estimates of $2.9 billion of exempt value and $75.3 million of forgone taxes for 2020 (table 2). However, we believe that the Indiana Legislative Services Agency estimates suffer from the same problems as our table 2 statewide estimates. In short, our county-specific analysis below suggests that both statewide estimates understate nonprofit hospitals' property tax benefits – perhaps significantly.

Indiana – results for five select counties

County Results

It is relatively straightforward to use the Indiana county tax records to identify hospital properties that are coded as tax-exempt and compute the related tax savings, but it is significantly more difficult to determine a *specific* hospital's property ownership and tax savings. Property tax bills have no "owner ID" that allows one to identify multiple properties owned by a single owner. And although tax bills do have an owner's name, the names for a single owner are not necessarily identical across different tax bills. This lack of a uniform owner variable makes it difficult to identify all property parcels owned by a single taxpayer. This is true for Indiana, and to our knowledge, almost all state and local property tax systems. Accordingly, we next examine the tax rolls for our five selected counties to determine the property owned by each nonprofit hospital in the county and estimate the hospital's property tax savings from its nonprofit status.We first identified the hospitals in each county using the Centers for Medicare & Medicaid Services (CMS) Hospital Cost Reports. Table 3 shows that the composition of for-profit (FP) versus nonprofit (NFP) hospitals varies significantly across counties. Allen County has six hospitals (one NFP and five FP); Bartholomew has one hospital (governmental/city-county); Marion has nine hospitals (seven NFP, one FP, and one governmental/county); Monroe has two hospitals (one NFP and one FP); and Tippecanoe has two hospitals (both NFP).

Table 3. Selected Indiana Counties and their Acute-Care Hospitals[1]

County	Hospital	Owner Code	Ownership Type	City
Allen	Parkview Regional Medical Center	2	Non-profit	Fort Wayne
Allen	Lutheran Hospital of Indiana	4	For-profit	Fort Wayne
Allen	St. Joseph Hospital	4	For-profit	Fort Wayne
Allen	Dupont Hospital	4	For-profit	Fort Wayne
Allen	Orthopedic Hospital at Parkview North	4	For-profit	Fort Wayne
Allen	The Orthopedic Hospital of Lutheran Health	4	For-profit	Fort Wayne
Bartholomew	Columbus Regional Hospital	8	Governmental (city-county)	Columbus
Marion	Ascension St. Vincent Hospital	1	Non-profit (church)	Indianapolis
Marion	Franciscan Health Indianapolis	1	Non-profit (church)	Indianapolis
Marion	Indiana University (IU) Health	2	Non-profit	Indianapolis
Marion	Community Hospital East	2	Non-profit	Indianapolis
Marion	Community Hospital South	2	Non-profit	Indianapolis
Marion	Community Hospital North	2	Non-profit	Indianapolis
Marion	Fairbanks	2	Non-profit	Indianapolis
Marion	Eskenazi Health	9	Governmental (county)	Indianapolis
Marion	Orthoindy Hospital	5	For-profit	Indianapolis
Monroe	IU Health Bloomington Hospital	2	Non-profit	Bloomington
Monroe	Monroe Hospital	4	For-profit	Bloomington
Tippecanoe	Franciscan Health Lafayette	1	Non-profit (church)	Lafayette
Tippecanoe	Indiana University (IU) Health Arnett Hospital	2	Non-profit	Lafayette

[1] Hospitals identified from CMS cost reports (2019).

For each of the nonprofit hospitals in table 3, we searched the 2021 county tax rolls by hospital name and/or address to identify properties owned by each hospital. Table 4 provides summary information for each hospital. For each hospital, the first three columns show the number of tax bills identified, the number of distinct owner names on those bills, and the number of different taxing districts in which a hospital's property is located. The last two columns provide the average tax rate for the hospital's taxing districts, before and after the 3% circuit breaker cap. For example, Parkview Regional Medical Center has 262 different tax bills, with 13 distinct owner names. The hospital owns property in 12 different taxing districts, with an average tax rate of about 2.5%. The Appendix provides details on the distinct owner names for each hospital.

Table 4. Hospitals and Property Tax Information for 2021 assessment year[1]

County	Hospital (and affiliates)	# of Tax Bills[2]	# of owner names [3]	# of Taxing Districts	Average (mean) tax rate	
					Before circuit breaker cap[4]	After circuit breaker cap
Allen	Parkview Regional Medical Center	262	13	12	2.5827	2.5410
Bartholomew	Columbus Regional Hospital	35	12	1	2.6583	2.6583
Marion	Ascension St. Vincent Hospital	119	55	13	2.9539	2.8030
Marion	Franciscan Health Indianapolis	14	2	4	3.6362	2.9764
Marion	Indiana University (IU) Health	140	17	10	3.0324	2.8808
Marion	Community Hospital - East, South, & North	42	20	7	2.9428	2.9263
Marion	Fairbanks	2	2	1	2.6754	2.6754
Marion	Eskenazi Health	3	3	1	2.9665	2.9665
Monroe	IU Health Bloomington Hospital	57	8	8	1.8377	1.8377
Tippecanoe	Franciscan Health Lafayette	96	4	6	2.4031	2.4031
Tippecanoe	Indiana University (IU) Health Arnett	41	5	7	2.6039	2.6039

Note: *The data in this table is obtained by searching county tax rolls using hospital name and/or address.*

[1] Property tax information is from the "2021 pay 2022" tax bills.
[2] Number of separate tax bills for each hospital and its affiliates.
[3] Number of distinct owner names on property tax bills. See Appendix for names of record on property tax bills.
[4] Average (mean) tax rate for the hospital's relevant taxing districts, before (or after) applying the 2% or 3% circuit breaker cap

Table 5 presents information on each hospital's assessed values and tax due, both with and without the property tax exemption. The first column presents the net assessed value (i.e., after exemptions) for all properties we identified as being owned by a hospital. The second column is the tax paid on those properties. The next two columns show the total gross assessed value (before exemption) and the tax that would be paid on that gross assessed value (before exemptions but after the circuit breaker cap). The last column presents the total estimated tax savings for each hospital because of their nonprofit status. This is their total estimated property tax benefit. For example, Parkview Hospital owns property with a gross assessed value (before exemption) of $719.8 million, but a net assessed value (after exemption) of $198.5 million. The hypothetical property tax that would be paid on the gross property value would be $14.8 million, but Parkview's actual tax due is $4.07 million – a tax savings of $10.7 million.

Table 5. Non-profit hospitals' property tax information for 2021

County	NFP Hospital	Net Assessed Value (after exemption)	Actual Tax Due	Gross Assessed Value (before exemption)	Tax Due on Gross AV (after 2% or 3% caps)	Tax savings from exemption
Allen	Parkview Hospital	$ 198,521,249	$ 4,072,108	$ 719,792,780	$ 14,805,032	$ 10,732,924
Bartholomew	Columbus Regional [1]	2,163,050	51,890	61,723,700	1,640,801	1,588,911
Marion	Ascension St. Vincent	12,470,240	345,054	228,773,100	6,167,310	5,822,256
Marion	Franciscan Health Ind.	5,442,140	136,726	83,362,400	2,428,685	2,291,959
Marion	IU – Health	42,793,360	1,267,123	227,085,100	6,677,381	5,410,258
Marion	Community Hospital	36,637,920	925,681	249,241,200	6,883,296	5,957,615
Marion	Fairbanks	0	0	7,420,700	198,533	198,533
Marion	Eskenazi [2]	0	0	N/A	N/A	N/A
	Total	97,343,660	2,674,584	795,882,500	22,355,205	19,680,621
Monroe	IU Health	439,880	8,018	102,903,730	2,099,594	2,091,576
Tippecanoe	Franciscan Health	2,273,900	47,919	50,937,480	1,355,682	1,307,763
Tippecanoe	IU Health	398,102	9,702	99,699,520	2,621,877	2,612,175
	Total	2,672,002	57,621	150,637,000	3,977,559	3,919,938

[1] Columbus Regional is a city-county hospital. We include it in our analysis for several reasons: (1) the hospital is the 'flagship facility' of Columbus Regional Healthcare System, a §501(c)(3) nonprofit; (2) the hospital's financial statements state that the hospital is exempt from taxes under both Internal Revenue Code §115 and §501(c)(3); and (3) the hospital's assessed values are provided in the tax rolls.
[2] Eskenazi is a county hospital. The hospital has tax bill accounts, but there are no assessed values provided for their properties.

Comparing Results from the Two Approaches

We next compare our results from Approach 1, which uses the state code to identify hospital properties, with results from Approach 2, where we search the tax rolls using hospital name and/or address. Table 6 present results. The first column shows nonprofit hospitals' tax savings totals $22.2 million for all five counties combined when we identify properties using the "hospital" adjustments code (table 2), while the second column shows nonprofit hospitals' combined tax savings totals $38.0 million when we search the county tax rolls for each hospital individually (table 5). By undertaking a more careful – albeit laborious – approach, we identify 564 additional nonprofit hospital properties in those five counties, with an additional tax savings of $15.8 million – a 71.0% increase.

It is not surprising that there are nonprofit hospital-owned properties with exemptions that are not coded as "hospital" in the property tax database. First, hospitals own properties other than their primary hospital building (e.g., office buildings, strip malls, physicians' practice, parking structures and parking lots, ambulatory surgical centers, vacant land). Indiana property tax law provides that these additional properties qualify for property tax exemption if the hospital shows that the property is substantially related to or supportive of the hospital's inpatient facility, or it provides or supports the provision of charity care or community benefits, including research, education, or government-sponsored indigent health care (Indiana Code §6-1.1-10-16). It is unlikely that an incorrect exemption or property code will receive any attention as long as the nonprofit hospital obtains its tax exemption. Second, property tax databases are not subject to systematic audits or data cleansing. From our experience with other property tax datasets, errors in property descriptions, inconsistent coding, and other clerical errors are not unusual. The local appraisal district is generally responsible for all property tax appraisal and exemption administration in their geographic boundaries, as well as sending taxpayers their notice of assessed values, and then scheduling and hearing all property tax protests. Unless a taxpayer complains, districts are unlikely to review tax rolls and correct errors.

It should be noted that table 2 uses 2020 assessed values, while table 5 uses 2021 values. If property values are increasing, we would expect the tax savings in table 5 to be greater than the savings in table 2. However, in Indiana, gross and net assessed values increased 4.7% and 4.6%, respectively, from 2019 to 2020, and the average annual increase for 2017- 2020 was 4.2% (DLGF 2022b, table 1). This suggests that the tax savings in table 5 would be somewhat greater than the tax savings in table 2 (e.g., 5%-10% perhaps), but an increase in assessed values would not explain a 71.0% greater tax savings.

Table 6. Comparing Estimates of Property Tax Savings for Five Counties

County	Estimate of Tax Savings using statewide dataset (Table 2)	Estimate of Tax Savings using county dataset (Table 5)	Difference in estimates of tax savings	Difference as %age of tax savings
	(a)	(b)	(c) = (b) – (a)	(c) ÷ (a)
Allen	$ 8,455,649	$ 10,732,924	$ 2,277,275	26.9%
Bartholomew	1,792,543	1,588,911	(203,632)	(11.4%)
Marion	9,663,819	19,680,621	10,016,802	103.7%
Monroe	2,188,133	2,091,576	(96,557)	(4.4%)
Tippecanoe	125,073	3,919,938	3,794,865	3,034.1%
Total	$ 22,225,217	$ 38,013,970	$ 15,788,753	71.0%
Total # of nonprofit hospital bills identified	247	811	564	

Conclusions and policy implications

State and local policymakers are increasingly interested in quantifying nonprofit hospitals' tax benefits and weighing them against hospitals' community benefit. Prior studies have generally been undertaken by researchers not well-versed in property taxation and its unique challenges. We examined Indiana's nonprofit hospitals in order to estimate their property tax benefits, measured as their forgone property taxes. We then examined nonprofit hospitals in five counties to quantify property tax benefits for specific hospitals. This latter analysis demonstrates the difficulties encountered with identifying property ownership, even with a relatively easy-to-use property tax database.

The advantages of using Indiana's property tax data for our analysis cannot be overstated. First, the property tax rolls in Indiana provide assessed values for nonprofit hospitals. No estimation is required to determine a nonprofit hospital's hypothetical property tax (i.e., the amount the hospital would pay if it were not tax-exempt). Second, Indiana property tax data is available in bulk datasets for all counties, and all counties report in the same format. These data include parcel-specific property tax data for all properties in the state. These two features allow for a more manageable and reliable analysis compared with most other states. Nevertheless, identifying property tax benefits for a *specific* nonprofit hospital remains challenging and cumbersome, even with Indiana's unique data. Furthermore, Indiana's coding system does not allow one to easily identify all nonprofit hospital-owned properties, which can significantly understate property ownership and the related tax savings from property exemptions.

Given that property taxes represent a sizable portion – 20% or more – of nonprofit hospitals' tax benefits, state and federal policymakers should consider requiring appraisal districts and/or nonprofit hospitals to report the information necessary to estimate their (unpaid) property taxes. The necessary information would include estimated values of nonprofit hospitals' real estate holdings (buildings and land), personal property (if taxable), and the applicable tax rates.

Because property tax values are determined by local appraisal districts, the availability and quality of this information will vary significantly across states, and across appraisal districts within a state. For states like Indiana, property tax rolls already include assessed values for non-taxable properties. However, property tax rolls in other states may include no information at all, or may include values other than market or assessed values. In addition, property tax rolls would need to undergo "data cleaning" to help ensure all hospital-owned properties could be identified. Thus, reporting property tax benefit would be possible but would impose additional reporting burdens and costs on appraisal districts and hospitals. Policymakers would need to weigh the costs and benefits before pursuing such policies.

In addition, self-reported hospital data that is not subject to systematic audit by an independent party would almost certainly be subject to inaccuracies and misrepresentations. We found this to be the case with nonprofit hospitals in Texas, a state that currently requires some nonprofit hospitals to self-report the estimated value of their tax-exempt benefits (Bai et al. 2021; Texas Department of State Health Services 2021). States could take steps to help reduce such problems with self-reported data. For example, in 2021, the Florida legislature repealed a law (scheduled to become effective January 1, 2022) that would have effectively limited a nonprofit hospital's property tax exemption to the amount of community benefit the hospital provided. The law would have required county property appraisers to calculate hospitals' property tax benefit and submit the information to the Florida Department of Revenue (EY 2021). Such state involvement enhances reporting reliability, but would increase governments' administrative costs.

It is worth noting that some nonprofits enter into agreements with municipalities known as payments in lieu of taxes (PILOTS) and/or services in lieu of taxes (SILOTs). We are not aware of any PILOTS or SILOTS for Indiana nonprofit hospitals. However, the value of these payments and/or services (if any) would decrease our estimate of a nonprofit hospital's property tax benefits.

Lastly, our study does not address tax incidence issues. When nonprofits do not pay property taxes, the tax burden is shifted to taxpaying property owners, both business and residential. Future research should examine how the property tax exemption for nonprofit hospitals affects the tax distribution. Tax shifting can lead to negative externalities, such as increased tax regressivity and distorted market incentives. These are important factors when quantifying costs associated with nonprofit hospitals' tax exemptions. When evaluating whether nonprofits can justify their tax-exempt status, policymakers should compare the community benefits provided by nonprofit hospitals with not only the costs of hospitals' tax-exempt benefits (i.e., foregone tax revenues) but also costs associated with any externalities created by their tax exemptions.

References

American Hospital Association (AHA). 2022. Fast Facts on U.S. Hospitals, 2022. Available at **https://www.aha.org/statistics/fast-facts-us-hospitals**.

Bai, G., E. Plummer, and G. F. Anderson. 2021. "Use the Hospital Compare Website to make Hospital Community Benefit more Transparent." *Health Affairs Forefront*, September 10, 2021. Available at **https://www.healthaffairs.org/do/10.1377/forefront.20210903.507376/**.

Bai, G., H. Zare, M. D. Eisenberg, D. Polsky, and G. F. Anderson. 2021. "Analysis Suggest Government and Nonprofit Hospitals' Charity Care is not Aligned with their Favorable Tax Treatment." *Health Affairs* 40(4):629-636.

Bai, G., F. Yehia, and G. F. Anderson. 2020. "Charity Care Provision by US Nonprofit Hospitals." *JAMA Internal Medicine* 180(4):606-607.

BKD, LLP. 2021. *Columbus Regional Hospital - A Component Unit of Bartholomew County, Indiana Auditor's Report and Financial Statements - December 31, 2020 and 2019*. Available at

https://www.in.gov/health/files/Columbus-Regional-Hospital-YE12312020-and-2019.pdf.

Department of Local Government Finance (DLGF). 2022a. "Citizens' Guide to Property Tax." Available at **https://www.in.gov/dlgf/understanding-your-tax-bill/citizens-guide-to-property-tax/**.

Department of Local Government Finance (DLGF). 2021. "DLGF Series Webinar: Circuit Breaker (April 21, 2021)." Available at **https://www.in.gov/dlgf/files/210421-Van-Dorp-Presentation-Circuit-Breaker.pdf**.

Department of Local Government Finance (DLGF). 2022b. *Report on Property Tax Exemptions,* Deductions, and Abatement - April 29, 2022. Available at **https://www.in.gov/dlgf/files/2022-reports/ExemptionsDeductionsReport-2022.pdf**.

Department of Local Government Finance (DLGF). 2022c. "Tax Bill Search." Available at **https://www.in.gov/dlgf/understanding-your-tax-bill/assessed-value-search/**.

Ernst & Young (EY). 2022. "Estimates of the federal revenue forgone due to the tax-exemption of non-profit hospitals compared to the community benefit they provide, 2019." EY report prepared for the American Hospital Association, May 2022. Available at **https://www.aha.org/system/files/media/file/2022/06/E%26Y-Benefit-of-of-Tax-Exemption-Report-FY2019-FINAL-with-links.pdf**.

Ernst & Young (EY). 2021. "Florida Legislature repeals law limiting nonprofit hospital's property tax exemption to community benefit provided." EY Tax Alert 2021-1181 (June 14, 2021). Available at **https://taxnews.ey.com/news/2021-1181-florida-legislature-repeals-law-limiting-nonprofit-hospitals-property-tax-exemption-to-community-benefit-provided**

Frissel, Scott C. 2020. Property Tax Exemptions Threatened for Indiana Nonprofit Hospitals. Available at **Property Tax Exemptions Threatened for Indiana Nonprofit Hospitals (kriegdevault.com)**.

Herring, B., D. Gaskin, H. Zare, and G. Anderson. 2018. "Comparing the Value of Nonprofit Hospitals' Tax Exemption to their Community Benefits." *INQUIRY: The Journal of Health Care Organization, Provision, and Financing* 55:1-11.

Indiana Gateway. 2022. "Download Data – Property Files." Available at **https://gateway.ifionline.org/public/download.aspx**).

Kennedy, W., and J. Johnson. 2022. "'Non-charitable' Nonprofit Hospital Ordered to Start Paying Property Taxes." *Bloomberg Tax* (January 7, 2022). Available at **https://news.bloombergtax.com/tax-insights-and-commentary/non-charitable-nonprofit-hospital-ordered-to-start-paying-property-taxes**.

Rosenbaum, S., D. A. Kindig, J. Bao, M. K. Byrnes, and C. O'Laughlin. 2015. "The Value of the Nonprofit Hospital Tax Exemption was $24.6 billion in 2011." *Health Affairs* 34(7): 1225-1233.

Texas Department of State Health Services. 2021. "Texas Nonprofit Hospitals: Annual Statement of Community Benefits Standard – Worksheet 5." Available at **https://www.dshs.texas.gov/sites/default/files/chs/hosp/Forms/ASCBSNP-2021.pdf**.

Zare, H., M. D. Eisenberg, and G. Anderson. 2022. "Comparing the Value of Community Benefit and Tax-Exemption in Non-profit Hospitals." *Health Services Research* 57(2):270-284.

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Appendix: Property owner names of record on 2021 tax bills

Panel A: Allen County, Parkview Regional Medical Center and affiliates

PARKVIEW RETAIL SERVICES LLC
PARKVIEW PPG WALK-IN CLINIC
PARKVIEW ORTHO CENTER LLC
PARKVIEW OCCUPATIONAL HEALTH CTRS INC
PARKVIEW HOSPITAL INC
PARKVIEW HOSPITAL
PARKVIEW HEALTHY LIVING
PARKVIEW HEALTH SYSTEMS INC
PARKVIEW HEALTH SYSTEMS
PARKVIEW HEALTH SYSTEM INC
PARKVIEW HEALTH SYSTEM
PARKVIEW FOUNDATION INC
PAR PARKVIEW HOSPITAL INC 70.3% & PARKVIEW HEALTH SYSTEM INC 22% & GARDNER SUSANNE K KVIEW RETAIL SERVICES LLC

Panel B: Bartholomew County, Columbus Regional Hospital and affiliates

BARTHOLOMEW CO HOSPITAL BOARD OF TRUSTEES
BARTHOLOMEW COUNTY HOSPITAL
BARTHOLOMEW COUNTY HOSPITAL TR
BOARD OF TRUSTEES BARTHOLOMEW COUNTY HOSPITAL
BOARD OF TRUSTEES OF COLUMBUS REGIONAL HOSPITAL
COLUMBUS HOSPITAL LLC
COLUMBUS HOSPITAL, LLC(BEHAVIORVAL [sic] CENTER)
COLUMBUS REGIONAL HOSPITAL
COLUMBUS REGIONAL HOSPITAL - BOARD OF TRUSTEES
COLUMBUS REGIONAL HOSPITAL BOARD OF TRUSTEES
COLUMBUS REGIONAL HOSPITAL FOUNDATION
COLUMBUS REGIONAL HOSPITAL TRUST

Panel C: Marion County, Ascension St. Vincent Hospital and affiliates

ASCENSION LIVING ST VINCENT PACE INC
ASCENSION MED GROUP ST VINCENT (46049-71)
ASCENSION MEDGROUP ST VINCENT - PRIMARY CARE ADMIN
ASCENSION MEDGROUP ST VINCENT - REMOTE CARE MGMT 4
ASCENSION MEDGROUP ST VINCENT - TCG @ ST VINCENT (
ASCENSION MEDGROUP ST VINCENT - TCG CLINICAL LAB (
ASCENSION MEDGROUP ST VINCENT- CORVASC - 86TH ST
ASCENSION MEDICAL GROUP ST VINCENT - GLEANERS CLIN
ASCENSION MEDICAL GROUP ST VINCENT - PRIMARY CARE
ASCENSION MEDICAL GROUP ST VINCENT - ST VINCENT CE
ASCENSION MEDICAL GROUP ST VINCENT (46049)-65
ASCENSION MEDICAL GROUP ST VINCENT- ADMIN (42772)

Panel C: (continued)

ASCENSION ST VINCENT - NAAB RD ECHO TREADMILL (139
ASCENSION ST VINCENT (64263 64279 64314) 46028-01
ASCENSION ST VINCENT BREAST CENTER (34952) 46029-0
ASCENSION ST VINCENT CARDIAC TRANSPLANT (26852) 46
ASCENSION ST VINCENT EMERGENCY SERVICES (32150) 46
ASCENSION ST VINCENT FOUNDATION (46237-01)
ASCENSION ST VINCENT HOUSE (66750) 46029-61
ASCENSION ST VINCENT INDIANAPOLIS HOSPITAL 46029-0
ASCENSION ST VINCENT LILLY CONFERENCE CENTER (8860
ASCENSION ST VINCENT MICI-AHEC 46028-11
ASCENSION ST VINCENT NEURO SCIENCE SERVICE LINE (1
ASCENSION ST VINCENT ONCOLOGY SURVIVORSHIP (16450)
ASCENSION ST VINCENT OUTPATIENT ONCOLOGY CENTER (1
ASCENSION ST VINCENT PAN WAREHOUSE (70654 70730) 4
ASCENSION ST VINCENT PATIENT ACCESS (65750 65850)
ASCENSION ST VINCENT PCC RADIOLOGY (34503) 46029-
ASCENSION ST VINCENT PEDIATRIC GASTROENTEROLOGY (5
ASCENSION ST VINCENT PEDIATRIC NEUROLOGY (56707) 4
ASCENSION ST VINCENT PEDIATRIC NEUROSURGERY (56714
ASCENSION ST VINCENT PEDIATRIC ORTHO (55800 69168)
ASCENSION ST VINCENT PTC (23889)46029-50
ASCENSION ST VINCENT RAS LAWRENCE (67956) 46083-04
ASCENSION ST VINCENT RENAL TRANSPLANT (26850) 4602
ASCENSION ST VINCENT SETON SPECIALTY HOSPITAL INC
ASCENSION ST VINCENT SPORTS PERFORMANCE (46084-01)
ASCENSION ST VINCENT STAR PROGRAM 46028-10
ASCENSION ST VINCENT STRESS CENTER 46043-01
ASCENSION ST VINCENT VIP CARE LAB (14151) 46029-44
ASCENSION ST VINCENT WOMENS HOSPITAL 46029-54
ASCENSION ST VINCENT-CASTLETON (46091-04)
ASCENSION ST VINCENT-INDPLS SOUTH (46091-05)
SOCIETY OF ST VINCENT
SOCIETY OF ST VINCENT DE PAUL
ST VINCENT HEALTH-WELLNESS & PREVENTATIVE CARE INS
ST VINCENT HOSPITAL &
ST VINCENT HOSPITAL & HEALTH CARE CENTER INC
ST VINCENT HOSPITAL AND
ST VINCENT HOSPITAL PHARMACY
ST VINCENT MEDICAL CENTER NORTHEAST INC
ST VINCENT NEW HOPE
ST VINCENT NEW HOPE INC
ST VINCENT SETON

ST VINCENTS EMERGENCY PHYSICIANS INC

Panel D: Marion County, Franciscan Health Lafayette

SISTERS OF ST FRANCIS
SISTERS OF ST FRANCIS HEALTH SERVICES INC

Panel E: Marion County, Indiana University (IU) Health

CLARIAN HEALTH PARTNERS INC [1]
CLARIAN HEALTH PARTNERS
CLARIAN HEALTH
INDIANA HEALTH CARE ASSOCIATION
INDIANA HEALTH CENTERS INC
INDIANA HEALTH CENTERS INCORPORATED
INDIANA HEALTH INFORMATION EXCHANGE INC
INDIANA HEALTHY MARRIAGE & FAMILY COALITION
INDIANA HEALTH CENTERS INCORPORATED
INDIANA HEALTH INFORMATION EXCHANGE INC
INDIANA UNIVERSITY HEALTH CARE ASSOCIATES INC
INDIANA UNIVERSITY HEALTH INC
INDIANA UNIVERSITY RADIOLOGY ASSOC INC
REHABILITATION HOSPITAL
COMMUNITY HEALTH NETWORK REHABILITATION HOSPITAL L
REHABILITATION HOSPITAL OF INDIANA
NEURO REHABILITATION HOSPITAL OF INDIANA

[1]In January 2011, Clarian Health adopted the new name of Indiana University Health. The new brand did not change the corporate structure. IU Health remained an independent, nonprofit health system.

Panel F: Marion County, Community Hospital - East, South & North, and affiliates

COMMUNITY HEALTH NETWORK INC
COMMUNITY HEALTH NETWORK OF IN INC
COMMUNITY HEALTH NETWORK REHABILITATION HOSPITAL L
COMMUNITY HEALTHCARE PROPERTIES LLC
COMMUNITY HOSPITAL
COMMUNITY HOSPITAL HUMAN RESOURCES
COMMUNITY HOSPITAL INDPLS REGIONAL CANCER CENTER
COMMUNITY HOSPITAL NORTH
COMMUNITY HOSPITAL OF
COMMUNITY HOSPITAL REHAB & SPORTS MED - SHADELAND
COMMUNITY HOSPITAL REHAB & SPORTS MEDICINE EAST
COMMUNITY HOSPITAL SOUTH
COMMUNITY HOSPITAL SOUTH INC
COMMUNITY HOSPITAL SOUTH,
COMMUNITY HOSPITALS
COMMUNITY HOSPITALS – INDIANAPOLIS
COMMUNITY HOSPITALS FOUNDATION INC
COMMUNITY HOSPITALS OF
COMMUNITY HOSPITALS OF INDIANA INC

COMMUNITY NORTH MEDICAL CENTER LLC

Panel G: Marion County, Fairbanks

FAIRBANKS HOSPITAL
FAIRBANKS HOSPITAL INC

Panel H: Marion County, Eskenazi

ESKENAZI HEALTH FOUNDATION INC
ESKENAZI MEDICAL GROUP INC
ESKENAZI MEDICAL GROUP INC

Panel I: Monroe County, IU Health Bloomington Hospital

INDIANA UNIVERSITY HEALTH BLOOMINGTON INC
INDIANA UNIVERSITY HEALTH CARE ASSOCIATES INC
INDIANA UNIVERSITY HEALTH INC
INDIANA UNIVERSITY HEALTH URGENT CARE, LLC
INDIANA UNIVERSITY HEALTH, INC
IU HEALTH SOUTHERN IN PHYSCIANS
IU HEALTH SOUTHERN IN PHYSICIANS, INC.
IU HEALTH SOUTHERN INDIANA PHYSICIANS, INC.

Panel J: Tippecanoe County, Franciscan Health Indianapolis and affiliates

FRANCISCAN ALLIANCE INC
FRANCISCAN SISTERS OF CHICAGO SERVICE CORPORATION
FRANCISCAN ALLIANCE, INC ID#3625
FRANCISCAN ALLIANCE INC ID#7774

Panel K: Tippecanoe County, Indiana University Health Arnett Hospital

DSI-IU HEALTH ARNETT DIALYSIS LLC
INDIANA UNIVERSITY HEALTH ARNETT INC
INDIANA UNIVERSITY HEALTH CARE ASSOCIATES INC
INDIANA UNIVERSITY HEALTH INC
INDIANA UNIVERSITY HEALTH INC & ARNETT REAL ESTATE PAR

Enterprise Value to Invested Capital: The Best Multiple You've (N)ever Used

BY SCOTT SAMPSON

Abstract

Many states exempt intangible personal property (IPP). Often people conflate, combine, and confuse IPP with goodwill when those are distinct concepts. Furthermore, to apply the IPP exemption, many people attempt to estimate IPP and goodwill value using ad hoc solutions.

This article proposes a simple and transparent method, the enterprise value to invested capital (EVIC) multiple, to estimate the taxable property's value. The multiple's algebraic equivalence, advantages, simplicity, and transparency compared to the discounted cash flow (DCF) method, without "slippery inputs," is discussed. The model values tangible property according to the law of one price and IPP values are correlated with the firm's expected profitability. The paper uses publicly available data from the airline, electric, gas distribution, pipeline, railroad, telecom, and wireless industries are used as examples to demonstrate valuation accuracy and consistency across companies for tangible property values and excluding IPP values. The model is most useful for utility sectors and industrial properties that have a combination of real, personal, and intangible personal property where tangible assets are a key value driver.

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Understanding and defining the problem to be solved

Many states exempt intangible personal property (IPP). Often people conflate, combine, and confuse IPP with goodwill when those are distinct concepts. Goodwill is invisible, indescribable, immeasurable, and definitionally not property. Furthermore, to apply the IPP exemption many people attempt to estimate IPP and goodwill value using ad hoc solutions.

> *While some state statutes allow the inclusion and taxation of all unitary property, without regard to whether or not some of that property may be classified as real, personal, tangible or intangible, many states exempt certain items as intangible personal property. ... Dealing with the intangible personal property exemption issue is a perplexing problem to appraisers conducting unitary valuation. (Western States Association of Tax Administrators, Committee on Centrally Assessed Properties 2009.)*

While there are a variety of approaches to consider intangible personal property values, they have a "substantial ad hoc component, and little or no foundation in finance theory." (Western States Association of Tax Administrators, Committee on Centrally Assessed Properties 2009.)

Asking what's the value of something indescribable is the wrong question. The better question is: how to estimate the taxable property's value that you can see and touch while demonstrating that the exemption has been fairly applied?

This article proposes a simple and transparent method, grounded in valuation theory, to estimate the taxable property's value. Empirical data and examples demonstrate valuation consistency across taxpayers.

Defining the problem

Lord Kelvin said, "When you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind." (1883). Therefore, we must define exactly what we are measuring otherwise our measurements are meaningless. If we are attempting to measure the taxable property value, then we must begin by defining what we mean by property.

Generally, Black's Law Dictionary (2019) defines property as the right to possess, use, and enjoy a determinate thing. Rights are legally enforceable in court. Property is categorized as either tangible or intangible. Tangible property is either real or personal. Real property is land, buildings, and everything permanently attached to the land. Personal property is all other tangible property that is not permanently attached to the land. Personal property also includes intangible personal property, which consists of rights and privileges having a legal, but not a physical existence. Copyrights, trademarks, customer lists, and patents conforms with the IPP the legal definition.

Another important aspect of defining property is that it helps to identify assets that are not property, assets that are to be neither added to nor deducted from the value, for example, goodwill. Most definitions describe goodwill as an asset that arises from other unidentified and unquantified assets. The IAAO Special Committee on Intangibles explains:

> *Under FASB Topic 805, an intangible asset is recognized as an asset apart from goodwill only if it arises from contractual or legal rights, such as a patent or trademark, or if it is separable, able to be sold, transferred, licensed, rented, or exchanged (FASB 2016). An assembled workforce does not typically meet that test, so in the accounting world it is not considered an intangible asset, but rather a residual asset categorized as goodwill. A residual asset arises in the purchase of a business, when all other assets have been catego-*

rized and valued. The residual is whatever is left over (2017).

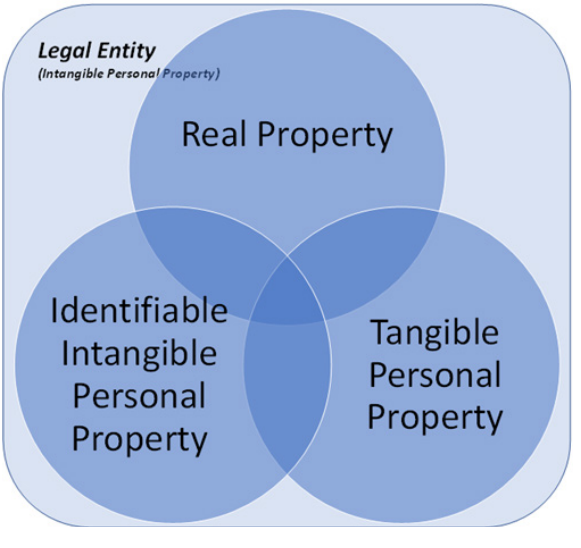
The accountant's identified intangible assets definition is consistent with the legal definition of IPP, while goodwill is not. Definitionally goodwill is not property because it is an indescribable asset without legal rights. If goodwill is not property, then what is it?

While accountants measure goodwill as the residual after deducting the fair value of identified assets from the purchase price of the business, a business sale is not required, there are other aspects of goodwill. Black's Law Dictionary defines goodwill as "A business's reputation, patronage, and other intangible assets that are considered when appraising the business, esp. for purchase; the ability to earn income in excess of the income that would be expected from the business viewed as a mere collection of assets" (2019). The IRS Tax Court stated that goodwill "is an intangible consisting of the excess earning power of a business. A normal earning power is expected of the business assets, and if the business has greater earnings, then the business may be said to have goodwill." *Staab v. Comm'r of Internal Revenue*, 20 T.C. 834, 840 (U.S.T.C. 1953). Mertens defines goodwill as "the expectation of earnings in excess of a fair return on the capital invested in tangibles or other means of production" (2022).

One characteristic of goodwill that has emerged over the past century is that it is inseparable from the business. It can not be sold without selling the business that is associated with it. If you can sell what you are calling goodwill, then it is something other than goodwill. It may be contract rights, a client list, distribution channels, or any number of other things and should be labeled as such, instead of lumped into the goodwill account (Johnson and Tearney 1993).

Essentially goodwill is a characteristic of a business. While not intuitively obvious, a business is a form of IPP. A business is a legal entity that is defined as "a body, other than a natural person, that can function legally, sue or be sued, and make decisions through agents. A typical example is a corporation" (Garner and Black 2019). A business is a describable legal entity that has legally protected rights and can be bought and sold. These are all characteristics of IPP. Figure 1 shows the inter-relationships of the four primary property types that the assessor must consider in the property valuation. The graphic illustrates that the legal entity is the container that owns, leases, manages, or controls all the property and non-property resources it uses to deliver products and services to customers. Uniform Standards of Professional Appraisal Practice (USPAP) Standards 1, 7, and 9 state that when the scope of work includes the appraisal of real, personal, trade fixtures or intangible items the appraiser must analyze the effect on value. (Standards 1-4, 7-4, 9-4) (The Appraisal Foundation 2020).

Figure 1.



From this illustration and these property definitions, we see that if IPP is broadly exempt the assessors' assignment narrows to real and tangible personal property valuation. The valuation must also consider the influence of intangible property on tangible property. These influences may be either positive (synergy) or negative (economic or external obsolescence).

The Interaction of Intangible and Tangible Property in Enterprise Value

Various authors make the point that intangible assets involve using assets jointly:

> *Most intangible assets are not stand-alone assets that can be valued on a balance sheet independently of other assets; rather, their value comes from producing cash flow streams jointly with other assets. Brands, distribution networks, and customer relationships work together to produce value at the Coca Cola Company, and they cannot work without tangible assets such as delivery trucks and bottling plants. 'Knowledge capital" is employed with productive processes, marketing, and management, and cannot work without tangible assets. "Organization capital" involves the organization of assets to be used jointly. Indeed, it is the firm that is the asset; the firm is an organization of assets designed to gain competitive advantage, and the entrepreneurial idea that translates to a business plan for organizing the assets is the source of value (Penman 2009).*

Lev and Daum (2004) say: "Intangible assets by themselves neither create value nor generate growth: they need to be combined with other production factors. They need efficient support and enhancement systems – otherwise the value of intangibles dissipates much quicker than that of physical assets." They add "Intangibles are not only inert – many are also commodities since most business enterprises have equal access to them ... Since competitors have equal access to such assets they do not create a competitive advantage by itself and as a result, at best, return only the cost of capital (zero value added)."

Other authors say intangibles, however they are defined, are the main source of a firm's sustainable competitive advantage. A firm has a competitive advantage when it implements a value-creating strategy not simultaneously implemented by current competitors or potential competitors. A sustained competitive advantage (SCA) occurs with current or potential competitors are unable to duplicate the benefits of the strategy. Four aspects of competitive advantage or SCA are that the firm's resources are rare, imperfectly imitable, causally ambiguous (i.e., not easily understood), socially complex, and without a strategically equivalent substitute (Barney 1991). "The IGG [internally generated goodwill] (also called "going-concern goodwill") represents "the ability [of a company] as a stand-alone business to earn a higher rate of return on an organized collection of net assets than would be expected if those assets had to be acquired separately." (Johnson and Peterone 1998), (Paugam, Stolowy and Casta 2011). The firm is not simply the sum of readily available components but is the "unique combination of complementary and co-specialized assets" that is worth more or less than the sum of the parts. It is the intangible resources that a firm "owns," not the physical resources or individual intangible assets, but rather the bundle of property rights to use, transfer, exclude others from access, appropriate economic rents, and etcetera, complementary property rights, that can be a source of value creation (Asher, Mahoney and Mahoney 2005). The more a company can prevent competitors from replicating their bundled assets, the longer it will have a competitive advantage.

Complex physical technology generally is not a source of sustainable competitive advantage because other firms should be able to purchase the same or functionally similar equipment (Cornell, Cornell and Cornell, Valuing the Automotive Industry 2021), (Koller, Goedhart and Wessels 2015). For example, the domestic airline industry is homogenous on price, quality, and passenger load factor dimensions. They share common resources such as aircraft, fuel, and labor that are interchangeable and minimally customizable. Competitors are quickly able to imitate innovations, e.g., loyalty programs and computerized reservation systems. Consequently, operational efficiency (a characteristic of a business' IPP) is the primary performance driver (Hannigan, Hamilton III and Mudambi 2015). Yet there are some physical properties without an equivalent substitute. For example, Norilsk Nickel's nickel mine in northern Siberia have higher ore content than competing Canadian and Indonesian mines (Koller, Goedhart and Wessels 2015). North American Class I railroads have cost advantages and efficiencies for bulk commodities compared to aircraft and truckers. Additionally, impossible-to-replicate rail networks and huge startup costs are barriers to entry for potential competitors and allow the existing railroads to be quite profitable (Young 2021).

Valuing the Tangible Property

Valuing a business is exceedingly difficult and

> *[a] careful review of finance theory as applied to corporate value shows that there is no generally agreed upon method for identifying and isolating intangible value from the enterprise unit value. … Markets typically do not distinguish between tangible and intangible value. Value is based on expected future earnings. In principle it would be possible to value tangible and intangible assets separately if the cash flows associated with each type of asset could be isolated. In practice it is impractical if not impossible to so isolate the income streams. (Walters, Pinegar and Schallheim 1997).*

Madhani says "Businesses have not clearly defined the best approach to valuing intangible assets" (2012).

> *Perhaps surprisingly, mainstream economic theory has almost completely failed to come to grips with the role of intangibles, including the intuition and skills of top management, in creating value … Indeed, figuring out the foundations, at a deep level, of enterprise-generated cash flow continues to be one of the greatest conundrums in economic and financial theory (Teece 2015).*

In that context, attempting to value only the tangible property of companies seems like a Sisyphusian task. How do you separate the values of tangible and intangible, taxable and exempt properties when you're appraising complex properties such as factories and utility companies where you have a mix of real, personal, and intangible property? Blair and Wallman suggest: "Because one cannot see, or touch, or weigh intangibles, one cannot measure them directly but must instead rely on proxies, or indirect measures to say something about their impact on some other variable that can be measured" (2001).

Most college finance courses teach the discounted cash flow (DCF) model as the preferred valuation method for cash flow-generating assets. The DCF model relies on the time value of money theory that a dollar received in the future is less valuable than a dollar received today. Some advantages of the DCF model are its flexibility, precise and explicit assumptions, cash flow consideration over the investment's entire economic life, and intrinsic value estimate. Disadvantages of the DCF are that it requires a lot of financial data, it requires model input forecasts of revenue, expense, capital expenditures, cash flows, and the discount rate that affect the model's output accuracy. Additionally, the DCF valuation estimates are sensitive to the discount rate, which can only be inferred, and

> *[n]one of the standard finance models provide estimates that describe the actual data very well. The discount rate that you use in your valuation has a large impact on the result, yet you will rarely feel very confident that the rate you have assumed in the right one. The best we can hope for is a good understanding of what the cost of capital represents and some ballpark range for what a reasonable estimate might be (Lundholm and Sloan 2007).*

Fortunately, the DCF model can be replaced or supplemented with the much simpler, algebraically equivalent, market multiple model.

The single-stage DCF key value driver formula has been called “the “Tao of corporate finance” because it relates a company’s value to the fundamental drivers of economic value: growth, ROIC, and the cost of capital. You might go so far as to say that this formula represents all there is to valuation. Everything else is mere detail” (Koller, Dobbs and Huyett 2011). With the formula, it is possible to show that return on invested capital (ROIC) and growth determine the enterprise value (EV) to invested capital multiple.

Enterprise value is defined as the total company value (the market values of common equity, preferred equity, and debt). This definition aligns with the enterprise DCF model, which is the cash flow available to all investors from operations discounted at the weighted average cost of capital (WACC) plus cash and other non-operating assets (Canessa and Jarrell 2022).

The key value driver formula is:

$$V = \frac{NOPLAT(1 - \frac{g}{ROIC})}{k - g}$$

where:

EV is the enterprise value;
NOPLAT is net operating profit less adjusted taxes;
ROIC is return on invested capital;
k is the weighted average cost of capital (WACC); and
g is the growth rate.

Substitute invested capital x ROIC for NOPLAT and the formula becomes

$$EV = \frac{Invested\ Capital \times ROIC\ (1 - \frac{g}{ROIC}}{k - g}$$

Divide both sides by Invested capital and the formula becomes

$$\frac{EV}{Invested\ Capital} = \frac{ROIC\ (1 - \frac{g}{ROIC}}{k - g}$$

Simplify the right side of the equation

$$\frac{EV}{Invested\ Capital} = \frac{ROIC - g}{k - g}$$

This equation shows that the EVIC multiple is the implied ROIC to WACC spread (technically ratio). This spread is important because a company only creates value when ROIC is greater than its WACC. Additionally, only if ROIC exceeds WACC will growth create value. If ROIC is less than WACC growth reduces a company’s value. Higher ROICs are always better than lower ones. Values increase with any ROIC improvements at any growth level.

Define the multiple as

$$\frac{EV}{Invested\ Capital} = \frac{ROIC - g}{k - g}$$

Rearrange the equation to estimate Enterprise Value using the multiple

$$EV = Invested\ Capital\ \times EVIC$$

Consistently Defining the EVIC multiple

Multiples are a relative valuation technique where the subject property is valued based on the prices paid for similar properties. A multiple is simply dividing what you are paying for the property by what you are getting in return. This means that terms need to be consistently defined by the analyst. Numerators and denominators must both refer to either the firm or equity value. For example, a price-earnings ratio is consistently defined because both price and earnings are measured on a per share basis. However, a price to sales ratio mismatches an equity measure with a firm measure. Analysts may define and compute multiples very differently even though they use the same name, for example, PE ratio. The current price is typically used in the numerator, while the denominator may be the last financial year (current PE), last 4 quarters (trailing PE), or next financial year (forward PE).

- For purposes of this analysis, I define enterprise value as:

  Market value of common equity
  + Market value of preferred stock
  + Market value of debt
  + Market value operating leases
  = Enterprise Value

  ○ Operating lease value is estimated as $value = \frac{Rental\ Expense}{\left(k_d + \frac{1}{Asset\ Life}\right)}$, where k_d is the AA-rated yield (Koller, Goedhart and Wessels 2015).

  ○ While many texts and practitioners recommend deducting excess cash from the enterprise value and invested capital estimates, however, Canessa and Jarrell (2022) make a compelling argument that this practice is incorrect. They show that according to the symmetry principle, cash should be included as a non-operating asset when computing total asset value. Cornell et al (2021) say that cash can be used to "pay for new investments and can, therefore, be thought of as part of invested capital." Therefore, no excess cash adjustment is made.

- The data needed to estimate a publicly traded company's enterprise value is freely available using the company's website investor relations section, the U.S. Securities and Exchange Commission EDGAR database, or investor websites like Yahoo! Finance and Morningstar.com. Here I use Alaska Airlines as an example of how I estimate its enterprise value on January 1, 2022.

Table 1.

Category	Computation (in millions)	Data Sources	Comment
Market value of common equity	$52.10 * 125.91 = 6,559.70	Yahoo! Finance, 10-K balance sheet	Adjusted closing price and common shares outstanding.
+ Market value of preferred stock	$0	Yahoo! Finance, 10-K balance sheet	Alaska has issued no preferred stock.
+ Market value of debt	$366 + 1,919 + 738 = $3,023	10-K balance sheet, Fair Value Measurement notes to the financial statements.	Current portion of debt, fair value of long-term fixed rate debt, and variable rate notes. The fair value of debt is the market price investors would be willing to buy a company's debt for, which differs from the book value on the balance sheet. Alaska's book value of its debt is $2,539.
+ Market value operating leases	$254 ÷ (.043 + (394 ÷ 6,138)) = $2,369.62	10-K income statement, aircraft lessor bond yield to maturities (alternatively use AA-rated yields)	To estimate the asset value, the formula is the rental expense ÷ (cost of debt + (depreciation ÷ net PP&E)) (Koller, Goedhart and Wessels, 438).
= Enterprise Value	**$11,952.32**		

Invested Capital represents the capital necessary to operate a company's core business. There are two approaches to estimating invested capital: the financing approach which begins with the book value of debt and equity; and the asset approach. The approaches provide similar results except when there are minority holdings on the balance sheet and long-term debt-equivalents, such as unfunded pension benefits, on the balance sheet. As with enterprise value, various texts (Damodaran (2007), Mauboussin and Callahan (2014), Koller (2015)) define invested capital slightly differently. For this analysis, I define invested capital as:

+ Current Assets
- Non-interest bearing current liabilities
+ Fixed Assets
= Invested Capital

Fixed assets include net PP&E, operating lease right-to-use assets, and identified intangible assets. Cash is included in current assets for symmetry with the enterprise value definition. Goodwill is excluded from the invested capital estimate. Koller (2015) points out that excluding goodwill allows for comparisons unaffected by acquisition price premiums. Secondly, my regression analysis indicates that accounting goodwill is not a significant input of enterprise value.

Here I use Alaska Airlines as an example of how I estimate its invested capital on January 1, 2022.

Table 2.

Category	Computation (in millions)	Data Sources	Comment
Current assets	**3,920**	10-K balance sheet	
Non-interest bearing current liabilities			A non-interest bearing current liability is an item in a corporate balance sheet that reflects short-term expenses and debts that are not accruing interest. Examples include accounts payable, accrued salaries and wages, unpaid taxes not accruing penalties or interest, and current income taxes.
Accounts payable	200	10-K balance sheet	
Accrued wages, vacation, and payroll taxes	457	10-K balance sheet	
Air traffic liability	1,163	10-K balance sheet	
Other accrued liabilities	625	10-K balance sheet	
Deferred revenue	912	10-K balance sheet	
Total non-interest bearing current liabilities	**3,357**		
Operating working capital	563		Current assets less non-interest bearing liabilities
Net PP&E	6,138	10-K balance sheet	Aircraft and other flight equipment, buildings and land improvements, capitalized leases and leasehold improvements, computer hardware and software, other furniture, and equipment.
Operating lease assets	1,453	10-K balance sheet	This is PP&E, primarily aircraft, that the airline chooses to rent rather than own.
Other intangibles	101	10-K balance sheet	The 10-K balance sheet lists $2,044 in goodwill and other intangible assets and doesn't separate the two types. In prior years, However, in prior years Alaska identified goodwill value of $1,943. Deducting this goodwill value from the balance sheet amount results in $101 attributable to other intangible assets, consisting primarily of indefinite-lived airport slots, finite-lived airport gates and finite-lived customer relationships.
Other long-term assets	0	10-K balance sheet	The airline has no investments in minority interests, discontinued operations assets held for sale, or tax assets that generate operating profit and value.
Total invested capital	**$8,255**		

Is Invested Capital Correlated with Enterprise Value?

As an exploratory procedure, backward stepwise regression analysis was performed to determine which invested capital inputs should be good predictors of enterprise value in the airline, electric utility, gas distribution, pipeline, railroad, wired telecom, and wireless telecom industries. The stepwise approach is useful for this exploration because it reduces the number of predictors, reducing the multicollinearity problem and it is one of the ways to resolve overfitting. This iterative approach begins with a regression performed on a model full of potential explanatory variables. At each step, the least significant independent variable is removed. The iterative process stops when all variables have p-values less than 0.05 or no variables are left in the model. The result is a model with the fewest number of independent variables that best correlate with enterprise value.

Enterprise value is defined as the dependent variable. From the balance sheet, working capital, net PP&E, operating leased property, goodwill, other intangibles, other long-term assets, and equity method investments were identified as potential independent continuous variables. Industry group, airline, electric utility, gas distribution, pipeline, railroad, wired telecom, and wireless telecom were identified as potential dummy variables.

In the final regression model net PP&E, operating lease property, other intangibles, and membership in the railroad and telecom industries were all significant at the 0.05 significance level. The inputs have an adjusted R-square of 0.947, indicating that these input categories are highly correlated with enterprise value. This result is consistent with Lie and Lie (2002) who found that for nonfinancial companies of all sizes the enterprise value to book value multiple provided the most accurate valuations. Table 3 displays the multiple regression results.

Table 3.

SUMMARY OUTPUT								
Regression Statistics								
Multiple R	0.975197641							
R Square	0.951010439							
Adjusted R Square	0.947354502							
Standard Error	22483.65289							
Observations	73							
ANOVA								
	df	*SS*	*MS*	*F*	*Significance F*			
Regression	5	6.57492E+11	1.31498E+11	260.1276627	1.88142E-42			
Residual	67	33869481362	505514647.2					
Total	72	6.91361E+11						
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2139.410197	4180.423765	0.511768739	0.610495573	-6204.750561	10483.57096	-6204.750561	10483.57096
Net PP&E	1.28003163	0.11944563	10.71643751	3.60767E-16	1.041617155	1.518446106	1.041617155	1.518446106
Leased Property	3.07225855	0.839214466	3.660874154	0.000496766	1.397179464	4.747337636	1.397179464	4.747337636
Other intangibles	1.337290962	0.117334573	11.39724577	2.45976E-17	1.103090175	1.57149175	1.103090175	1.57149175
Railroad	58054.69033	10700.09103	5.425625836	8.56852E-07	36697.21925	79412.16142	36697.21925	79412.16142
Telecom	19618.73762	8823.077285	2.223570869	0.029553344	2007.801656	37229.67359	2007.801656	37229.67359

Using the EVIC Multiple

In general, multiples are the relationship between market value and a statistic that is assumed to relate to that value, in this case, invested capital. Multiples focus on key information that investors use to make decisions and are useful because they provide a framework to make value judgments. They are simple to calculate and may help the analyst "avoid the potentially misleading precision of other, more 'precise' approaches such as discounted cash flow (DCF) valuation" (Souzzo, et al. 2001).

Damodaran makes the points that,

It may seem obvious that making a model more complete and complex should yield better valuations; but it is not necessarily so. As models become more complex, the number of inputs needed to value a firm tends to increase, bringing with it the potential for input errors. These problems are compounded when models become so complex that they become "black boxes" where analysts feed in numbers at one end and valuations emerge from the other. All too often when a valuation fails, the blame gets attached to the model rather than the analyst. The refrain becomes "It was not my fault. The model did it." There are three important points on all valuation. The first is the principle of parsimony, which essentially states that you do not use more inputs than you absolutely need to value an asset. The second is that there is a trade-off between the additional benefits of building in more detail and the estimation costs (and error) with providing the detail. The third is that the models don't value companies—you do. In a world where the problem that we often face in valuations is not too little information but too much, separating the information that matters from the information that does not is almost as important as the valuation models and techniques that you use to value a firm (Damodaran 2002, 4-5).

Damodaran continues:

[*A] valuation based on a multiple and comparable firms can be completed with far fewer explicit assumptions and far more quickly than a discounted cash flow valuation. Second, a relative valuation is simpler to understand and easier to present to clients and customers than a discounted cash flow valuation. Finally, a relative valuation is much more likely to reflect the current mood of the market, ... In fact, relative valuations will generally yield values that are closer to the market price than discounted cash flow valuations* (2002, 453-454).

The EVIC multiple "is a useful measure for sectors where tangible assets are key. Because of its close linkage to return on capital, it is useful to view this measure together with return on capital" (Souzzo, et al. 2001). Damodaran (2022) compiles average EVIC multiple and ROIC data by industry. In the U.S. from 2011 – 2021 the average correlation between the two measures was 0.711, meaning that as ROIC increases, the EVIC multiple also increases. In a comparative study to determine which multiples perform best, Lie and Lie (2002) found that for nonfinancial companies of all sizes the enterprise value to book value multiple provided the most accurate valuations. Spitznagel (2011) says this multiple:

separate[es] the wheat from the chaff, whenever $\frac{Value}{IC}$ *is high it simply and precisely means that implied ROIC exceeds WACC, and this is really all we need to know. Significantly, we are left with an unarguably robust valuation metric that requires no forecasts or assessments of the slippery inputs to DCF models. We avoid the need to predict the unpredictable.*

Applying the Multiple in a Property Tax Context

"The basic idea behind using multiples for valuation is that similar assets should sell for similar prices, whether they are houses or shares of stock" (Koller, Goedhart and Wessels 2015). The law of one price states that, in a nearly perfect market, two identical goods must have nearly identical prices. In other words, similar assets sell for similar prices, whether it is a house or a share of stock (Cornell 1993). Consistent with the assumption that the same or similar tangible property is available to all competitors and that tangible property does not provide sustainable competitive advantages or disadvantages, I assume that the tangible property earns at the same rates in companies within an industry. If this assumption is true, multiplying the benchmark sector multiple by the basis of the multiple (the denominator) of the target company, may be considered a sound estimation approach. This assumption means that excess profits are correlated to IPP of undefined origin, e.g., internally generated goodwill. This is consistent with the Black's Law Dictionary and I.R.S. Tax Court definitions that there is a normal level of expected earnings and goodwill is the excess earning power of a business. The corollary is that a profit shortfall is correlated with negative goodwill. If a business purchase occurs in this circumstance, under current accounting rules, the purchaser is required to record the difference between the fair value of the acquired net assets and the purchase price as a gain on its income statement due to negative goodwill.

Because value is driven by expected cash flows discounted at a cost of capital, Koller (2015) emphasizes that companies have two primary value creation drivers to focus on, ROIC and growth. Companies with high ROICs use their assets more efficiently and generating more profit and cash flow than their lower ROIC peers. This implies that high ROIC companies should have a greater proportion of their enterprise value allocated to IPP than lower ROIC companies.

To estimate enterprise value for a subject company, the steps are to estimate the multiple (harmonic mean (Agrrawal, et al. 2010)) from the subject company's industry peers, then multiply by the subject company's invested capital by the multiple. When the goal is to value only the tangible property, net property, plant, and equipment (including right-to-use assets) are substituted for invested capital.

Multiples were estimated and applied to the airline, electric utility, gas distribution, pipeline, railroad, telecom, and wireless telecom industries for the year ending December 2021. Table 4 summarizes the results by industry. The multiples range from 1.06 to 2.47 and imply that the market expects these industries' ROICs will exceed their WACC and create value. The R2 measure indicates that from 41.4 percent to 96.7 percent of the industries' IPP value is explained by this simple model.

Table 4.

Industry	EVIC ex Goodwill Multiple	R^2: Invested Capital Multiple and IPP
Airline	1.11	0.414
Electric Utility	1.21	0.746
Gas Distribution	1.28	0.807
Pipeline	1.50	0.614
Railroad	2.47	0.898
Telecom	1.43	0.699
Wireless Telecom	1.06	0.967

Figures 2-22 are grouped by industry and show the EVIC multiple distributions, PP&E cost, PP&E value, and enterprise value compare, and that as the multiple increases the percentage of value attributable to the company's IPP also increases.

Conclusions

The IPP exemption in many states is a difficult problem for appraisers conducting unitary valuation to apply with many ad hoc solutions attempted. This paper examines the importance of defining the problem to be solved. Only after words, terms, and models are defined can an attempt to measure and explain the results be made consistently and accurately. For property tax purposes it is important to understand the overlap between property, characteristics, and assets. This paper takes a broad view of what constitutes IPP. It also takes a broad view of synergies when estimating the taxable properties' value.

The paper explores which types of invested capital are correlated with enterprise value via regression analysis and the exploratory analysis indicates that booked goodwill is not significantly correlated with a firm's enterprise value. As an alternative to booked goodwill, this paper offers an alternative, intuitive, explanation: that unidentified IPP, e.g., internally generated goodwill, is correlated with excess value. Consistent with that explanation is that negative internally generated goodwill is correlated with inferior value.

This article proposes and demonstrates a simple and transparent valuation model, the EVIC multiple, to estimate taxable property's value. The model is most useful for sectors and properties that have a combination of real, personal, and intangible personal property where tangible assets are a key value driver. The multiple's algebraic equivalence to the DCF method is demonstrated. The model's advantages, observable data, simplicity, and transparency, while avoiding unmeasurable or unobservable "slippery inputs" is discussed. Empirical data demonstrates that the EVIC multiple is positively correlated with ROIC. The model values tangible property according to the law of one price and IPP values are correlated with the firm's expected profitability. Examples from several industries demonstrate valuation accuracy and consistency across taxpayers.

Charts by Industry

Airlines

Figure 2.

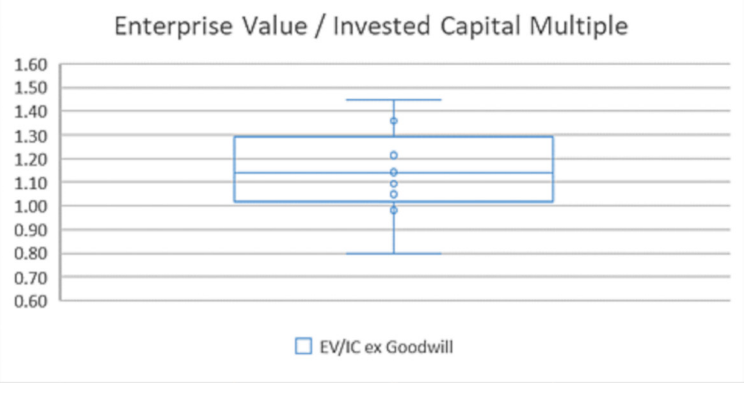


Figure 3.

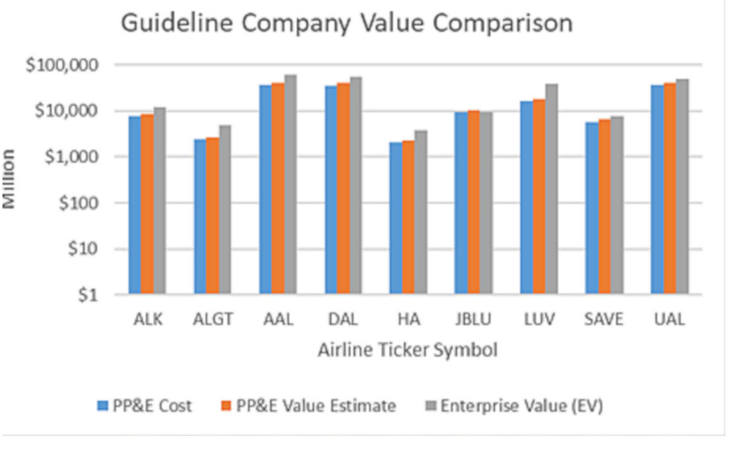
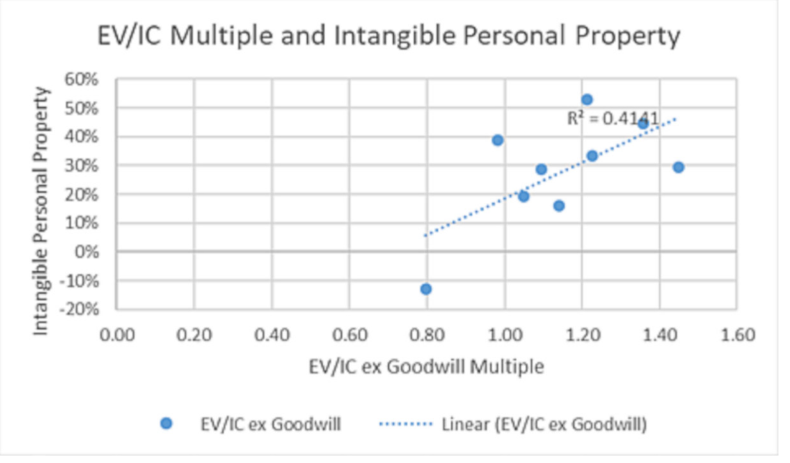


Figure 4.



Electric Utilities

Figure 5.

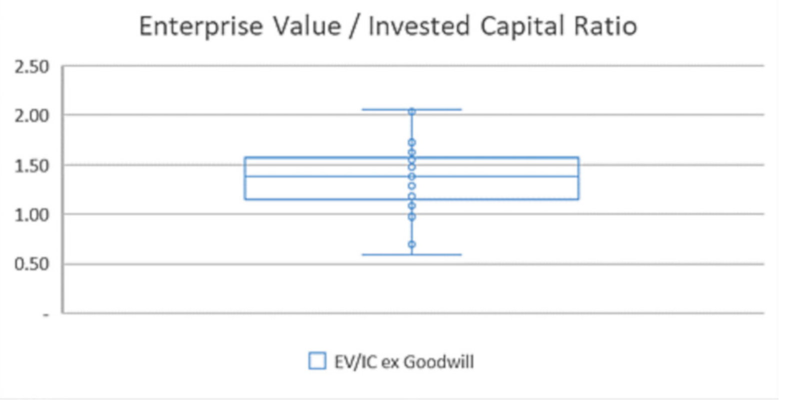


Figure 6.

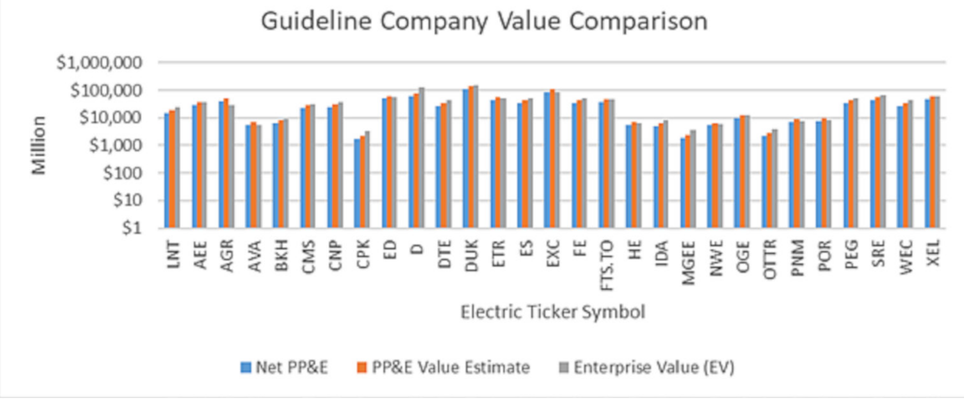
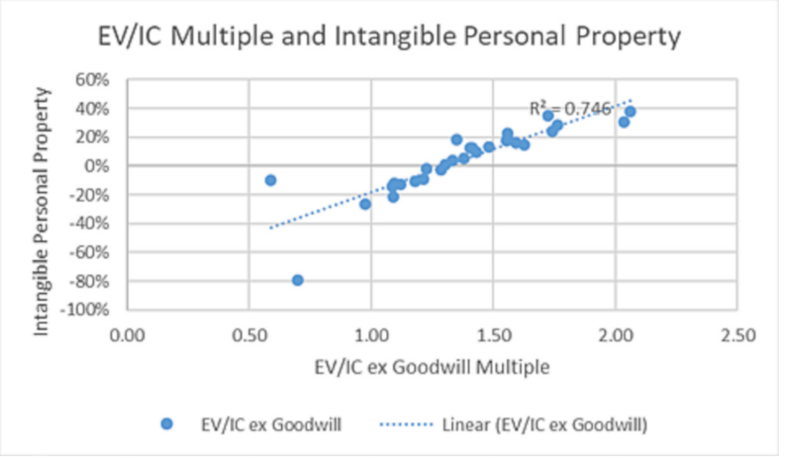
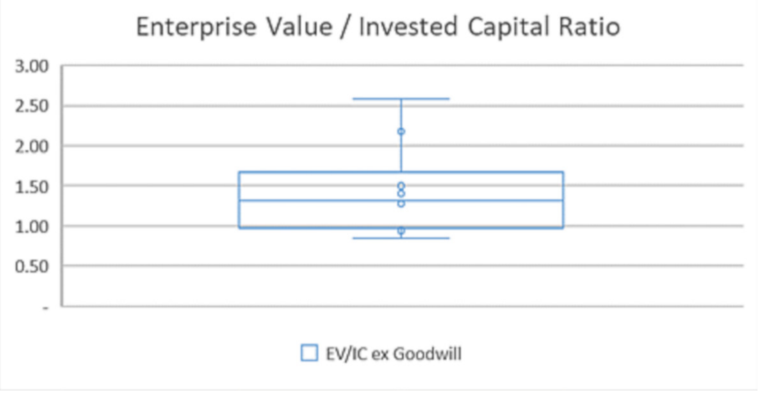


Figure 7.



Gas Distribution

Figure 8.



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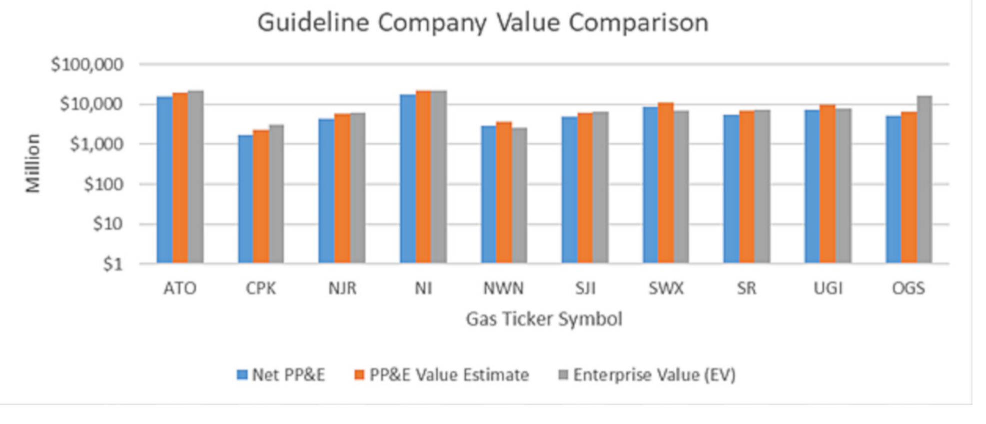

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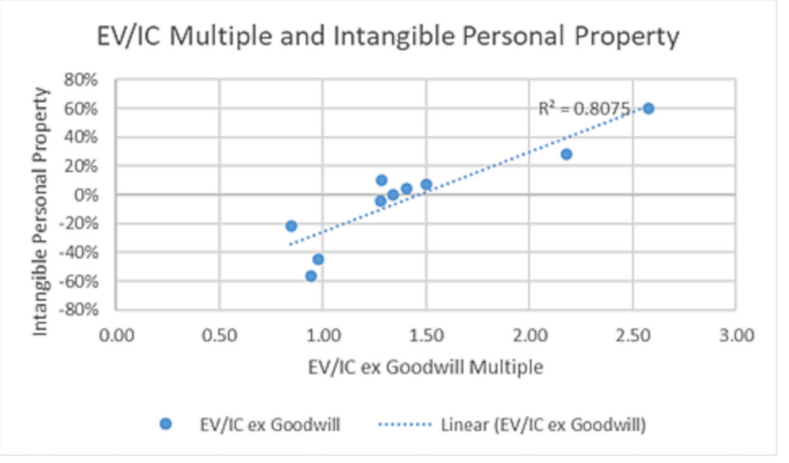
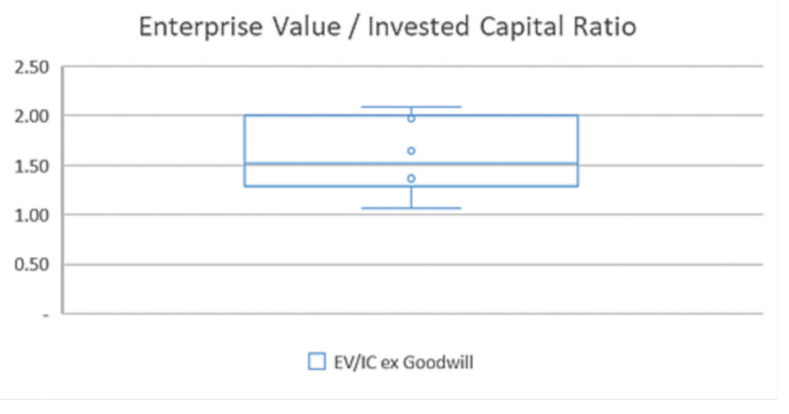


Pipeline

Figure 11.



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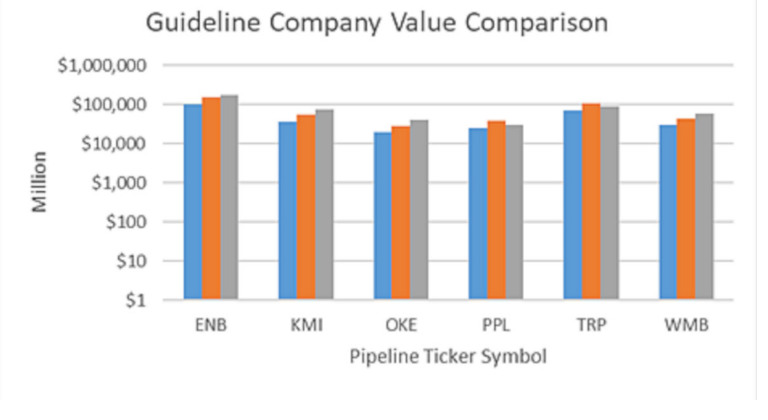
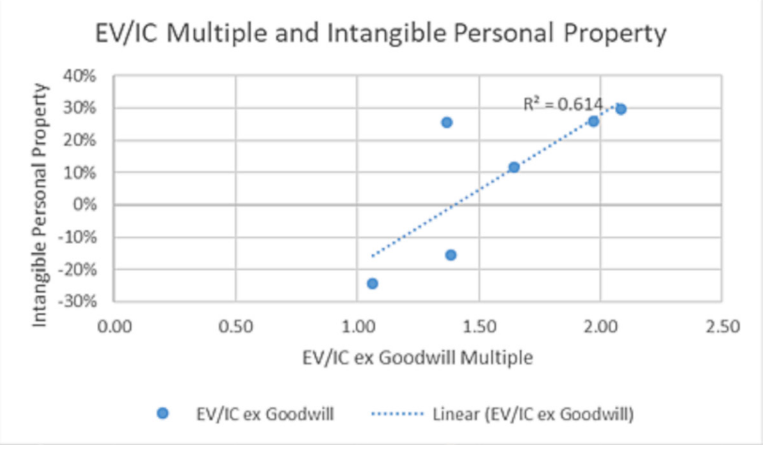
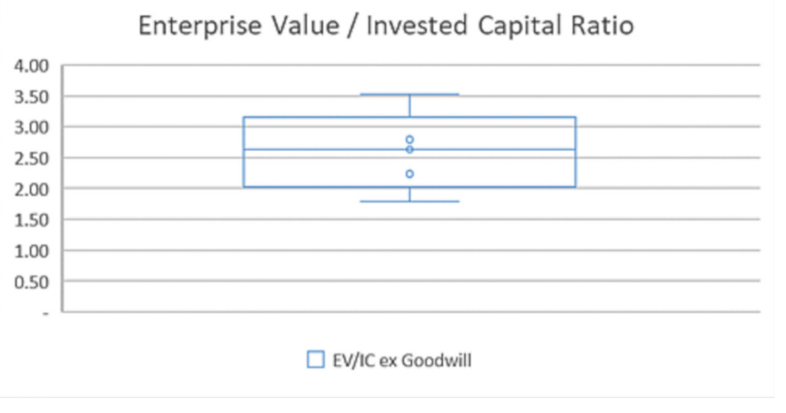


Figure 13.



Railroad

Figure 14.



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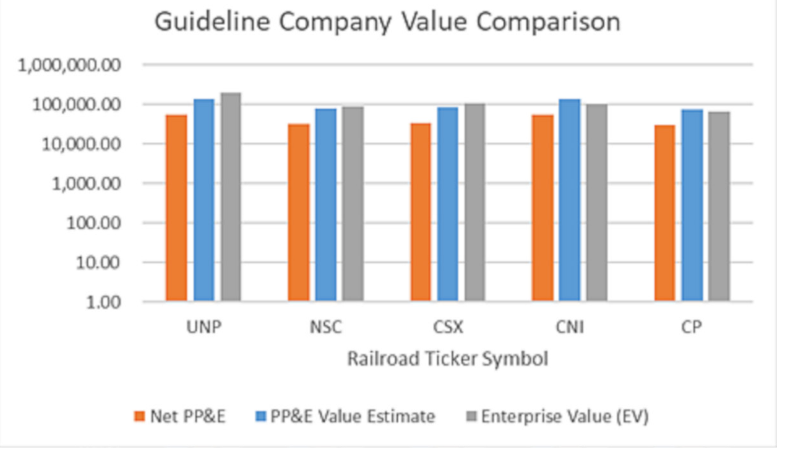
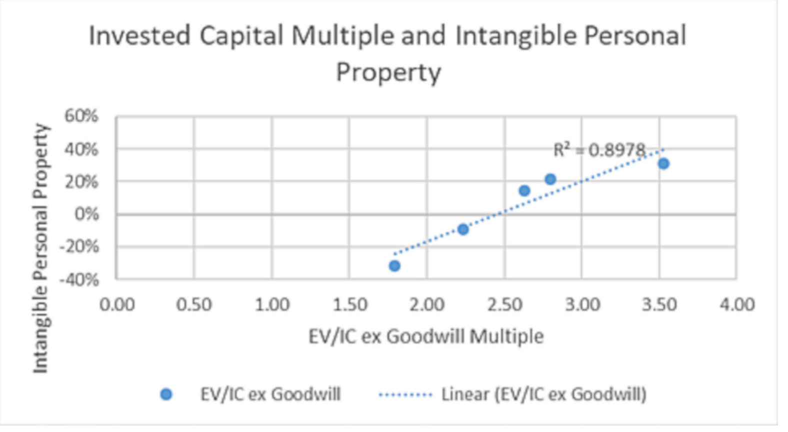
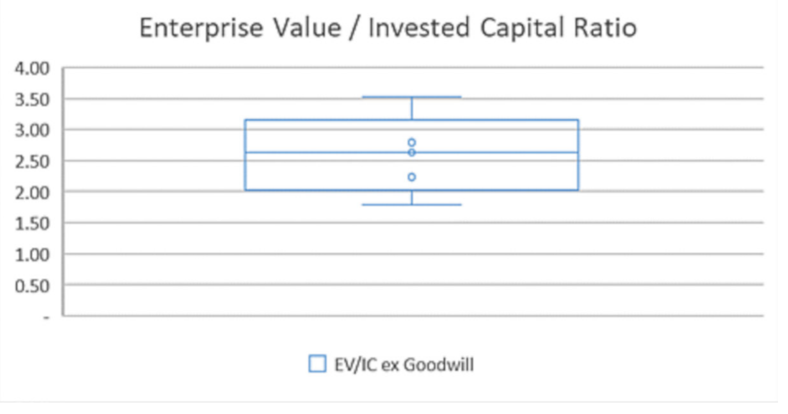


Figure 16.



Telecom

Figure 17.



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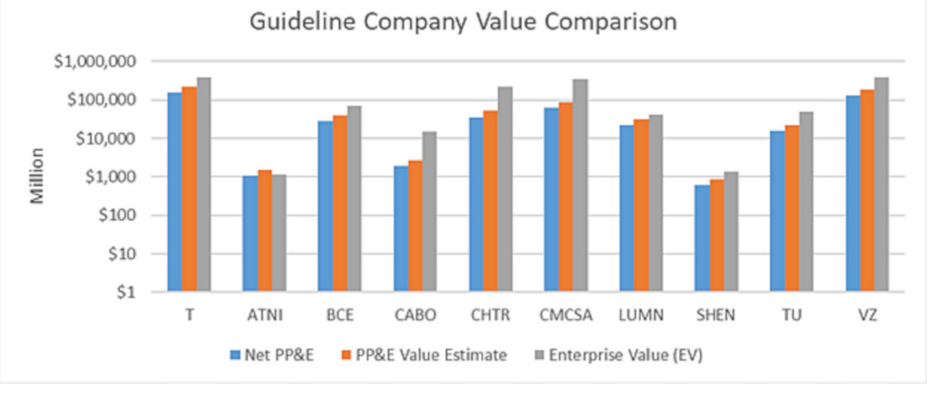

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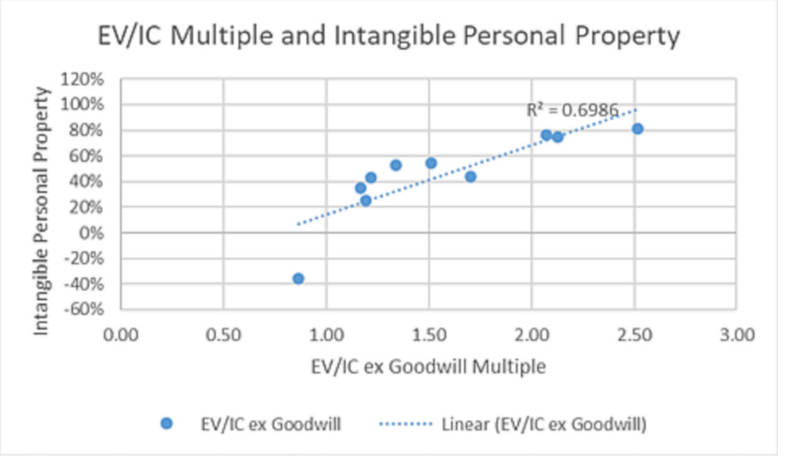
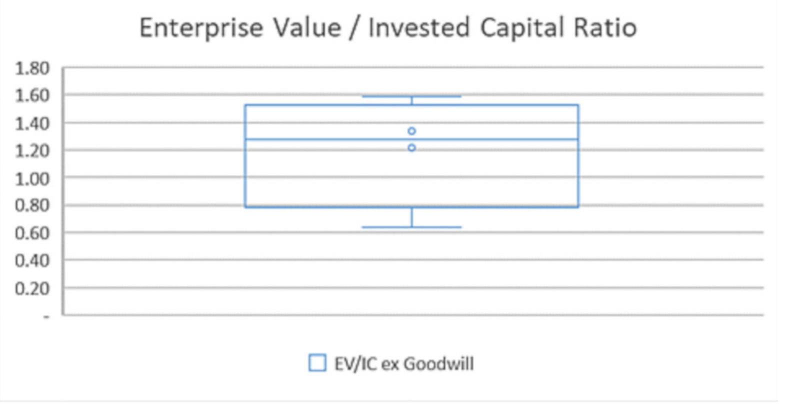


Wireless

Figure 20.



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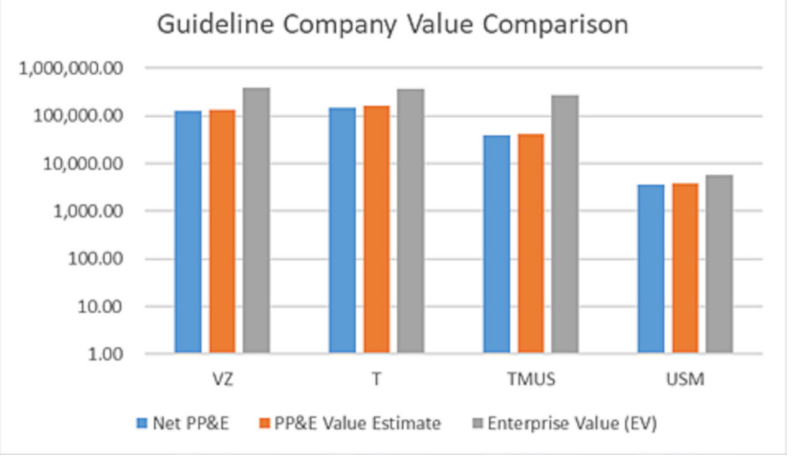

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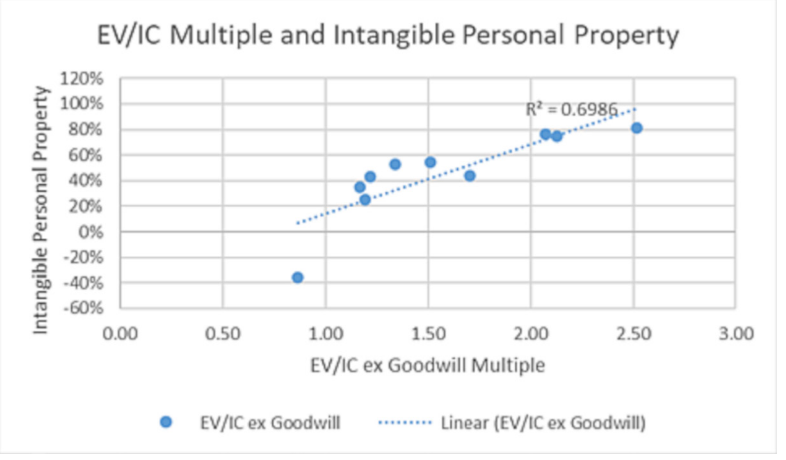

References

Agrrawal, Pankaj, Richard Borgman, John M. Clark, and Robert Strong. 2010. "Using the Price-to-Earnings Harmonic Mean to Improve Firm Valuation Estimates." *Journal of Financial Education* 98-110.

Asher, Cheryl Carleton, James M. Mahoney, and Joseph T. Mahoney. 2005. "Towards a Property Rights Foundation for a Stakeholder Theory of the Firm." *Journal of Management and Governance* 5-32.

Barney, Jay. 1991. "Firm Resources and Sustained Competitive Advantage." *Journal of Management* 99-120.

Blair, Margaret M., and Steven M. H. Wallman. 2001. *Unseen Wealth: Report of the Brookings Task Force on Intangibles.* Washington, D.C.: Brookings Institution Press.

Canessa, James L., and Gregg A. Jarrell. 2022. "The Proper Treatment of Cash Holdings in DCF Valuation Theory and Practice [Unpublished manuscript]."

Contractor, Farok J. 2001. "Intangible Assets and Principles for their Valuation." In *Valuation of Intangible Assets in Global Operations*, by Farok J. Contractor, 3-24. Westport: Quorum Books.

Cornell, Bradford. 1993. *Corporate Valuation: Tools for Effective Appraisal and Decision Making.* Burr Ridge: Irwin Professional Publishing.

Cornell, Bradford, Shaun Cornell, and Andrew Cornell. 2021. "Valuing the Automotive Industry." *Cornell-Capital.com.* November 22. https://www.cornell-capital.com/blog/2021/11/valuing-the-automotive-industry.html.

CS First Boston. 2021. "Plus Ça Change, Plus C'est Pareil: The More Things Change, the More They Stay the Same." *Mayur Jain: Thoughts on Investing.* 11 30. https://mjbaldbard.files.wordpress.com/2020/09/michael-mauboussin-e28093-research-articles-and-interviews-1995-2004.pdf.

Damodaran, Aswath. 2002. *Investment Valuation: Tools and Techniques for Determining the Value of Any Asset.* New York: John Wiley & Sons, Inc.

—. 2022. "Price and Value to Book Ratios and ROE by Industry Sector." *Damodaran Online.* January 5. https://pages.stern.nyu.edu/~adamodar/New_Home_Page/data.html.

—. 2007. "Return on Capital (ROC), Return on Invested Capital (ROIC) and Return on Equity (ROE): Measurement and Implications." *SSRN.com.* July. https://ssrn.com/abstract=1105499 or https://dx.doi.org/10.2139/ssrn.1105499.

—. 2013. *The Little Book of Valuation.* Hoboken: Wiley.

Garner, Bryan A., and Henry Campbell Black. 2019. *Black's Law Dictionary.* St. Paul: Thomson/West.

Hannigan, T. J., Robert D. Hamilton III, and Ram Mudambi. 2015. "Competition and competitiveness in the US airline industry." *Competitiveness Review* 134-155.

Harvey, Campbell R. 2021. "Be Skeptical of Asset Management Research." *SSRN.com.* August 16. https://ssrn.com/abstract=3906277.

IAAO Special Committee on Intangibles. 2017. "Understanding Intangible Assets and Real Estate: A Guide for Real Property Valuation Professionals." *IAAO.org.* January 6. https://www.google.com/url?client=internal-element-cse&cx=014250748049018362712:lgfwxspg9mi&q=https://www.iaao.org/library/2017_Intangibles_web.pdf&sa=U&ved=2ahUKEwjW3eXHl7jyAhVjLH0KHSolADYQFjAAegQIAhAB&usg=AOvVaw0bsqUNffJvc8tpcxfHv7us.

Johnson, Jeannie D., and Michael G. Tearney. 1993. "Goodwill - An Eternal Controversy." *The CPA Journal* 58.

Johnson, L. T., and K. R. Peterone. 1998. "Is goodwill an asset?" *Accounting Horizons* 293-303.

Kelvin, Lord. 1883. “Lecture to the Institution of Civil Engineers.” *Oxford Essential Quotations.* Edited by Susan Ratcliffe. May 3. Accessed October 24, 2022. https://www.oxfordreference.com/view/10.1093/acref/9780191826719.001.0001/q-oro-ed4-00006236?rskey=ITvfEr&result=2067.

Koller, Tim, Marc Goedhart, and David Wessels. 2015. *Valuation: Measuring and Managing the Value of Companies, Sixth Edition.* Hoboken: John Wiley & Sons, Inc.

Koller, Tim, Richard Dobbs, and Bill Huyett. 2011. *Value: The Four Cornerstones of Corporate Finance.* Hoboken: John Wiley & Sons, Inc.

Larrabee, David T, and Jason A. Voss. 2013. *Valuation Techniques: Discounted Cash Flow, Earnings Quality, Measures of Value Added, and Real Options.* Hoboken: John Wiley & Sons, Inc.

Lev, Baruch, and Juergen H. Daum. 2004. “The Dominance of intangible assets: consequences for enterprise management and corporate reporting.” *Measuring Business Excellence* 6-17.

Lie, Erik, and Heidi J. Lie. 2002. “Multiples Used to Estimate Corporate Value.” *Financial Analysts Journal* 1-11.

Lundholm, Russell J., and Richard G Sloan. 2007. *Equity Valuation and Analysis, 2nd ed.* Boston: McGraw-Hill Irwin.

Madhani, Pankaj M. 2012. “Intangible Assets: Value Drivers for Competitive Advantage.” In *Best Practices in Management Accounting*, by Greg N. Gregoriou and Nigel Finch, 147-164. UK: Palgrave Macmillan.

Mauboussin, Michael J., and Dan Callahan. 2014. “Calculating Return on Invested Capital: How to Determine ROIC and Address Common Issues.” *credit-suisse.com.* June 14. https://research-doc.credit-suisse.com/docView?language=ENG&format=PDF&sourceid=csplusresearchcp&document_id=806230540&serialid=dBve3cH%2BHSFm1zoXnWVgkwZUHD2g0c1RqyUyHTE3o%2BM%3D&cspId=null.

Paugam, Luc, Hervé Stolowy, and Jean-François Casta. 2011. “An explanation of the nature of internally generated goodwill based on.” *International Conference of the French Finance Association.* http://ssrn.com/abstract=1833624.

Penman, Stephen H. 2009. “Accounting for Intangible Assets: There is also an Income Statement.” *Abacus* 358-371.

Pinto, Jerald E., Elaine Henry, Thomas R. Robinson, and John D. Stowe. 2010. *Equity Asset Valuation.* Hoboken: John Wiley & Sons, Inc.

Powell, K.E. 2020. “Identifying Exempt Intangible Assets in State Property Tax: Urging Stricter Application of Burden of Proof.” *Cornell Journal of Law and Public Policy* 235-277.

Smith, Edward J. 2022. “15 Mertens Law of Federal Income Taxation.” Chap. 59, §59:64. Eagan, MN: Westlaw. Accessed October 25, 2022.

Souzzo, Peter, Stephen Cooper, Gillian Sutherland, and Zhen Deng. 2001. “Valuation Multiples: A Primer.” *UBS Warburg: Valuation and Accounting* 1: 1-47. http://www.rgquintero.com/media/91f679831d8e9521ffff80e8ffffe906.pdf.

Spitznagel, Mark. 2011. “The Dao of Corporate Finance, Q Ratios, and Stock Market Crashes.” *Universa Working White Paper.* June 13. https://lionscrestadvisors.com/uploads/3/4/1/8/34182934/spitznagel_-_the_dao_of_investing_7.pdf.

Teece, David J. 2015. “Intangible Assets and a Theory of Heterogeneous Firms.” In *Intangibles, Market Failure and Innovation Performance*, by Ahmed Bounfour and Tsutomu (Eds.) Miyagawa, 217-240. New York: Springer. doi:https://dx.doi.org/10.2139/ssrn.2844864.

The Appraisal Foundation. 2020. “Uniform Standards of Professional Appraisal Practice.” *Uniform Standards of Professional Appraisal Practice (USPAP).* Washington, DC: The Appraisal Foundation.

Walters, Lawrence C., J. Michael Pinegar, and James S. Schallheim. 1997. *A Review of Centrally Assessed Property Tax Issues in Utah.* Salt Lake City: Utah Office of Legislative Research and General Counsel.

Western States Association of Tax Administrators, Committee on Centrally Assessed Properties. 2009. “Appraisal Handbook: Unit Valuation of Centrally Assessed Properties.”

Young, Matthew. 2021. “Morningstar Equity Analyst Report: Union Pacific Corp.” *Morningstar.com.* December 21. https://www.morningstar.com/stocks/xnys/unp/quote.

Zhang, Mei. 2013. “The Impact Of Internally Generated Goodwill on Financial Performance of Firms.” *The Journal of Applied Business Research* 1809-1814.

Aircraft Opportunity Costs and Estimating Airline Intangible Returns

BY SCOTT SAMPSON

Abstract

A difficulty that assessment officials, lenders, and valuation analysts face with complex properties is disentangling the income streams, risks, and values associated with the multiple types of assets in use. A hole in the existing research literature is that measurement error caused by tangible property resource rent appropriation has not been corrected and the incremental cash flows attributable to the intangible assets have not been isolated leading to an incomplete understanding of the intangible assets' cash flow volume and volatility.

This study directly estimates intangible assets' cost of capital and expected returns for the domestic airline industry. Using Monte Carlo simulations the study reveals that four of the 10 airlines are unlikely to produce positive returns on their intangible assets in the long run. Five of the airlines have expected returns on their intangible assets that exceed their intangibles cost of capital and create value.

The study has implications for assessors and lenders of complex properties. For assessors, the study's findings suggest the need to consider the impact of resource holders' rent appropriation when assessing taxable property value. More nuanced valuation approaches that explicitly model expected cash flows, returns, and values associated with intangible assets as a residual may be required. For lenders, the findings indicate that rent appropriation skews profitability ratios and cash flows. Some borrowers may have intangible assets that are unlikely to generate positive returns in the long run. This information could be relevant when evaluating the creditworthiness of borrowers and assessing the risk associated with lending to them.

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The views expressed in this paper are those of the author and do not reflect the views of the state of Washington or the Washington State Department of Revenue.

Literature Review

A fundamental difficulty separating income streams associated with tangible and intangible assets and resources is that "… profit confounds rent generation with rent appropriation [the share of rent that a stakeholder can claim], however, it is a poor indicator of total rent in the nexus. Indeed, most performance measures focus on the residual that accrues to shareholders and ignores other rent" (Coff 1999). "Fundamentally, economic rents accrue to resource owners, not to the resources themselves (Coff, 1999). Thus, firms do not necessarily appropriate economic rents from value-creating resources, rather owners of those value-creating resources appropriate economic rents" (Kim and Mahoney 2007). The airline business owns, rents, and uses a wide variety of tangible and intangible properties, assets, and resources. "[F]irm resources include all assets, capabilities, organizational processes, firm attributes, information, knowledge, etc. controlled by a firm that enable the firm to conceive of and implement strategies that improve its efficiency and effectiveness (Daft 1983), (Barney 1991). In other words, the aircraft resource doesn't get paid, the aircraft resource owner, the lessor or the airline, gets paid. And the airline only gets paid for owning the aircraft in the form of residual profits, after the other stakeholders have appropriated their share of economic rent. To disentangle the value of the tangible assets from the intangible assets and resources requires "… examining rents at the factor [resource] level, rather than the firm level" (Coff 1999).

Intangibles are given different labels by different groups, for example; goodwill assets by accountants, knowledge assets by economists, and intellectual capital in management and legal literature. These labels all mean essentially the same thing – a non-physical claim to future benefits. However they are defined, intangible assets are the main source of sustainable competitive advantage. While intangibles are critical to a firms future success, the tools to identify, manage, and measure them are poor or non-existent. The inability to identify, measure, and value intangibles is a serious problem for managers and investors. For managers a key reason to measure intangibles is to assess performance drivers of intangibles and to assist them in making better strategic decisions. For investors there is a gap between what companies disclose and what matters for valuation, the gap between a firm's book and market values. The value of intangibles is dependent on a firm's ability to transform the intangible asset into financial returns. Indirect measures to measure intangibles are return on assets ratio (ROA) comparison and market to book ratio comparison (Madhani 2012).

While the income, market, and cost methods all may be used to value intangibles, in practice the market and cost methods are difficult to apply in practice, leaving the income approach as the most viable. After identifying the asset and its expected future cash flows an appropriate discount rate must be selected (Madhani 2012), (Wirtz 2012). "Because one cannot see, touch, or weigh intangibles, one cannot measure them directly but must instead rely on proxies, or indirect measures to say something about their impact on some other variable that can be measured" (Blair and Wallman 2001). Cornell et al explore "…conceptual issues related to growth options and intangible capital" using Alphabet (Google's parent) as an example. Three items that "can have a large impact on measures of profitability" need disentangling: 1) book and market value differences; 2) tangible assets on the balance sheet (capitalized), while internally generated intangibles aren't (expensed); 3) assets in place and the residual growth options. If a firm has valuable growth options, while another doesn't, the difference is presumably related to some type of intangible capital that is difficult to identify and measure (Cornell, Cornell and Cornell, The Role of Growth Options and Intangible Assets in Valuation: The Case of Alphabet 2018).

A Tobin's Q ratio significantly greater than one signifies an unmeasured value source that may be attributed to intangible value of a firm's investments (Bharadwaj, Bharadwaj and Konsynski 1999). For airlines, a Tobin's Q ratio greater than one may be an indication of intangible assets, such as routes and slots, that aren't captured in an airlines financial statements (Malighetti, et al.

2011). Oum, Zhang and Li explored European, American, and East Asian airlines Tobin's Q ratio with an "analysis of the relationship between accounting indicators and operational and economic factors." Their analysis found a weak Q ratio correlation with EBITDA margin. They also suggest a low Tobin's Q ratio, often less than one for the airlines, reflecting a high level of risk (2004).

With knowledge of the firm's enterprise value and weighted average cost of capital (WACC), much like allocating debt and equity invested capital in the capital structure, it is possible to allocate the WACC and income attributable to various asset classes, such as tangible and intangible assets, by considering their relative weights and risks (Parr 2018), (Pratt and Grabowski 2008). The WACC allocation to asset classes within the company is commonly known as the weighted average return on assets (WARA). "This analysis breaks apart each asset class and assigns a rate of return applicable to each, then weights the rates according to the percent of value that each class occupies and averages these weighted returns. … In general, intangible assets (i.e., goodwill and brand value) required returns are the highest because of the inability to attract debt capital and high volatility while tangible assets tend to be lower because of the ability to attract debt capital and more stable earnings" (Pratt and Grabowski 2008). Stegink, Schauten, and de Graaff compare the WARA method with three suggested risk proxies: the WACC, unlevered cost of capital, and levered cost of equity, and find that the levered cost of equity is the best proxy for the intangible assets cost of capital (2010). Building on Stegink et al, Crane finds that "[t]here is no real statistical relationship of the weighting of the intangibles within the industries" (2019).

Accounting principles dictate that for a resource to be an asset it must be well defined, distinct, the firm must have control of it, and it must be possible to predict the asset's future economic benefit (Blair and Wallman 2001). Zhang examined the link between a firm's internally generated goodwill and financial performance using several financial ratios and found that firms with positive internally generated goodwill had better liquidity, profitability, and leverage ratios (Zhang 2013). Vance compared the return on assets (ROA) of internally generated and booked goodwill and found that generally goodwill is a "rent generating asset." However, "the return on booked goodwill was less than that of other assets for several industries." Vance also notes that other research methods might estimate the goodwill returns better (Vance 2008). A gap in the research is that these empirical studies haven't isolated the incremental cash flow attributable to the intangible assets and measurement error caused by the use of book value for tangible property. Nor has expected returns on airlines' intangible assets been estimated.

In the airlines' process of creating value, various resource owners, such as employees, management, fuel suppliers, manufacturers, lessors, and airports, debt and equity holders appropriate (capture) rent for their contribution. (IATA 2013). The domestic airline industry is homogenous along price, quality and passenger load factor characteristics. They share common resources such as aircraft, fuel, and labor are commodities that are fungible (interchangeable) and minimally customizable. Competitors are quickly able to imitate innovations, such as American Airlines loyalty program and computerized reservation system, and there are not sustainable competitive advantages. Consequently, operational efficiency is the primary performance driver (Hannigan, Hamilton III and Mudambi 2015).

Kim and Mahoney point out that "Fundamentally, economic rents accrue to resource owners, not to the resources themselves (Coff 1999). Thus, firms do not necessarily appropriate economic rents from value-creating resources, rather owners of those value-creating resources appropriate economic rents" (2007). In other words, the aircraft resource does not get paid, the aircraft resource owner, the lessor or the equity holder, gets paid. The equity holder is paid for owning the aircraft in the form of residual profits, after the other stakeholders have appropriated their share of economic rent. The opportunity cost of aircraft ownership is embedded in the airlines' operating and net income." Lustosa opines "Opportunity cost is the value of a resource in its best alternative use, as defined by Coase (1938). Since it is anchored in the market, it represents the genuine economic value of each of the assets acquired or generated internally by the company, and of the liabilities constituted … The opportunity cost of an in-use asset is the lowest price the company would pay in the market to obtain the same services (utilities) generated by the asset being used. On the other hand, the rent that the company would pay in the market to value the physical asset, such as equipment, land, buildings, occurs over a future time. The expectation of future benefits embeds an expectation of inflation, and so the real flows of payments would have to be discounted by a real interest rate since market rates are nominal and also incorporate expected inflation. In addition, the discount rate for the assets would have to be that of raising money in the market, since the opportunity for the area responsible for the capital that is incorporated in an asset for use is to borrow this resource in the market" (2017).

A fundamental principle of corporate finance is that companies create value by investing capital to generate future cash flows at rates of return that exceed their cost of capital. Industries and firms with sustainable competitive advantages (SCA) tend to have higher returns on capital than their competitors without SCAs (Koller, Goedhart and Wessels 2010). A firm has a competitive advantage when it implements a value creating strategy not simultaneously implemented by current competitors or potential competitors. A SCA occurs when current or potential competitors are unable to duplicate the benefits of the strategy. Four aspects of a competitive advantage or SCA are that the firm's resources are rare, imperfectly imitable, causally ambiguous (i.e. not easily understood), socially complex, and without a strategically equivalent substitute (VRIN). Complex physical technology isn't a source of sustainable competitive advantage because other firms should be able to purchase these tools (Barney 1991). An implicit or explicit assumption of sustained competitive advantage is evidenced by "above average" accounting or economic performance over a long time period. However, Coff showed that stakeholders may appropriate income, which masks superior performance and SCA (García-Castro and Ariño 2011). Rent appropriation by shareholders is clearly seen in the operating profit margin changes when the opportunity cost of aircraft ownership is accounted for.

Modeling Intangible Cash Flows

The multi-period excess earnings method isolates the cash flows attributable to the intangible assets by deducting the contributory asset charges (rents) for all other assets from the unit's cash flows (Wirtz 2012), (Appraisal Practices Board 2016). Tangible property rents are estimated using the equilibrium rent formula (McConnell and Schallheim 1983), (Sampson 2020).

$$L_{it} = [R_f + \beta_{it}\,[\overline{R_m} - R_f] + \overline{d_{it}} + [P_{it} \div A_{it}]\,]\,A_{it}$$

where L_{it} is the equilibrium rental payment for the use of asset i over t. A_{it} is the beginning-of-period market value of asset i, R_f, is the current risk-free rate; $\overline{R_m}$ is the expected rate of return on the market portfolio; $\overline{d_{it}}$ the expected rate of economic depreciation of asset i during period t.

It is important to note that the expected depreciation rate is negatively correlated with an asset's remaining useful life. In other words, the expected depreciation rate increases as an asset ages and remaining useful life decreases. For example, the expected depreciation rate is 10%/year for an asset with a 10-year remaining useful life, the expected depreciation rate is 20% per year for an asset with a 5-year remaining useful life.

$$\beta_{it} = \text{cov}(\overline{d_{it}}, \overline{R_{mt}}/\text{var}(\overline{R_{mt}})$$

is the standard capital asset pricing measure of the relative non-diversifiable risk of asset i in period t. And P_{it} is the lessee's embedded put option, i.e. the cancellation option. The residual value risk is modeled using the dividend modified Black-Scholes model to estimate the cost of an American put option (Hamill, Sternberg and White 2006). Residual value risk is related to volatility, a key input in the Black-Scholes model. Black-Scholes model inputs are the spot price of the asset (S), the strike price, equal to the spot price less depreciation (X), the time to the end of the lease (t), the interest rate (r), dividend yield (δ) as modeled by depreciation, and volatility (σ) (Sampson 2020).

Profitability ratios measure a firm's ability to generate profits from revenue and assets. The operating profit margin ratio indicates how much profit a company makes after paying for variable costs of production such as wages, raw materials, etc. It is also expressed as a percentage of sales and then shows the efficiency of a company controlling the costs and expenses associated with business operations. Thus the operating profit margin is indicative of how well a firm is managed. Ratio analysis is useful to forecast future potential payoffs an investor might expect.

Table 1 shows the summary statistics for the 10 domestic airlines reported operating profit margin defined as operating income divided by revenue from 2008- 2017. All of the airlines have positive operating profit margins. Spirit (2012 is the first full year with data as a publicly traded company) is the most profitable followed by Allegiant and Alaska airlines. American, United, and SkyWest are the least profitable airlines.

Table 1.

Year: 2008 - 2017	Min	Max	Mean	Std. Dev.	Rank
Alaska Air Group, Inc.	(0.1299)	0.1529	0.0555	0.0904	3
Allegiant Travel Co	0.0483	0.2042	0.1038	0.0518	2
American Airlines Group	(0.1420)	0.0895	(0.0207)	0.0851	10
Delta Air Lines, Inc.	(0.1320)	0.1777	0.0316	0.0953	7
Hawaiian Holdings, Inc.	(0.0336)	0.1324	0.0574	0.0513	5
JetBlue Airways Corp.	(0.0930)	0.1044	0.0057	0.0621	4
SkyWest, Inc.	(0.1597)	0.0179	(0.0371)	0.0505	8
Southwest Airlines Co.	(0.0609)	0.1352	0.0245	0.0727	6
Spirit Airlines	0.0863	0.2014	0.1529	0.0402	1
United Continental Holding, Inc.	(0.1392)	0.0840	(0.0031)	0.0645	9

However, when looking at financial statements and ratios, trends in the data, whether they are improving or deteriorating, are as important as the current absolute or relative levels. Trend analysis provides important information regarding historical performance and growth and, given a sufficiently long history of accurate seasonal information, can be of great assistance as a planning and forecasting tool for management and analysts. Figure 1 shows the reported operating margin for the 10 domestic airlines from 2008-2017. The beginning of this time period includes the Great Recession that lasted from December 2007 to June 2009. During the Great Recession operating profit margins were suppressed with several companies posting negative margins. In 2008 the average margin was 0.0054. The recovery period brought improved passenger yields and lower fuel costs that helped margins peak in 2015 at 0.1731. However, embedded in these results are the rents avoided and attributable to the owned aircraft and other property.

Figure 1. Operating Profit Margin 2008-2017

The cost of ownership formula for a machine is:

$$C_{it} = [E\,(R_{it}\,) + \mathrm{E}(d_{it}\,)]\,A_{it}$$

where $E\,(R_{it})$ is the expected return, $E(d_{it})$ is the expected depreciation, and A_{it} is the investment cost. This is the risk equivalent opportunity cost plus the expected rate of depreciation. (Miller and Upton 1976).

Because the income statement already deducts depreciation, I subtract depreciation from each side of the equation and the formula for adjusted cost of ownership becomes:

$$E(R_{it}\,) = \frac{C_{it}}{A_{it}} - E(d_{it}\,)$$

Thus we see that the income statement includes the opportunity cost of the expected return on the owned resource. Because the airlines equity holders own the aircraft resource they are appropriating its rent.

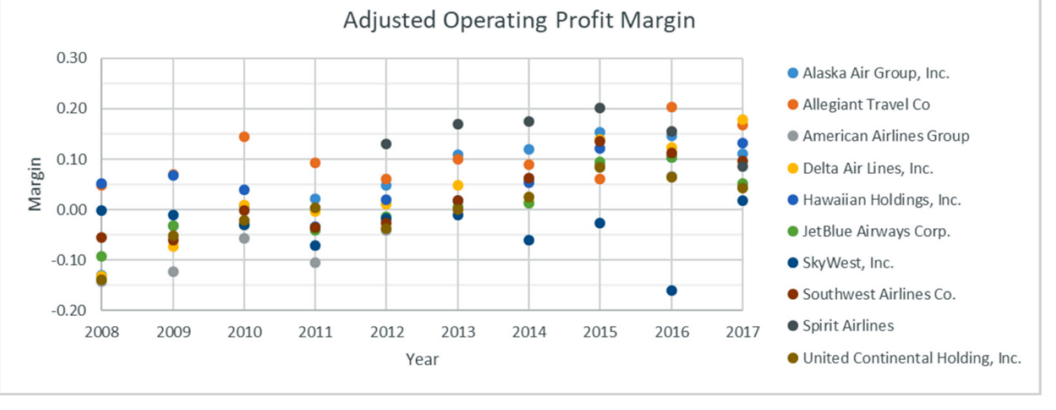
When income statement is adjusted for this hidden rent appropriation we get a better picture of the airlines actual performance and their ability to convert tangible resources into profit as seen in table 2. The adjusted gross profit margins (adjusted operating income divided by revenue) drop an average of 0.0738 to 0.0204. The 0.0738 drop are the aircraft opportunity cost rents that the shareholders are appropriating. The adjusted operating profit margin gives a much better picture of how well the airline business is performing. Four of the 10 airlines have negative adjusted operating profit margins. Spirit, and Allegiant remain at the top of the profitability rankings and American, SkyWest, and United remain the least profitable airlines.

Table 2. Adjusted Operating Profit Margin

Year: 2008 - 2017	Min	Max	Mean	Std. Dev.	Rank
Alaska Air Group, Inc.	(0.1299)	0.1529	0.0555	0.0904	4
Allegiant Travel Co	0.0483	0.2042	0.1038	0.0518	2
American Airlines Group	(0.1420)	0.0895	(0.0207)	0.0851	10
Delta Air Lines, Inc.	(0.1320)	0.1777	0.0316	0.0953	5
Hawaiian Holdings, Inc.	(0.0336)	0.1324	0.0574	0.0513	3
JetBlue Airways Corp.	(0.0930)	0.1044	0.0057	0.0621	7
SkyWest, Inc.	(0.1597)	0.0179	(0.0371)	0.0505	9
Southwest Airlines Co.	(0.0609)	0.1352	0.0245	0.0727	6
Spirit Airlines	0.0863	0.2014	0.1529	0.0402	1
United Continental Holding, Inc.	(0.1392)	0.0840	(0.0031)	0.0645	8

Figure 2 shows the adjusted operating profit margin for the 10 domestic airlines from 2008 – 2017. In 2008, at the beginning of the recession, the average adjusted margin was -0.0659. At the height of the recovery in 2015, adjusted operating profit margins peaked at 0.1051. From the chart it is apparent that often the airline business operations contribute negatively to the firm's profitability.

Figure 2. Operating Profit Margin 2008-2017



Aircraft Portfolio Valuation

Just as the income statement is adjusted for the opportunity cost of aircraft ownership, the airlines' enterprise value needs to be adjusted for the aircraft values. Subtracting the aircraft market values from the enterprise value results in the airlines' market value for all intangible assets. A market value estimate for the airlines' aircraft portfolio is needed for the calculation.

Forsberg argues that the industry's "…standard appraisals do not take into consideration any value enhancement, or decrement, deriving from an associated lease structure which generates cash flows and an income stream for the aircraft owner" even though over 90% of traded aircraft are leased (2016). Gorjidooz and Vasigh argue that academic research has not focused much on valuing commercial aircraft. They believe that aircraft valuation is complex, dependent both on aircraft physical characteristics and exogenous market conditions. They "employ a modified Discounted Cash Flow (DCF) model…" and "… conclude that the discounted cash flow model provides the best estimate of aircraft value." Their model includes many complex revenue and expense estimates and assumptions that are aircraft specific such as block hours, revenue per passenger mile, fuel cost per gallon, gallons of fuel consumed, maintenance expenses, and etcetera. While their model's theoretical values are 2.6 and 21.6 percent less than list prices, they recognize that the purchase price is a function of buyers' and sellers' bargaining power and market equilibrium (2010). Raghavan argues that there is insufficient research on modeling lessor cash flows and returns. He develops a net present value model with key inputs of purchase price, lease rates, maintenance reserves, residual values, and transactions costs (2017). If the inputs required to develop these DCF models are unavailable, then a simpler valuation model is required.

The value of an individual or portfolio of leased assets stems from its cash flow, which mirrors the price the market is willing to pay for their use (Grenadier 2003). While about 54% of commercial aircraft are owner-used, market rents represent an opportunity cost of owning the aircraft. The cost of ownership formula for machine, C_{it}, is $C_{it} = [E(R_{it}) + E(d_{it})]\, A_{it}$ where A_{it} is the investment cost. This is the risk equivalent opportunity cost plus the expected rate of depreciation. (Miller and Upton 1976). The equilibrium rent formula is $L_{it} = [R_f + \beta_{it}\,[\overline{R}_m - R_f] + \overline{d}_{it} + [P_{it} \div A_{it}]\,]\, A_{it}$

The value of an asset or portfolio with an indefinite life is using the cash flow perpetuity formula is:

$$V = \frac{FCF_{t=1}}{(WACC - g)}$$

Assuming that the aircraft lessor refreshes their portfolio with new aircraft to replace depreciated, retired, or sold aircraft a perpetual valuation formula may be used to estimate the portfolio's value. When the market is in equilibrium the economic-profit key value driver formula may be used to estimate value (Koller, Goedhart and Wessels 2010), (Cornell, Corporate valuation: tools for effective appraisal and decision making 1993). A key input in the perpetuity formula is the selected growth rate, which Damodaran argues should not exceed the riskless rate used in the valuation (2011). The formula links value to what drives free cash flow: growth, ROIC, and the cost of capital. The key value driver formula is:

$$V = \frac{NOPLAT_{t=1} \times (1 - \frac{g}{RONIC})}{(WACC - g)}$$

where: V = value;
$NOPLAT_{t=1}$ = net operating profit less adjusted taxes in year 1;
g = growth in NOPLAT;
$RONIC$ = Return on new invested capital, and;
$WACC$ = weighted average cost of capital.

"NOPLAT is the after-tax profit generated from core operations, excluding any gains from non-operating assets or financing expenses, such as interest." For a net-lease leased aircraft portfolio, NOPLAT, is the rents less depreciation, selling, general and administrative expenses (SG&A), and operating income taxes.

$$NOPLAT = (L_{it} - d_{it} - SG\&A_{it}) \times (1 - T_o)$$

where: L = lease income;
d = depreciation;
$SG\&A$ = selling, general, and administrative expenses, and;
T_o = operating income tax rate.

The general equation for Return on Invested Capital (ROIC) is

$$ROIC = \frac{NOPLAT}{IC}$$

Where: IC = invested capital

Substituting the expanded equation for *NOPLAT* the *ROIC* equation becomes:

$$ROIC = \frac{(L_{it} - d_{it} - SG\&A_{it}) \times (1 - T_o)}{IC}$$

Decomposing the terms into individual ratios transforms the *ROIC* equation to:

$$ROIC = \left(\frac{L_{it}}{IC}\ \frac{d_{it}}{IC}\ \ \frac{SG\&A_{it}}{IC} \right) \times (1 - T_o)$$

Because the lease payment includes a depreciation component the expected return on invested capital is:

$$\frac{k_{it}}{IC} = \left(\frac{L_{it}}{IC} - \frac{d_{it}}{IC} \right)$$

Substituting the expected return into ROIC formula simplifies it to:

$$ROIC = \left(\frac{k_{it}}{IC} - \frac{SG\&A_{it}}{IC} \right) \times (1 - T_o)$$

A ratio is an indicator of some aspect of a company's performance, reduces economy of scale effects, and improves comparison between companies and across time (Robinson, et al. 2009). Isolating each term as a ratio shows the relationship between the ROIC and the individual terms. The decomposition of ROIC can also be useful in forecasting ROIC based upon expected changes in lease, depreciation, SG&A, and operating tax rates.

The aircraft lessors SG&A expense averaged slightly more than 1 percent of net book value (M= 0.0113, SD= 0.0033), operating tax expense averaged slightly more than 9 percent of net book value (M= 0.0927, SD= 0.1804) from 2013 through 2017) and ROIC averaged slightly less than 6 percent (M= 0.0592, SD= 0.0190).

Substituting the mean values for lease rates, depreciation, SG&A, and operating taxes into the ROIC formula estimates an average ROIC of 0.0587 for the period from 2013 to 2017.

$$\overline{ROIC} = \left(\frac{\overline{L_{it}}}{IC} - \frac{\overline{d_{it}}}{IC} - \frac{\overline{SG\&A_{it}}}{IC} \right) \times (1 - \overline{T_o})$$

$$= (0.1228 - 0.0468 - 0.0113) \times (1 - 0.0927) = 0.0587$$

Table 3.

Average of ROIC Nbv	Column Labels					
Row Labels	2013	2014	2015	2016	2017	Grand Total
AerCap	0.0591	0.1051	0.0860	0.0828	0.0836	0.0833
Air Lease Corp	0.0609	0.0567	0.0633	0.0636	0.0637	0.0617
Aircastle Limited	0.0469	0.0586	0.0527	0.0452	0.0494	0.0506
Aviation Capital Group LLC				0.0513	0.0278	0.0395
Avolon Holdings		0.0343		0.0738	0.1150	0.0744
BOC Aviation	0.0355	0.0504	0.0424	0.0447	0.0595	0.0465
Fly Leasing Limited	0.0667	0.0585	0.0564	0.0466	0.0623	0.0581
SMBC Aviation				0.0451	0.0478	0.0465
Grand Total	**0.0538**	**0.0606**	**0.0602**	**0.0566**	**0.0637**	**0.0592**

For 2018, the expected equilibrium return is 0.024 + 0.6577 * 0.0508 + 0.0169 = 0.0743. The expected ROIC is (0.0743– 0.0113) * (1- 0.0927) = 0.0572.

"By definition, invested capital times return on invested capital (ROIC) equals NOPLAT at time 1. Thus, we replace NOPLAT with invested capital times ROIC."

$$V = \frac{Invested\ Capital_{t=0} \times ROIC \times (1 - \frac{g}{RONIC})}{(WACC - g)}$$

"If we assume that the return on new invested capital (RONIC) equals the return on existing invested capital (ROIC), we can simplify the preceding equation by distributing ROIC in the numerator:

$$V = Invested\ Capital_{t=0} \times \left(\frac{ROIC - g}{WACC - g}\right)$$

(Koller, Goedhart and Wessels 2010).

By definition the expected ROIC is a function of expected NOPLAT. Implicit in the analysis is the assumption that depreciation, SG&A, and operating tax ratios follow a random walk process and revert to their means. When holding these rates constant, we see that the expected lease rate is positively correlated with the expected ROIC.

$$[E]\ ROIC = \left(\frac{[E]\ L_{it}}{IC} - \frac{\overline{d_{it}}}{IC} - \frac{\overline{SG\&A_{it}}}{IC}\right) \times (1 - \overline{T_o})$$

Collateral, Capital Structure, and Debt Rate

Aircraft lessors and airlines use a variety of debt tools to finance their equipment. There are three basic tools to finance equipment: leases, bank debt, and secured bonds. The rates associated with these tools are based on the borrower's creditworthiness, ability to pay, and collateral quality. Rampini and Viswanathan argue that tangible assets are a "key determinant of leverage" and that firms with a low percentages of tangible assets also have low percentages of debt (2013). Campello and Giambona (2013), analyze the effects of different components of tangible assets on leverage. They show that it is not only the tangibility of assets that increases the use of leverage, but also the ease with which tangible assets can be sold.

The Financial Industry Regulatory Authority (FINRA) TRACE (Trade Reporting and Compliance Engine) database captures and report transactions in eligible fixed income securities by registered broker-dealers to FINRA. A review of 38 aircraft leasing company bonds that traded in December 2017 had an average yield to maturity of 3.23% and a remaining term of 4.5 years, with an average issued term of 7.4 years. In the case of Air Lease Corporation, their capital structure and financing strategy has four targets: debt to equity ratio of 2.5:1; an 80/20 fixed to floating debt ratio; a 90/10 unsecured to secured debt ratio; and a balanced debt maturity profile (Air Lease Corporation 2017).

Airlines and aircraft lessors often use secured debt in the form of Enhanced Equipment Trust Certificates (EETC) using the aircraft as collateral to raise capital. Analysis of 96 EETC tranches issued between 2013 and 2018 reveals that higher rated tranches have lower loan to value (LTV) ratios and longer maturity terms than lower rated tranches (AircraftInvestor.com 2018). The average LTV is 61.7% with a maturity of 6.3 years (table 4).

Table 4.

Credit Rating	LTV	Maturity
AAA-	38.6%	9.1
AA	42.8%	9.0
AA-	49.5%	7.4
A+	58.0%	6.6
A	53.7%	7.3
A-	58.1%	5.9
BBB+	65.4%	5.7
BBB	69.7%	4.9
BBB-	69.7%	5.8
BB+	86.0%	2.8
BB	82.2%	5.1
BB-	83.0%	5.0
B-	93.0%	2.1
Average	**61.7%**	**6.3**

In Gavazza analysis of the leasing and secondary markets in 2010, he chose to use "… the yield of BAA corporate bonds because the average spread of the BAA corporate bond yield over the Treasury bond yield during our sample period is close to the average spread of the yield of aircraft-backed Securities, Equipment Trust Certificates (ETC) and Enhanced Equipment Trust Certificates (EETC) over the Treasury bond yield. More precisely, the spread of the BAA bond yield over the average between the 10-year Treasury bond yield and the 20-year Treasury Bond yield in our sample is equal to 198 basis points, while the spread of ETC and EETC over the corresponding treasury yields is 194 in the sample of Benmelech and Bergman (2009). All results where [sic] unchanged when using Moody's Seasoned AAA Corporate Bond Yield instead" (2010).

As of January 1, 2018, the Moody's Seasoned Baa corporate bond yield was 3.90%, whereas the ICE BofAML US Corporate BBB Index effective yield was 3.59% (Federal Reserve Bank of St. Louis 2018). Bloomberg reports that the equivalent S&P BBB December 2017 bonds with 7-year maturities had an average yield of 3.626 percent. In this analysis, the S&P BBB 7-year maturity rate is chosen as the most indicative of the lessor's marginal debt cost.

A complete discussion of the various company and country specific debt and tax influences is beyond the scope of this paper. The tax system of the countries where a multinational firm operates influences where the firm places its debt. In general, interest expenses are income tax deductible and firms incorporate those differences into their optimal debt policy. Also, international taxation affects leverage to a small extent. (Huizinga, Laeven and Nicodème 2007). With that disclaimer in place, the US 2018 statutory rate of 21 percent is used to estimate the debt shield influence.

Cost of Equity

Like the equilibrium rent model, CAPM is used to estimate the lessors' cost of equity. For the CAPM formula components, the risk free rate, is estimated from the 10-year treasury constant maturity rate (Board of Governors of the Federal Reserve System 2018). Damodaran's implied free cash flow from equity risk premium, estimate is used (2018). For the non-diversifiable risk, the unlevered beta coefficient,is used to eliminate the effect of financial leverage on risk. Schallheim et al., suggest that the asset users, the U.S. airline industry, is a reasonable proxy for this beta estimate (1987). Damodaran estimates firm beta is annually by industry (Damodaran 2018).

As of January 1, 2018, the estimated unlevered cost of equity K_{eu} is 0.0574.

R_f	0.0240
β_u	0.6577
ERP	0.0508
K_{eu}	0.0574

The Hamada (1972) formula is used to estimate the levered beta:

$$\beta_L = \beta_u\,[1 + (1 - T)\,(\frac{D}{E})\,]$$

Where:

β_L = Levered beta
β_U = Unlevered beta
T =Tax rate
D/E = Debt to equity ratio

Assuming a tax rate of 0.21 and a debt to equity ratio of 0.70/0.30, the levered beta is 1.8701. The levered cost of equity is 0.024+ (1.8701 X 0.0508) = 0.1190. The weighted average cost of capital is:

$$0.30 \text{ X } 0.1190 + 0.70 \text{ X } 0.0363 \text{ X } (1\text{-}0.21) = 0.0558.$$

The 2018 equilibrium value of a leased aircraft portfolio, assuming growth at the risk free rate, becomes:

$$V = Invested\ Capital_{t=0} \times \left(\frac{ROIC - g}{WACC - g}\right) = IC \times \left(\frac{0.0572 - 0.024}{0.0558 - 0.024}\right) = IC \times 1.0436$$

At the beginning of 2018 the value a portfolio of commercial aircraft is approximately 104 percent of its net book value.

The vast majority of an airlines plant, property and equipment is invested in aircraft. For example, in 2017, Delta Airlines refinery accounts for only 2.5%, 1.6%, and 3.1% of Delta's total assets, depreciation, and capital expenditures respectively. Assuming that investments in other property earns at the same rates as aircraft, the market values of the airlines' tangible property are shown in table 5.

Table 5.

Company	Net PP&E	Market Value Estimate
Alaska Air Group, Inc.	6,284,000,000	6,535,360,000
Allegiant Travel Co	1,512,415,000	1,572,911,600
American Airlines Group	34,156,000,000	35,522,240,000
Delta Air Lines, Inc.	26,563,000,000	27,625,520,000
Hawaiian Holdings, Inc.	1,691,611,000	1,759,275,440
JetBlue Airways Corp.	8,049,000,000	8,370,960,000
SkyWest, Inc.	4,183,003,000	4,350,323,120
Southwest Airlines Co.	18,539,000,000	19,280,560,000
Spirit Airlines	2,238,468,000	2,328,006,720
United Continental Holding, Inc.	26,208,000,000	27,256,320,000

Airlines Tangible and Intangible Property Values

Enterprise value is commonly defined as the market value of interest-bearing debt plus the market value of equity, minus excess cash. This is the market value of all the tangible and intangible assets and resources. Penman makes the point that it is the joint use of assets that produces cash flow. Intangible assets, resources, knowledge, and organizational capital work together with the tangible assets and that it is the firm itself that is the intangible asset. Positive earnings provides evidence of intangible assets, while negative earnings indicates the absence of intangible assets (2009). Intangible assets can generally be valued using the cost, market, income, or residual methods (Parr 2018). The residual method is used in this analysis.

As of January 1, 2018, the 10 publicly owned airlines had enterprise values (unadjusted for leases) as shown in table 6.

Table 6.

Company	Equity Value	Debt Value	Enterprise Value	D/E Ratio
Alaska Air Group, Inc.	9,070,189,985	2,262,000,000	11,332,189,985	0.2494
Allegiant Travel Co	2,488,056,418	950,000,000	3,438,056,418	0.3818
American Airlines Group	24,974,394,485	22,511,000,000	47,485,394,485	0.9014
Delta Air Lines, Inc.	39,592,000,000	6,592,000,000	46,184,000,000	0.1665
Hawaiian Holdings, Inc.	2,090,998,680	511,201,000	2,602,199,680	0.2445
JetBlue Airways Corp.	7,171,140,000	1,003,000,000	8,174,140,000	0.1399
SkyWest, Inc.	2,752,841,317	2,377,000,000	5,129,841,317	0.8635
Southwest Airlines Co.	38,877,300,000	3,320,000,000	42,197,300,000	0.0854
Spirit Airlines	3,111,558,450	1,387,000,000	4,498,558,450	0.4458
United Continental Holding, Inc.	19,967,414,119	11,703,000,000	31,670,414,119	0.5861

The industry's average debt rating from S&P is BB. SkyWest is not rated by S&P; however, Mergent's gives them a Caa1 rating that is equivalent to S&P's CCC+ rating. The BB effective yield is 0.0618 for this rating (Federal Reserve Bank of St. Louis 2020). Table 7 shows the S&P ratings for the airlines.

Table 7.

Company	Ticker	S&P Ratings
Alaska Air Group, Inc.	ALK	BB+
Allegiant Travel Co	ALGT	BB-
American Airlines Group	AAL	BB-
Delta Air Lines, Inc.	DAL	BBB-
Hawaiian Holdings, Inc.	HA	BB-
JetBlue Airways Corp.	JBLU	BB
SkyWest, Inc.	SKYW	-
Southwest Airlines Co.	LUV	BBB+
Spirit Airlines	SAVE	BB-
United Continental Holding, Inc.	UAL	BB-
Overall Average Debt Rating		**BB**

The industry's average debt to equity ratio is 0.4064 and the debt to value ratio is 0.2632. Using the Hamada (1972) formula to estimate the levered beta and assuming a tax rate of 0.21 and a debt to equity ratio of 0.75/0.25, the levered beta is 0.8309. The levered cost of equity is

$$0.024 + (0.8309 \text{ X } 0.0508) = 0.0662.$$

The industry's weighted average cost of capital is:

$$0.5 \text{ X } 0.0662 + 0.75 \text{ X } 0.0618 \text{ X } (1\text{-}0.21) = 0.0619.$$

Deducting the tangible property value from the enterprise value shows the firms' intangible asset value. The 10 companies' had an average intangible asset to enterprise value ratio of 0.3236. Table 8 shows that intangible assets account for nearly half of Southwest, Allegiant, and Spirit airlines enterprise value.

Table 8.

Company	Enterprise Value (EV)	Tangible Assets Value (TAV)	Intangible Assets Value (IAV)	IAV to V Ratio
Alaska Air Group, Inc.	11,332,189,985	6,535,360,000	4,796,829,985	0.4233
Allegiant Travel Co	3,438,056,418	1,572,911,600	1,865,144,818	0.5425
American Airlines Group	47,485,394,485	35,522,240,000	11,963,154,485	0.2519
Delta Air Lines, Inc.	46,184,000,000	27,625,520,000	18,558,480,000	0.4018
Hawaiian Holdings, Inc.	2,602,199,680	1,759,275,440	842,924,240	0.3239
JetBlue Airways Corp.	8,174,140,000	8,370,960,000	-196,820,000	(0.0241)
SkyWest, Inc.	5,129,841,317	4,350,323,120	779,518,197	0.1520
Southwest Airlines Co.	42,197,300,000	19,280,560,000	22,916,740,000	0.5431
Spirit Airlines	4,498,558,450	2,328,006,720	2,170,551,730	0.4825
United Continental Holding, Inc.	31,670,414,119	27,256,320,000	4,414,094,119	0.1394

The implied intangible asset discount rate is estimated by reconciling the airline and lessor WACCs and market tangible and intangible asset weights using the WARA method. The intangible asset discount rate is 0.0770. This rate is greater than the airline' levered cost of equity and consistent with Stegink et al., (2010) results. Table 9 shows the discount rates by company.

Table 9.

Company	Intangible Asset Discount Rate
Alaska Air Group, Inc.	0.0701
Allegiant Travel Co	0.0670
American Airlines Group	0.0799
Delta Air Lines, Inc.	0.0709
Hawaiian Holdings, Inc.	0.0745
JetBlue Airways Corp.	N/A
SkyWest, Inc.	0.0957
Southwest Airlines Co.	0.0670
Spirit Airlines	0.0684
United Continental Holding, Inc.	0.0993

Expected Returns on Intangible Assets

Nine of 10 airlines have positive market values ascribed to their intangible assets (table 8). Only Jet Blue has a negative intangible assets value. Monte Carlo simulation estimates the expected cash flows by repeatedly calculating the equation, using different random values for the uncertain revenue growth rates and adjusted operating profit ratios. The adjusted operating profit ratio is operating income less the imputed tangible property rent divided by revenue. Revenue growth rates and adjusted operating profit ratios are normally distributed and expected to follow a Wiener process. The model assumes a 21 percent marginal income tax and ignores net operating losses. The estimated cash flow forecasts are used to calculate the internal rate of return (IRR).

Adjusted operating income is defined as operating income less the imputed tangible property rent. The revenue growth rate and adjusted operating profit ratios are normally distributed and expected to follow a Wiener process. Assuming a marginal Income tax of 21% and net operating losses are ignored then the internal rate of return (IRR) is calculated from forecasted cash flows.

$$CF = \sum_{i=0}^{n} \left((R_t + \ \sigma\mu G R_{t+1}) * -\sigma\mu O \right) - fT$$

Where:

R = Revenue
G = Growth Rate
O = Adjusted Operating Profit Ratio
T = Income Taxes.

Companies create value when they generate returns that exceed their investors cost of capital. Table 10 shows the expected returns on their intangible assets. Surprisingly, 40 percent of the airlines aren't expected to earn a positive return on their intangible assets. Southwest Airlines is expected to earn less than their cost of intangible capital. When companies' returns are less than their cost of capital they destroy value. On the other hand, Alaska, Allegiant, Delta, Hawaiian, and Spirit airlines have an average IRR of 0.1178, which exceeds their intangibles discount rate. These companies are creating value on their intangible assets.

Table 10.

Company	Expected Return	Std. Dev.
Alaska Air Group, Inc.	0.1034	0.0237
Allegiant Travel Co	0.0894	0.0126
American Airlines Group	N/A	
Delta Air Lines, Inc.	0.0991	0.0229
Hawaiian Holdings, Inc.	0.1843	0.0381
JetBlue Airways Corp.	N/A	
SkyWest, Inc.	N/A	
Southwest Airlines Co.	0.0483	0.0107
Spirit Airlines	0.1128	0.0129
United Continental Holding, Inc.	N/A	
Average	*0.1062*	*0.0405*

Results

The opportunity cost of aircraft ownership is not on the airline's income statement, which distorts profitability and productivity comparisons between companies. Aircraft ownership opportunity costs have a significant impact on an airlines' operating profit margin. In the ten-year study period, shareholders appropriated 7.38 percent of revenues in the form of aircraft opportunity cost rents. This rent appropriation reduced industry operating profit margins from 9.42 percent to 2.04 percent. Additionally, after adjusting for the aircraft rent opportunity costs, four of the 10 airlines had negative operating profit margins. Lastly, Monte Carlo simulations reveal that four of the 10 airlines are unlikely to produce positive returns on their intangible assets in the long run. Five of the airlines have expected returns on their intangible assets that exceed their intangibles cost of capital and create value.

References

Air Lease Corporation. 2017. "2017 Investor Day." *Air Lease Corporation.* May 24. https://airleasecorp.com/files/investor_day_presentation/ALC_2017_Investor_Day_Presentation_F.PDF.

AircraftInvestor.com. 2018. *Enhanced Equipment Trust Certificate Data.* April 1. http://www.aircraftinvestor.com/articles/news/eetc-data-187-enhanced-equipment-trust-certificate-data/.

Appraisal Practices Board. 2016. *APB VFR Valuation Advisory #2: The Valuation of Customer-Related Assets.* Washington, DC: The Appraisal Foundation.

Asher, Cheryl Carleton, James M. Mahoney, and Joseph T. Mahoney. 2005. "Towards a Property Rights Foundation for a Stakeholder Theory of the Firm." *Journal of Managment and Governance* 5-32.

Barney, Jay. 1991. "Firm Resources and Sustained Competitive Advantage." *Journal of Management* 99-120.

Bharadwaj, Anandhi S., Sundar G. Bharadwaj , and Benn R. Konsynski. 1999. "Information Technology Effects on Firm Performance as Measured by Tobin's q." *Management Science* 1008-1024.

Blair, Margaret M., and Steven M. H. Wallman. 2001. *Unseen Wealth: Report of the Brookings Task Force on Intangibles.* Washington, D.C.: Brookings Institution Press.

Board of Governors of the Federal Reserve System, Federal Reserve Bank of St. Louis. 2018. "10-Year Treasury Constant Maturity Rate [DGS10]." *FRED.* April 15. fred.stlouisfed.org/series/DGS10.

Coff, Russell. 1999. "When Competitive Advantage Doesn't Lead to Performance: The Resource-Based View and Stakeholder Bargaining Power." *Organization Science* 119-133.

Cornell, Bradford. 1993. *Corporate valuation: tools for effective appraisal and decision making.* Burr Ridge: Irwin Professional Publishing.

Cornell, Bradford, Shaun Cornell, and Andrew Cornell. 2018. "The Role of Growth Options and Intangible Assets in Valuation: The Case of Alphabet." *Cornell Capital Group.* December 10. https://cornell-capital.com/wp-content/uploads/2018/12/The-Impact-of-Growth-Options-and-Intangible-Assets.pdf.

Crane, Matthew D. 2019. “The Legend of Weighted Average Return on Assets and Benchmarking Purchase Price Allocation Data.” *Journal of Forensic and Investigative Accounting* 1-23.

Daft, Richard. 1983. *Organizational Theory and Design.* New York: West.

Damodaran, Aswath. 2018. “Historical Implied Equity Risk Premiums.” *Damodaran Online.* http://people.stern.nyu.edu/adamodar/New_Home_Page/datafile/implpr.html.

—. 2018. “Levered and Unlevered Betas by Industry.” *Damodaran Online.* April 18. http://people.stern.nyu.edu/adamodar/New_Home_Page/datafile/Betas.html.

—. 2011. *The Little Book of Valuation: How to Value a Company, Pick a Stock and Profit.* Hoboken: John Wiley & Sons.

Federal Reserve Bank of St. Louis. 2020. *Ice Data Indices, LLC, ICE BofA BB US High Yield Index Effective Yield [BAMLH0A1HYBBEY].* St. Louis, MO, August 24. https://fred.stlouisfed.org/series/BAMLH0A1HYBBE.

—. 2018. “Moody’s Seasoned Baa Corporate Bond Yield.” *FRED Economic Data.* September 19. https://fred.stlouisfed.org/series/BAA.

Forsberg, Dick. 2016. “Values and Valuers: An Assessment of the Aircraft Valuation Business.” *Avolon.aero.* February 18. www.avolon.aero.

García-Castro, Roberto, and Miguel A. Ariño. 2011. “The Multidimensional Nature of Sustained Competitive Advantage: Test at a United States Airline.” *International Journal of Management* 230-248.

Gavazza, Alessandro. 2010. “Asset Liquidity and Financial Contracts: Evidence from Aircraft Leases.” *Journal of Financial Economics* 62-24.

Gorjidooz, Javad, and Bijan Vasigh. 2010. “Aircraft Valuation In Dynamic Air Transport Industry.” *Journal of Business & Economics Research* 1-16.

Grenadier, Steven R. 2003. “An Equilibrium Analysis of Real Estate Leases.” *NBER Working Paper Series* (The National Bureau of Economic Research). http://www.nber.org/papers/w9475.

Hamada, Robert. 1972. “The Effect of the Firm’s Capital Structure on the Systemic Risk of Common Stocks.” *Journal of Finance* 435-452.

Hamill, James R., Joel Sternberg, and Craig G White. 2006. “Valuation of the Embedded Option in a Non-Cancelable Lease: Theory and Application.” *Journal of Applied Business Research* 43-52.

Hannigan, T. J., Robert D. Hamilton III, and Ram Mudambi. 2015. “Competition and competitiveness in the US airline industry.” *Competitiveness Review* 134-155.

Huizinga, Harry, Luc Laeven, and Gaëtan Nicodème. 2007. “Capital Structure and International Debt Shifting.” *Journal of Financial Economics* 80-118.

IATA. 2013. *Profitability and the air transport value chain: IATA Economics Briefing No. 10.* Geneva: International Air Transport Association.

Kim, Jongwook, and Joseph T. Mahoney. 2007. “Appropriating economic rents from resources: an integrative property rights and resource-based approach.” *Int. J. Learning and Intellectual Capital* 11-28.

Koller, Tim, Marc Goedhart, and David Wessels. 2010. *Valuation: Measuring and Manageing the Value of Companies.* Hoboken: John Wiley & Sons, Inc.

Li, Michael Z. F., Tae H. Oum, and Yimin Zhang. 2004. “Tobin’s Q and Airline Performance.” *Public Works Management & Policy* 51-65.

Lustosa, Paulo Roberto B. 2017. *A New Approach to Accounting Goodwill (and Other Identified Intangibles with Indefinite Useful Lives): Theory and Empirical Evidence.* Brasília: University of Brasilia. doi:http://dx.doi.org/10.2139/ssrn.3023311.

Madhani, Pankaj M. 2012. “Intangible Assets: Value Drivers for Competitive Advantage.” In *Best Practices in Managment Accounting*, by Greg N. Gregoriou and Nigel Finch, 147-164. UK: Palgrave Macmillan.

Malighetti, Paolo, Michele Meoli, Stefano Paleari, and Renato Redondi. 2011. “Value Determinants in the Aviation Industry.” *Transportation Research Part E: Logistics and Transportation Review* (University of Begamo) 359-370.

McConnell, John J., and James S. Schallheim. 1983. “Valuation of Asset Leasing Contracts.” *Journal of Financial Economics* 237-261.

Miller, Merton H., and Charles W. Upton. 1976. “Leasing, buying, and the cost of capital services.” *Journal of Finance* 761-786.

Parr, Russell L. 2018. *Intellectual property : Valuation, Exploitation, and Infringement Damages.* Hoboken: John Wiley & Sons, Inc.

Pearson, James, David Pitfield, and Tim Ryley. 2015. “Intangible resources of competitive advantage: Analysis of 49 Asian airlines across three business models.” *ournal of Air Transport Management* 179-189.

Penman, Stephen H. 2009. “Accounting for Intangible Assets: There is Also an Income Statement.” *Abacus* 358-371.

Pratt, Shannon P., and Roger J. Grabowski. 2008. *Cost of capital: applications and examples.* Hoboken: John Wiley & Sons, Inc.

Raghavan, Sunder. 2017. "Modeling an Aircraft Lease Transaction for a Lessor." *Journal of International Finance and Economics* 15-20.

Rampini, Adriano A., and S. Viswanathan. 2013. "Collateral andcapitalstructure." *Journal ofFinancialEconomics* 466-492.

Robinson, Thomas R., Hennie van Greuning, Elaine Henry, and Michael A. Broihan. 2009. *International Financial Statement Analysis.* Hoboken: John Wiley & Sons, Inc.

Sampson, Scott T. 2020. "Aircraft Leasing (Working Paper)."

Schallheim, James S., Ramon E. Johnson, Ronald C. Lease, and John J. McConnell. 1987. "The Determinants of Yields on Financial Leasing Contracts." *Journal of Financial Economics* 45-67.

Stegink, Rudolf, Marc Schauten, and Gijs de Graaff. 2010. "The discount rate for discounted cash flow valuations of intangible assets." *Managerial Finance* 799-811.

Vance, David E. 2008. "Return on Booked Goodwill." *Northeastern Association of Business, Economics, and Technology Proceedings.* State College: National Association of Business, Economics and Technology. 268-284.

Wirtz, Harald. 2012. "Valuation of Intellectual Property: A Review of Approaches and Methods." *International Journal of Business and Management* 40-48.

Zhang, Mei. 2013. "The Impact of Internally Generated Goodwill on Financial Performance of Firms." *The Journal of Applied Business Research* 1809-1814.

Transitioning out of Capped Property Assessments: The Value Recapture Approach

BY CARMELA QUINTOS

Abstract

Assessment caps lead to inequities because the same growth limit is applied to high and low growth properties. High growth properties that fall under the cap have assessments artificially lowered relative to prices resulting in lower effective tax rates. This paper presents a method to transition out of a capped assessment system where instead of stipulating the percentage increase in assessment, this paper explores limiting the rate of value that can be captured, defined as the difference in the market value and the capped assessed value. Unlike the assessment cap approach which benefits high-growth properties, this approach conversely shifts the burden to high growth properties that have benefited from the cap. With the value recapture approach the burden is shifted to properties that have benefitted most from artificially low assessments, are furthest from market values, and therefore have more value to recapture.

The inequities resulting from capped assessment are well known and can be of two forms – horizontal and vertical inequity. Using New York City data we use Gini measures of equity to show that the value recapture approach converges to an equitable state faster than when assessment increases are capped. The measure of vertical equity is the Modified Kakwani Index whereas the index for horizontal equity is introduced in this paper for the first time as the ratio of the within-group Gini to the citywide Gini. The within-group Gini is the weighted average of the subregion Ginis. Horizontal equity exists when all the subregions have the same Gini as the citywide Gini, or that the ratio is one. With NYC data, we show that it is possible for the ratio to be at 1 within five years of transitioning out of capped assessments.

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Introduction

A property tax cap is an artificial cap on value increases intended to make property taxes stable, predictable and affordable. Assessment limits typically impose a constraint on the rate of growth of assessed value stipulating the allowable percentage increase. Some states have exceptions to the percentage limit such as when the property is sold, transferred or significantly altered. Regardless of how capped values are reset to the market value, the caps have the unintended consequence of higher growth properties receiving lower effective tax rates and increased tax savings.

The inequities resulting from capped assessment are well known and can be of two forms – horizontal and vertical inequity. Horizontal inequity exists when properties that are similar are assessed differently. Vertical inequity is defined relative to the price level. Regressive price inequity occurs when lower priced properties pay higher taxes while progressive taxes is the converse where lower priced properties pay less. Assessment caps lead to regressive assessments when the caps hold down assessments and prices scale up relative to other properties.

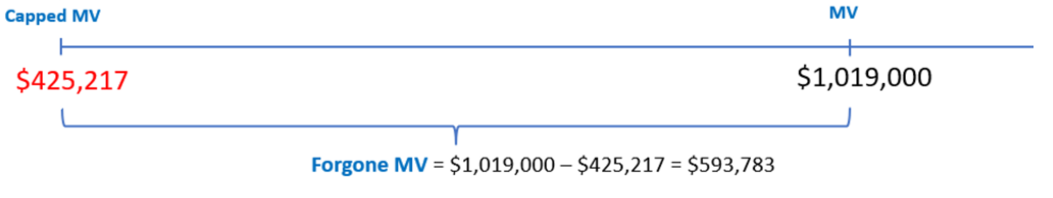
There are currently 18 states that have property assessment caps which are listed in the Appendix. Instead of stipulating the percentage increase in assessment, this paper explores limiting the rate of value that can be captured, defined as the difference in the market value and the capped assessed value. *When transitioning out of a capped assessment system that is regressive, i.e. high priced properties have lower effective tax rates and are therefore furthest from market value, the value recapture approach is naturally progressive.* With the value recapture approach the burden is shifted to properties that have benefitted most from artificially low assessments, are furthest from market values, and therefore have more value to recapture.

The following section discusses the value recapture approach and shows how ratios of assessed values to market values and taxes differ between the systems. Section 3 and 4 use New York City (NYC) data to show differences in not only assessed to market value ratios and taxes, but also in equity measures. Using Gini based measures, we show that the recapture value approach converges toward vertical and horizontal equity faster than the capped system approach. Section 5 summarizes the points of the paper.

Value Recapture Approach

Consider an actual parcel in New York City that is subject to a 6% assessment cap increase each year. Figure 1A illustrates the amount of lost revenue as a result of caps:

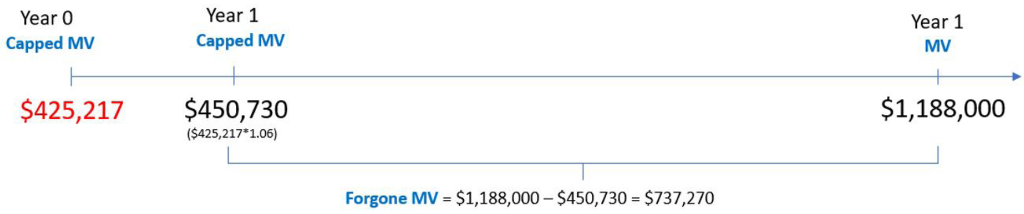
Figure 1A: Capped Assessments (Year 0)
Forgone Value Due to Caps



At year 0, the parcel has a market value (MV) of $1,019,000, however, under the capped system the property has a capped assessed MV equal to $425,217. The amount of forgone MV is the difference equal to $593,783, which translates to lost revenue due to capped assessments.

Suppose the following year, at year 1, the MV increases to $1,188,000 as shown in figure 1B.

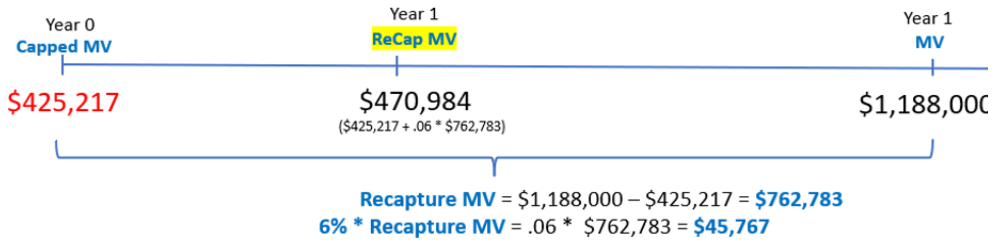
Figure 1B: Capped Assessments (Year 1)
Forgone Value Due to Caps



Because there is a 6% cap over the previous year's MV, the new AV is $450,730. The forgone MV for this year is $737,270.

Now suppose instead of applying the 6% as a capped increase to assessment, it applies the 6% as a rate that forgone MV can be captured, hereafter referred to as a recapture rate. Figure 1B' shows the assessment value difference of this parcel:

Figure 1B': Recaptured Assessments (Year 1)
Recaptured Value at 6% rate



At year 1, if this jurisdiction transitions out of a capped system, then the full amount of MV to recapture is $762,783, which is the difference between current year MV and previous year's capped MV. To phase in this difference, a jurisdiction sets the phase-in rate *k*, also called the recapture rate, at k = 6%. The amount phased in or the amount that can be captured is 6% of $762,783, or $45,767. This phased-in assessment of $45,767 is added to the previous year's assessment giving $470,984 as year 1 MV. This is denoted as Recap MV in Figure 1B'.

The formula for ReCap MV used to derive $470,984 for year 1 is,

$$ReCap\ MV_t = ReCap\ MV_{t\text{-}1} + k\ (MV_t - ReCap\ MV_{t\text{-}1}).$$

Thus if year 2 MV is $1,074,000 then its Recap MV, or its MV under this new value recapture approach is,

$$\$507{,}165 = \$470{,}984 + .06 \times (\$1{,}074{,}000 - \$470{,}984)$$

which appears in table 1, column E. Table 1 shows that in year 3, using the same formula that the ReCap MV is $554,435. In addition, table 1 shows tax calculations and ratios to MV for both the

Table 1: Capped Assessments versus Value Capture
6% capped increase versus 6% recapture rate

Capped MV			Recaptured MV			Taxes				Ratios to MV	
YEAR	MV	6% Cap MV	Recapture MV	6% Recapture MV	6% ReCap MV	Tax Rate	Cap MV Taxes	ReCap MV Taxes	Tax Difference	Cap MV/MV	ReCap MV/MV
Formulas	A	B	C(t)= A(t) - E(t-1)	D= 6% * C	E(t) = E(t-1) + D(t)	F	G = F*B	H = F*E	I = H-G	J = B/A	K = E/A
0	1,019,000	425,217			425,217	1.26%	5,337	5,337	0	42%	42%
1	1,188,000	450,730	762,783	45,767	470,984	1.27%	5,724	5,982	257	38%	40%
2	1,074,000	477,773	603,016	36,181	507,165	1.26%	6,033	6,404	371	44%	47%
3	1,295,000	506,440	787,835	47,270	554,435	1.20%	6,066	6,641	575	39%	43%

capped MV and Recap MV scenarios.

Table 1 shows that this approach will generate winners and losers. Winners are those properties whose capped assessments are below MV and losers are those whose capped assessments are above MV. For this parcel in table 1 whose capped assessment is below MV, we see that the tax dollars will increase by $575 in year 3 (this parcel will pay more taxes and is a loser under this new system). The ratio of the assessment to MV increases to 43% from the current system of 39% in year 3. The further the parcels capped MV is from actual MV, the more there is to recapture, the higher ReCap MV will be, and the more taxes this parcel will pay compared to a capped assessment system.

When the ReCap MV *exceeds* the MV for that year, then the parcel should be assigned the current MV. In other words, a property will be assigned the lower of MV or Recap MV, called a terminal condition,

$$\min\,(MV_{t.}, ReCap\ MV_{t.}).$$

This terminal condition is important as it guarantees that at some point all parcels reach market value, and fluctuate around market onward.

The recapture rate k is the policy tool that controls the rate of recapture. Important properties of the recapture rate k are:

- When properties reach the terminal condition, i.e. properties are assigned MV rather than ReCap MV, then k is interpreted as the allowable *year-over-year phase-in rate*

$$MV_t = k \times (MV_t - MV_{t\text{-}1}) + MV_{t\text{-}1}$$

- Increasing k gives a jurisdiction control of how quickly it will transition to market value. Table 2 illustrates this for our example parcel when recapture rates are set at 6%, 10% and 20%.

Table 2: Effect of Increasing Recapture Rate k

Capped MV			Recaptured MV			Taxes				Ratios			
YEAR	MV	6% Cap MV	6% ReCap MV	10% ReCap MV	20% ReCap MV	Cap MV Taxes	6% ReCap MV Taxes	10% ReCap MV Taxes	20% ReCap MV Taxes	Cap MV/MV	6% ReCap MV/ MV	10% ReCap MV/ MV	20% ReCap MV/ MV
0	1,019,000	425,217	425,217	425,217	425,217	5,337	5,337	5,337	5,337	42%	42%	42%	42%
1	1,188,000	450,730	470,984	501,495	577,773	5,724	5,982	6,369	7,338	38%	40%	42%	49%
2	1,074,000	477,773	507,165	558,746	677,019	6,033	6,404	7,055	8,549	44%	47%	52%	63%
3	1,295,000	506,440	554,435	632,371	800,615	6,066	6,641	7,574	9,590	39%	43%	49%	62%

- At a 20% recapture rate, year 3 taxes are $9,590 which is a $3,524 difference or a 58% increase from the current capped assessment system. The ratio to market value increases to 62% from 39% in year 3. The higher the recapture rate k the quicker the county will assess at full market value. As seen in the last three columns, a recapture rate of 6% will increase the assessed to MV ratio to only 43% as compared to k at 20% where 62% of the value is captured by year 3.
- It is important to periodically review k, say every 3-5 years, as a county's revenues can fall compared to a capped system when majority of the property's ReCap market values are below what they would be in a capped system. This happens when majority of the properties' assessed values are not far enough from market values, and the recapture rate k *is not high enough to counter the permissible increase c in the current assessment system.*

We illustrate how this can occur with a parcel whose capped MV are already close to actual MV – i.e. within 20% in table 3. The increases in MV in years 2 and 3 are modest so the capped MV grows at the same rate as MV. At year 3 however, MV increases by 7% ($670,000 from $624,000) so the 6% cap takes into effect ($526,075 capped MV from $496,297). In year 3, the

Table 3: Capped Limit c versus Recapture Rate k for a Property Close to MV

Capped MV			Recaptured MV			Taxes				Ratios			
YEAR	MV	6% Cap MV	6% ReCap MV	10% ReCap MV	20% ReCap MV	Cap MV Taxes	6% ReCap MV Taxes	10% ReCap MV Taxes	20% ReCap MV Taxes	Cap MV/MV	6% ReCap MV/ MV	10% ReCap MV/ MV	20% ReCap MV/ MV
0	609,000	484,367	484,367	484,367	484,367	6,079	5,337	6,079	6,079	80%	80%	80%	80%
1	614,000	488,343	492,145	497,330	510,293	6,202	5,982	6,250	6,481	80%	80%	81%	83%
2	624,000	496,297	500,056	509,997	533,035	6,267	6,404	6,314	6,731	80%	80%	82%	85%
3	670,000	526,075	510,253	525,997	560,428	6,301	6,641	6,112	6,713	79%	76%	79%	84%

ratio of capped MV to MV at 79% is higher than when the recapture rate is set at 6% (76% ratio). In this case, one needs a recapture rate higher than 6%. For example, a recapture rate of *k* equal to 20% gives the higher recapture ratio of 84% at year 3 with a modest increase in tax dollars of $412 ($6,713 - $6,301).

A review of the relationship between *c* and *k* must be done to establish the level that would generate the desired policy effect. Jurisdictions where majority of its parcels are close to its market value, say within 20%, would need a recapture rate *k* significantly larger than its capped limit to bring all parcels closer to full market value.

- At the end of the transition period, a jurisdiction sets *k*=1 so that all parcels are at full market value.

NYC Case Study

Residential properties are subject to two different caps on their assessed values (AV). First, no property's AV may increase more than 6% a year. Second, no property's AV may increase more than 20% in five years. This has the effect of reducing the 6% yearly cap to an effective 3.73% cap over the long term.

NYC's property tax reform proposal includes removing the caps and phasing out assessment increases over a five-year period.

- First, rather than a 6% cap on assessment increases which we denote as *c*, this new approach controls the rate of assessment increases by a value capture rate *k*. The value recapture approach differs from the reform proposal. As shown later, the relationship between *c* and *k* is the determining feature of how quickly the system approaches full market value, how progressive the tax system will be, and how much stability would be required in the tax system.
- Second, this new approach differs as follows: rather than a five-year phase-in period, the recapture rate *k* should be determined so that after a period to be determined by policy, say five to 10 years, parcels are set to their full market value by setting *k*=1. The advantage is transparency to the taxpayer since their taxes will be based on current market values rather than phased in historical values which are known to be regressive.
- Third, this new approach is easier to administer because assessment histories need not be created or carried out into future tax bills.

Over a five year period from 2019 to 2023, we compare assessment values and taxes under two systems — the current capped system versus a system with a 6%, 10% or 20% recapture rate.

Table 4 is similar to tables 2 and 3 except it is applied to residential properties in NYC. The table shows the mean market values, taxes, and ratios for years 2019-2023 using the tax roll AV's (capped AV's) and calculated AV's using the recapture rate method.

If the recapture rate method was applied five years ago in 2019, the last row shows that in 2023, on average, the 6% recapture rate will be similar to the current capped system in terms of the MV ratios both of which are 62%. Significant differences occur at a recapture rate of 20% where the ratio to MV is 77% at year 3 compared to 62% at the current system, with a mean tax difference of $2,411 ($10,294 - $7,884).

However, though MV ratios are similar, the way it is achieved is different between the systems. The capped system is regressive whereas the value recapture approach is not. Table 5 shows the tax difference distribution for 2023 broken down by MV quartiles. As MV increases, the tax differences increase meaning the burden is shifted to higher priced properties. At the highest recapture rate of 20%, properties at the highest quartile with MV greater than $907,000 pay a median of $4,370 more than in the current capped system, versus those at the lowest quartile who pay only $648 more than they currently do.

Table 4: NYC Capped versus Recaptured Market Values

Mean Market Values, Taxes, and Ratios

Capped MV				Recaptured MV			Taxes				Ratios			
YEAR	N	MV	6% Cap MV	6% ReCap MV	10% ReCap MV	20% ReCap MV	Cap MV Taxes	6% ReCap MV Taxes	10% ReCap MV Taxes	20% ReCap MV Taxes	Cap MV/MV	6% ReCap MV/ MV	10% ReCap MV/ MV	20% ReCap MV/ MV
2019	661,699	933,083	555,321	555,321	555,321	555,321	6,970	6,970	6,970	6,970	67%	67%	67%	67%
2020	661,679	972,419	579,441	580,520	597,190	638,865	7,359	7,369	7,581	8,110	67%	66%	68%	71%
2021	661,493	979,216	600,709	604,644	635,560	707,024	7,585	7,628	8,018	8,921	67%	67%	70%	76%
2022	661,396	1,043,584	622,445	630,908	676,247	774,137	7,456	7,553	8,096	9,269	65%	65%	69%	77%
2023	661,470	1,129,288	646,964	660,911	721,584	845,073	7,884	8,050	8,790	10,294	62%	62%	67%	77%

Table 5: NYC Tax Burden Shift to Higher Price Properties

Tax Differences for Tax Year = 2023

		k = 6%			*k = 10%*			*k = 20%*		
MV Quartiles	N	10th Pctl	50th Pctl	90th Pctl	10th Pctl	50th Pctl	90th Pctl	10th Pctl	50th Pctl	90th Pctl
MV <= $609,000	166,192	-$555	-$209	$144	-$351	$66	$537	$29	$648	$1,365
$609,000 < MV <= $715000	165,023	-$693	-$217	$283	-$425	$174	$846	$102	$987	$2,009
$715,000 < MV <= $907,000	165,020	-$833	-$113	$697	-$473	$443	$1,552	$240	$1,601	$3,300
MV > $907,000	165,235	-$783	$753	$3,886	-$80	$1,937	$6,820	$1,285	$4,370	$12,805

Equity Analysis

Measurement of vertical and horizontal equity analysis are based on the Gini approach introduced in Quintos (2020) and Quintos (2021). NYC data introduced in the previous section are used to show the impact on equity of the capped assessment versus the value recapture approach.

4.1 Redistributive Equity

Inequity exists when there is a significant difference in how assessments behave versus prices. These behaviors are captured by distributional statistics such as the difference in their means, variances, skewness and kurtosis. The ranking of parcels in the assessment versus price distributions will differ under inequality and can be captured by the Spearman rank correlation.

The Gini coefficient is a known distributional inequality measure which capture these effects into a single number. If the Gini coefficient of assessments is denoted as G_A and the Gini coefficient of prices as G_p, then we can measure their distance by subtraction or by taking a ratio. The Redistributive Equity (RE) index (see Aronson et. al. 1994) takes the difference,

$$RE = G_A - G_P$$

and the Modified Redistributive Equity (MRE) index takes the ratio,

$$MRE = G_A \,/\, G_P\,.$$

It is called "redistributive" equity because it measures how values are redistributed in the assessment distribution as compared to the price distribution. Distributional equity exists when $RE = 0$ or $MRE = 1$.

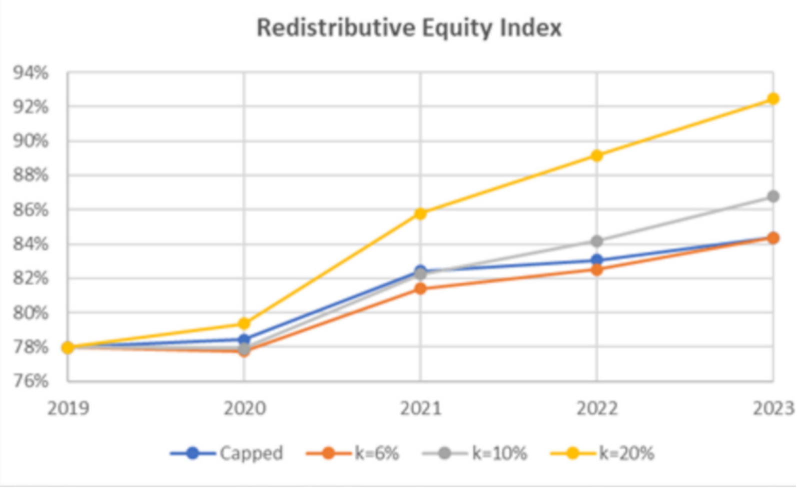
Table 6a shows NYC measures of *MRE* between prices versus the capped assessment system and the recapture value approach when the recapture rate is set at 6%, 10% and 20% respectively. The closer *MRE* is to 1 the closer the distributional properties are between market values and assessments under the different taxing regimes.

In 2023, just within five years, the recapture value approach has an *MRE* equal to 92%. In other words, the distributional properties of assessments under the tax system with a 20% recapture rate have similar distributional properties to market values. A recapture rate of 6% and 10% would not be the best policy tools if equity is a consideration within the five year period with *MRE* values below 90%. Given time, generally, because the value capture approach moves all properties toward market value, the *MRE* will go to 1 for all at a faster rate than a capped assessment value system.

Table 6a: NYC Redistributive Equity for Capped Versus Recapture MV

Modified RE Index

YEAR	CapMV	6% ReCap MV	10% ReCap MV	20% ReCap MV
2019	78%	78%	78%	78%
2020	78%	78%	78%	79%
2021	82%	81%	82%	86%
2022	83%	83%	84%	89%
2023	84%	84%	87%	92%



It is important to understand that RE and MRE are measures of total inequality, which includes effects of regressivity or progressivity and effects of reranking. Thus, two tax systems may have close measures of RE and MRE but they can be achieved in different ways. The next two sections decompose the MRE effects into vertical inequity and reranking effects.

4.2 Vertical Equity

Vertical inequity exists when there is a significant difference in the (distributional) behavior of assessments versus prices *at different price levels.* Regressivity (progressivity) occurs when lower priced properties have a higher (lower) share of assessments than prices.

Because vertical equity is concerned with distributional differences as prices increase, price ranking is part of the construction of the measurement. The Concentration Index (CI) measures how a variable behaves conditioned on the ranking of another variable. Thus, the Concentration Index of assessment which we denote by CI_A, measures how assessments behave conditioned on prices ranked in ascending order.

The measure of vertical equity is the Kakwani Index (KI) of Kakwani (1977) which is the subtraction of CI_A and the Gini coefficient of price,

$$KI = CI_A - G_P,$$

or the ratio called the Modified Kakwani Index (MKI) of Fukushige et. al. (2012),

$$MKI = CI_A \;/\; G_p.$$

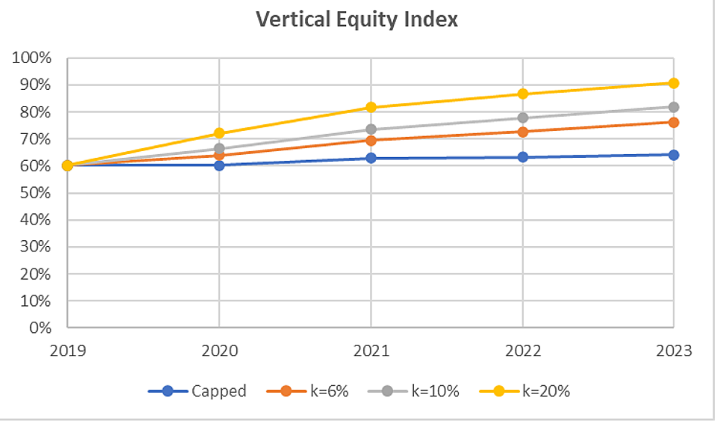
Vertical equity occurs when $KI = 0$ or $MKI = 1$. Regressive assessments occur when $KI < 0$ or $MKI < 1$. In contrast, progressive assessments occur when lower priced properties have a lower share of the tax burden so that $KI > 0$ or $MKI > 1$.

Table 6b shows NYC measures of *MKI* between prices versus the capped assessment system and the recapture value approach when the recapture rate is set at 6%, 10% and 20% respectively. Recall that the closer *MKI* is to 1 the closer assessments are to achieving vertical equity. The higher the recapture rate the faster the properties reach their market values and the higher the measure of vertical equity. In five years at 2023, when $k = 20\%$, the *MKI* is already at 92% which is significantly higher than the 64% *MKI* of the capped assessment system. The capped assessment system remains regressive at around 60-65% in five years whereas the recapture value approach is a progressive approach which accelerates through time.

Table 6b: NYC Vertical Equity for Capped Versus Recapture MV

Modified Kakwani Index

YEAR	CapMV	6% ReCap MV	10% ReCap MV	20% ReCap MV
2019	60%	60%	60%	60%
2020	60%	64%	66%	72%
2021	63%	70%	74%	82%
2022	63%	73%	78%	87%
2023	64%	76%	82%	91%



4.3 Reranking Effects

When vertical equity is subtracted from the total redistributive effect, we get a residual effect. It turns out that this residual effect coincides with the reranking effect of Atkinson (1980) and Plotnick (1981). Reranking occurs when there is a change in the order of properties when ranked according to their assessed values versus their prices (for example, a high priced property in the upper 90th percentile is assigned the median assessed value). The reranking effect is defined as a subtraction term,

$$RR = G_A - CI_A$$

or its modified form as a ratio with G_P,

$$MRR = (G_A - CI_A) / G_P .$$

Note that the total inequality *RE* or *MRE* consists of the sum of the vertical equity and reranking effects. In other words, RE is decomposed as

$$RE = KI + RR$$

or in its modified form,

$$MRE = MKI + MRR.$$

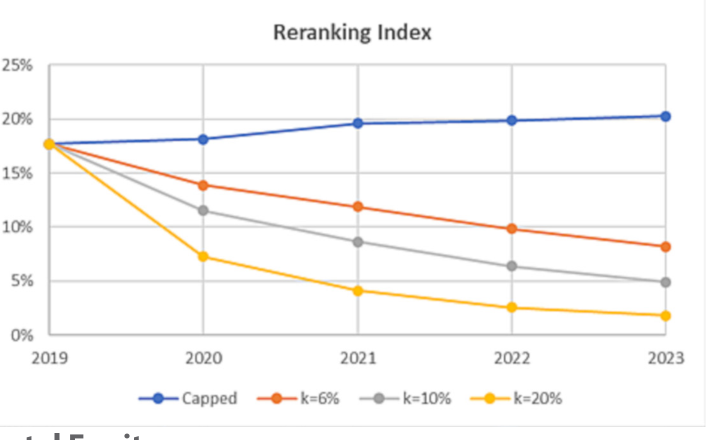
There are no reranking effects when $RR = 0$ or $MRR = 0$. When either is positive then reranking effects are present. This is interpreted in the literature as a form of horizontal inequity since some properties are reranked while others maintain their order.

Table 6c shows NYC measures of *MRR* between prices versus the capped assessment system and the recapture value approach when the recapture rate is set at 6%, 10% and 20% respectively. Recall that the closer *MRR* is to zero the closer to equity. The higher the recapture rate the faster the properties reach their market values and the lower the reranking effects. In five years in 2023, when k = 20%, the *MRR* is already down to 2% which is significantly lower than the 20% *MRR* of the capped assessment system. The capped assessment system remains with reranked assessments at around 20% in five years whereas the recapture value approach makes the correction, and the rank correction accelerates with time.

Table 6c: NYC Reranking Inequity for Capped Versus Recapture MV

Reranking Index

YEAR	CapMV	6% ReCap MV	10% ReCap MV	20% ReCap MV
2019	18%	18%	18%	18%
2020	18%	14%	12%	7%
2021	20%	12%	9%	4%
2022	20%	10%	6%	3%
2023	20%	8%	5%	2%



4.4 Horizontal Equity

While the reranking effect is a particular type of horizontal inequity, the typical measurement is to compare properties that are similar in location or physical characteristics. This section introduces a horizontal equity index for Gini based measurements.

The horizontal equity index is a ratio of the within-group Gini discussed in Quintos (2021) and the overall Gini. Under horizontal equity the two should be equal so the ratio equals one. *Horizontal inequity occurs when the within-group Gini deviates from the overall Gini.*

Suppose a town has two neighborhoods, 1 and 2. Each neighborhood has n_1 and n_2 properties so the total number of properties in the town is $n_0 = n_1 + n_2$. The total market value in town 1 is the sum of its prices, prices $P_1 = \sum_1^{n_1} P_{1i}$ and similarly for neighborhood 2, $P_2 = \sum_1^{n_2} P_{2i}$. The total market value of the town is the sum of all prices $P_0 = P_1 + P_2$.

How does one decompose the overall town Gini into the contributions of the two neighborhood Gini? Suppose each neighborhood has price Gini measurements denoted by G_{P_1} and G_{P_2} and the overall town has a price Gini denoted by G_{P_0}. The within-group Gini denoted as wG_{P_0} is a weighted average of the share of each town to the total,

$$wG_{P_0} = \left(\frac{n_1}{n_0}\frac{P_1}{P_0}\right) G_{P_1} + \left(\frac{n_2}{n_0}\frac{P_2}{P_0}\right) G_{P_2}.$$

Similarly, the within-group Gini for assessments just uses the assessed values instead of prices,

$$wG_{A_0} = \left(\frac{n_1}{n_0}\frac{A_1}{A_0}\right) G_{A_1} + \left(\frac{n_2}{n_0}\frac{A_2}{A_0}\right) G_{A_2}.$$

The within-group redistributive equity is the ratio,

$$wMRE = wG_{A_0} \,/\, wG_{P_0}.$$

Horizontal equity, in the sense that assessments have redistributed value in the same manner for the town and within each neighborhood, is the null hypothesis

$$H_O: MRE = wMRE.$$

Thus a measurement of the deviation of the within-group to the overall measure is the Horizontal MRE Index (*HMRE*),

$$HMRE = wMRE / MRE.$$

Measuring horizontal equity generalizes to any number of subgroups so that the *within-group Gini is the weighted average of the subgroup Gini coefficients.*

For our NYC case study, there are five subgroups called boroughs which are Manhattan (1), the Bronx (2), Brooklyn (3), Queens (4) and Staten Island (5). The within-group NYC Gini for prices is the weighted sum of five boroughs' inequality where the weights are their share of the population multiplied by their share of prices.

In calculating the weights for NYC, the total number of properties in NYC is the sum of the five borough population, $n_{NYC} = n1 + n2 + n3 + n4 + n5$, and the total price in NYC is the sum of the five borough prices, $P_{NYC} = P_1 + P_2 + P_3 + P_4 + P_5$. Then the within-group Gini for price is,

$$wG_{P_{NYC}} = \left(\frac{n_1}{n_{NYC}}\frac{P_1}{P_{NYC}}\right)G_{P_1} + \left(\frac{n_2}{n_{NYC}}\frac{P_2}{P_{NYC}}\right)G_{P_2} + \left(\frac{n_3}{n_{NYC}}\frac{P_3}{P_{NYC}}\right)G_{P_3} + \left(\frac{n_4}{n_{NYC}}\frac{P_4}{P_{NYC}}\right)G_{P_4} + \left(\frac{n_5}{n_{NYC}}\frac{P_5}{P_{NYC}}\right)G_{P_5}.$$

NYC within-group price inequality = Manhattan's share of price inequality + Bronx's share of price inequality + Brooklyn's share of price inequality + Queen's share of price inequality + Staten Islan share of price inequa

Similarly, the within-group NYC assessment inequality substitutes assessment for prices,

$$wG_{A_{NYC}} = \left(\frac{n_1}{n_{NYC}}\frac{A_1}{A_{NYC}}\right)G_{A_1} + \left(\frac{n_2}{n_{NYC}}\frac{A_2}{A_{NYC}}\right)G_{A_2} + \left(\frac{n_3}{n_{NYC}}\frac{A_3}{A_{NYC}}\right)G_{A_3} + \left(\frac{n_4}{n_{NYC}}\frac{A_4}{A_{NYC}}\right)G_{A} + \left(\frac{n_5}{n_{NYC}}\frac{A_5}{A_{NYC}}\right)G_{A_5}$$

Taking the ratio, the within-group NYC redistributive equity is,

$$wMRE_{NYC} = wG_{ANYC} / wG_{PNYC}.$$

The Gini based horizontal equity index is the ratio of the within-group to the citywide MRE,

$$HMRE_{NYC} = \frac{wMRE_{NYC}}{MRE_{NYC}}.$$

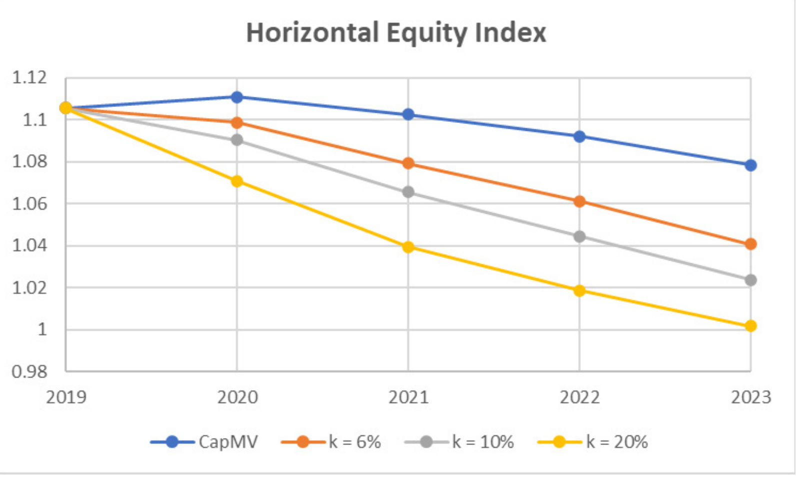
When $HMRE_{NYC}$ is around one then horizontal equity exists since the manner in which assessments redistribute market value is the same citywide in NYC and individually in its five boroughs. The further $HMRE_{NYC}$ is from 1 the more unequal the redistributive equity is between the boroughs.

Table 7 shows NYC measures of $HMRE_{NYC}$ across boroughs for the capped assessment system and the recapture value approach when the recapture rate is set at 6%, 10% and 20% respectively. The higher the recapture rate the faster the properties reach their market values and the faster the $HMRE_{NYC}$ approaches one. In five years in 2023, when k = 20% the $HMRE_{NYC}$ is already at 1 which is significantly lower than the 1.08 of the capped assessment system. The capped assessment system remains with horizontal inequity at around 1.08-1.11 in five years whereas the recapture value approach makes the correction, and the approach toward horizontal equity accelerates with time.

Table 7: NYC (Total) Horizontal Equity for Capped Versus Recapture MV

Ratio of Within Group MRE to Citywide MRE

YEAR	CapMV	6% ReCap MV	10% ReCap MV	20% ReCap MV
2019	1.11	1.11	1.11	1.11
2020	1.11	1.10	1.09	1.07
2021	1.10	1.08	1.07	1.04
2022	1.09	1.06	1.04	1.02
2023	1.08	1.04	1.02	1.00



Summary

The value recapture approach is a process that enables counties to transition out of a capped system in a manner where stability and progressivity are controlled by the recapture rate *k*. The advantages of the recapture value approach are:

- It is a progressive approach when transitioning out of a capped system that is regressive. Capped increases in assessed values are regressive when caps suppress growth in higher priced properties. Thus transitioning out of this system means the highest priced properties are furthest from their market values and are therefore subject to more taxes in the recapture value approach.
- It is transparent in that the only policy tool is the single parameter *k*. Setting the value determines the length of the transition period, the year-over-year stability of taxes, its progressivity/regressivity, and the affordability of the transitional approach. It is important to study, for different values of *k*, its effects on revenues, taxes, and equity as we have shown in this paper.
- It is simple since the steady state is that all properties will reach market value. At steady state, the parameter is simply the allowable year-over-year phase-in rate. There is no phase-in requirement when $k = 1$.

The comparison of the capped assessment increase versus the recapture value approach were compared in terms of their effects on vertical inequity, reranking inequity and horizontal inequity. Using NYC data as a case study, it was clear that the value recapture approach reached a more equitable state faster than a capped system.

References

Aronson, J.R., P. Johnson, P.J. Lambert (1994). Redistributive Effect and Unequal Tax Treatment, *Economic Journal*, 104: 262-270.

Atkinson, A. (1980). Horizontal Equity and the Distribution of the Tax Burden in H. Aaron & M. Boskin (eds.). *The Economics of Taxation, pp.3-18.*

Fukushige M., Noriko Ishikawa and Stoko Maekawa (2012). A Modified Kakwani Measure of Health Inequality. *Health Economics Review*, pages 2- 10.

Kakwani, N. C. (1977). Measurement of Tax Progressivity: An International Comparison. *Economic Journal*, 87: 71- 80.

Plotnick, R. (1981). A Measure of Horizontal Inequity. *The Review of Economics and Statistics*, 63(2), 283-288.

Quintos, C. (2020). A Gini measure for vertical equity in property assessments. *Journal of Property Tax Assessment & Administration*, 17(2).

Quintos, C. (2021). A Gini decomposition of the sources of inequality in property assessments. *Journal of Property Tax Assessment & Administration*, 18(2).

Significant Features of the Property Tax. https://www.lincolninst.edu/research-data/data-toolkits/significant-features-property-tax/access-property-tax-database/property-tax-limits. Lincoln Institute of Land Policy and George Washington Institute of Public Policy.

Appendix

States with Assessment Caps, Rate Limits, and Levy Limitations

State	Assessment	Levy	Rate
Alabama		x	x
Alaska		x	x
Arizona	x	x	x
Arkansas	x	x	x
California	x		x
Colorado	x	x	x
Connecticut	x	x	
Delaware		x	x
District of Columbia	x	x	x
Florida	x		x
Georgia	x		x
Hawaii	x		
Idaho		x	x
Illinois		x	x
Indiana		x	x
Iowa	x	x	x
Kansas		x	
Kentucky		x	x
Louisiana		x	x
Maine		x	
Maryland	x		
Massachusetts		x	x
Michigan	x	x	x
Minnesota		x	
Mississippi		x	
Missouri		x	x
Montana		x	x
Nebraska		x	x
Nevada		x	x
New Hampshire			
New Jersey		x	
New Mexico	x	x	x
New York	x	x	
North Carolina			x
North Dakota		x	x
Ohio		x	x
Oklahoma	x		x
Oregon	x		x
Pennsylvania		x	x
Rhode Island		x	
South Carolina	x		x
South Dakota		x	x
Tennessee			
Texas	x	x	x
Utah		x	x
Vermont			
Virginia		x	
Washington		x	x
West Virginia		x	x
Wisconsin		x	
Wyoming			x

Source: Significant Features of the Property Tax. Lincoln Institute of Land Policy and George Washington Institute of Public Policy.

Climate Change and Property Assessment Practices: An Investigation of the Impact of the Green Energy Transition on Property Assessment Organizations and Property Tax Policies in Canada

BY LAURA MacLEAN AND STÉPHANIE VIEILLE, PH.D.

Introduction

Climate change, climate emergency, global warming, extreme weather events…These terms have become recurrent in today's news and modern lexicon. According to the United Nations (2022), all refer to the "long-term shifts in temperature and weather patterns" and its nefarious impacts on our planet. The impact of climate change can be felt far and wide around the globe. In fact, the last several years have shown that Canada is not immune. Examples of recent extreme weather or climate events can be found in many provinces, including:

- British Columbia's Forest fires, floods, heat domes and atmospheric rivers
- Alberta's hailstorms and flooding caused by ice-choked rivers
- Nova Scotia's ongoing exposure to named storms and hurricanes
- Ontario and Manitoba's tornados
- Newfoundland's snowstorms causing lockdowns and a call to the Canadian Armed Forces

Looking forward, rising sea water and extreme weather events will continue to affect the lives of Canadians and will no doubt require that we re-think the way we live, build our homes, and design our urban spaces (Amado et. Al, 2016, pp. 476-485). In response to this, the Government of Canada, Canadian provincial governments, and local municipal governments have committed

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to various calls to action in support of climate change and the green energy transition. However, Fesenfld and Rinscheid (2021) indicate there appears to be a worrying gap between people and governments' concerns about the climate urgency and their actions towards mitigating it.

In terms of the real estate sector, it is imperative to understand whether these calls to action will address concerns about climate urgency and mitigation. A key stakeholder in the support for green energy transition in real estate is the assessment industry, and the adaptation of property valuation methods for assessment purposes in fulfilling the municipal, provincial and federal climate action plans. A review of the calls to action from these various levels of government in the context of the assessment industry is imperative to answer the question: how will the climate urgency impact Canadian property assessment practices and property tax policies?

This paper begins with the examination of the Canadian government's call to action and a sample of provincial responses before reviewing existing international efforts to imbed climate action within property assessment and tax policies. A literature review of recent research and work on the topic alongside the interviewing of experts and policy makers in Canada help shed light on the potential way forward for Canada.

Canadian Government Calls to Action

The Government of Canada has committed to supporting the green energy transitions for Canadian homeowners and businesses. Canada's Climate Actions for a Healthy Environment and a Healthy Economy (2022), for instance, identifies concrete steps taken by the government to further climate action and allow for more energy efficient homes and buildings. These include:

- The provision of grants to homeowners to make energy efficient improvements to their homes; and affordable financing to make deeper home energy retrofits
- An increase in the number of low-income households that benefit from energy retrofits, and
- A reduction of energy use and taxpayer dollars in municipal and community buildings.

Encouragingly, Canada's 2020 model building code has become a vital part of Canada's climate action plan and defines a minimum energy efficiency standard for the construction of new buildings across the country. It sets the path for a net-zero energy goal and can even be supplemented by municipalities wishing to establish to further optimize energy efficiency (Efficiency Canada 2023).

Canada's climate action plan is also supported through various programs such as the Canada Greener Homes Grant and the Green Home Refund. The Canada Greener Homes Grant helps homeowners save money, create new jobs across Canada for energy advisors, and fight climate change, while helping Canadians make where they live more energy efficient (Government of Canada, 2022). An obvious limitation of the scheme is the ineligibility of multi-residential buildings of more than 600m2 to qualify for the grant. It is problematic given the recent and fast increase in urban populations across the country, leading many municipalities to develop plans for increased density (Statistics Canada, 2022). Canada's Greener Home Grant excludes most apartment buildings that make up a large portion of urban centers.

Canada Mortgage and Housing Corporation (CMHC), is a Crown Corporation of the Government of Canada with the goal of housing affordability for all. In Canada, mortgage loan insurance is required for all home purchases with less than a 20% down payment. As part of that goal, the corporation offers a Green Home Refund of up to 25% on the CMHC mortgage loan insurance premium when you buy or build an energy-efficient home, or you buy an existing home and make energy-saving renovations (CMHC, 2022). The program does support potential buyers of new energy efficient condos, but like Canada's Greener Home Grant, it fails to include owners of older apartment buildings for retrofitting. This is a gap given that buildings contribute to about 30% of the country's GHG emission and that there are about 250,000 large buildings (residential, commercial, mixed-used and other) in Canada according to Thomas Mueller, president and CEO of the Canada Green Building Council (Zeidler, 2019).

Furthermore, it is important to note that both these programs are no more than incentives to support the green energy transition through home retrofitting or the building of energy efficient homes. These grants and refunds operate on an entirely voluntary basis. And whilst the initial uptake on Canada's Greener Home Grant is encouraging, with about 182,400 applications submitted within nine months of its launch, it is too early to tell if such programs will have a sufficient impact (Government of Canada, 2022).

In addition to the federal government, several Canadian provinces have followed suit and pledged to support green energy for homeowners and businesses alike (Amado, 2016). Municipal governments also have a role to play as partners in the assessment industry and property tax recipients. What follows is a brief overview of existing provincial legislation and municipal programs as it relates to climate change in several provinces, thereby highlighting the diversity of approaches used across the country.

Property Assessed Clean Energy Programs

Property Assessed Clean Energy (PACE) programs are emerging in Canada, already widely available across the United States. The Pembina Institute, a Canadian organization dedicated to solving energy challenges, created a guide for design consideration for PACE programs and enabling legislation in Canada (Pembina Institute, 2022). The guide states that "mechanisms are already in place to allow municipalities to recuperate the costs of public infrastructure upgrades (e.g. improved roads, sidewalks) by adding a local improvement charge to the property taxes of adjacent properties." (Pembina Institute, 2022 p.1) The Institute, however, specifies that more needs to be done, including "changes in provincial legislation […] to authorize municipalities to use such mechanisms to finance upgrades to a private property (such as energy efficiency upgrades)" (Pembina Institute, 2022 p.6). PACE legislation is in place in Nova Scotia, Ontario, and Alberta and in development in Prince Edward Island.

Nova Scotia's PACE program, the Halifax Solar City program is the first of its kind in Canada. PACE programs are available in 13 counties, districts, towns, and municipalities across Nova Scotia: Amherst, Barrington, Bridgewater, Digby, Halifax Regional Municipality (specifically for solar energy projects), Lunenburg, Cumberland, Colchester, Yarmouth, Wolfville, New Glasgow, and Victoria County. If additional municipalities want to participate in a PACE program, they can create their own, or join a turn-key existing program such as Clean Energy Financing or PACE Atlantic. In the first year of starting a program, Nova Scotia's department of Natural Resources and Renewables offers a $15,000 grant to cover startup costs including design, initial marketing and administration and other advice (Nova Scotia PACE, 2022).

Alberta's Clean Energy Improvement Program (CEIP), a PACE program, is available in the town of Rocky Mountain House, the town of Devon and the City of Edmonton. An additional eleven municipalities have passed a CEIP bylaw which means they can now go ahead with their own programs, similar to the four municipalities with programs already available: Canmore, Leduc, Okotoks, St. Albert, Lethbridge, Grande Prairie, Drayton Valley, Calgary, Stirling, Sturgeon County, and Westlock.

According to Kennedy, Frappé-Sénéclauze, and Agar of the Pembina Institute, the province of Ontario, "passed amendments to legislation in 2012 to explicitly enable municipalities to establish PACE programs."(2020, p.7) In 2022, the province maintains PACE programs in Toronto and Guelph. The City of Toronto's Energy Retrofit Program offers fixed, long-term, low-interest financing to enable building owners to invest in low-carbon energy-efficient capital improvements with financing up to 100 percent of project costs with repayment terms up to 30 years. In addition, applicants can be eligible for up to one-year interest-free and payment free terms (City of Toronto, 2023).

Some PACE programs, such as the Nova Scotia Clean Energy Financing and Halifax Solar City programs and the Alberta Clean Energy Improvement Program even allow outstanding repayments to remain with the property (e.g., in the case of a property is sold, the new owners could take on the repayments).

The remaining Canadian provinces have some energy efficiency programs in place such as on-bill financing through utility companies, climate change action plans, clean energy loans and heat pump loans. The theme of these programs is similar, providing energy efficiency upgrades to homeowners through a loan payback program, in some cases added to the homeowner's property tax bill or other financing options. These programs are all voluntary and not coordinated outside of the individual province. Organizations like the Pembina Institute track these programs but individual participation by local or provincial governments is voluntary and often subject to legislative change. The following section will explore climate change policies and practices in Canadian jurisdictions at a more granular level – within Canadian assessment organizations and property tax policies.

Canadian Assessment Practices and Tax Policies

Although climate change is at the forefront of many Canadian provinces and green building technologies are becoming more popular, there is a lack of focus on the topic in the assessment industry. Questions regarding the impact of the green energy transition on assessed property values and property taxes remain largely unaddressed:

- How does the replacement of an oil tank with a heat pump impact property value?
- Does the market indicate a premium for energy efficient heating sources?
- Are there any property tax advantages to having a more efficient home?
- And how can this be reflected in both property assessment practices and property tax policies in a fair and consistent manner?

Most of the research on assessment practices, policies and methods focus on historical references to the equitable distribution of property taxes as described in Assessment Methods for Urban Real Property (Ring, 1949). More recent assessment practices can be referenced in industry accepted standards of practice. The International Association of Assessing Officers (IAAO)'s Standard on Mass Appraisal of Real Property discusses the widely used practice of mass appraisal for assessment purposes, stating, "mass appraisal is the process of valuing a group of properties as of a given date and using common data, standardized methods, and statistical testing. To determine a parcel's value, assessing officers must rely upon valuation equations, tables and schedules developed through mathematical analysis of market data," (IAAO, 2017, p. 1). Nowhere in this standard of practice is the mention of climate change or sustainability. It is imperative to review climate change more thoroughly in current provincial assessment legislation to determine if climate change has been considered in property assessment practices in Canadian assessment organizations.

Additional research has been conducted on agricultural, conservation and forest land policies. Greenwood and Whybrow (1992) have studied the preferential treatment of agricultural and forestland types in assessment and property tax systems in several Canadian provinces, which is illustrative of the current focus of the literature on this topic area.

Although the treatment of agricultural and forest land properties is advantageous from an assessment and property tax perspective in many Canadian jurisdictions, it is far more complex to distinguish if these land use types are considered good for climate change. There is research both in support and in opposition to agriculture and forest lands and their contribution to climate change. For example, the World Future Council (2012), an international organization who works to promote sustainable ecosystems and livelihoods, states that, "modern agriculture, food production and distribution are major contributors of greenhouse gases. Agriculture is directly responsible for 14 percent of total greenhouse gas emissions. Deforestation currently accounts for an additional 18 percent of emissions." Another article from the BBC states, "One paper says that financial incentives to plant trees can backfire and reduce biodiversity with little impact on carbon emissions. A separate project found that the amount of carbon that new forests can absorb may be overestimated (BBC, 2020)."

The Massachusetts Institute of Technology's (MIT) Climate Portal takes a different perspective, emphasizing the "carbon sink function of forests," (MIT Climate Portal, 2021). Accordingly, "careful forest management can therefore be an important strategy to help address climate change," (MIT Climate Portal, 2021). Similar to MIT, the BBC addresses "how farming can help to heal nature", the title of an article focused on how to change the world's food system to make it more sustainable. Solutions posed include a shift to a plant-based economy and the use of technological solutions (BBC, 2023).

To summarize, in studying climate change, there are opposing views on whether forest and agricultural land are good for climate change. As this is a complex topic, the use of favourable assessment and tax policies have been included in the analysis below, however more research into how to combat climate change is still required by experts in the field.

The following section includes a brief review of the ten provinces' and three territories' assessment legislation and publicly shared reports and plans revealed minimal focus on climate change or the green energy transition. A review of property tax policies to support climate change resulted in very sparse information revealing how little consideration has been given to this topic (CBC, 2022). The provinces with the most identifiable policies, practices or legislation in place to support climate change in assessment or property tax include Alberta, British Columbia, Nova Scotia and Ontario. A brief overview of the impact the climate urgency is having on these four provinces' assessment practices and property tax policies follows.

Alberta

In addition to their PACE program, the Government of Alberta has focused its effort on the province's energy industry. In 2022, it introduced a three-year property tax exemption beginning for energy companies drilling new wells or building new pipelines and has eliminated the well drilling equipment tax for new drills. These supports for the energy industry are in place to bolster the recovery of the province's economy during the COVID-19 pandemic. Assessed values for less productive oil and gas wells, or shallow wells, will also be reduced by 35 percent for three years (CTV News, 2020). Alberta's Municipal Affairs department also provides property tax exemptions for wetlands on Provincial or Federal Crown land used for Ducks Unlimited (Canada) purposes (Government of Alberta, 2005).

British Columbia

Climate change action is well documented in British Columbia (BC). The province of BC, through its CleanBC better homes and better buildings initiative, aims to help households and businesses reduce their energy consumption and greenhouse gas (GHG) emissions, (Government of BC, 2022).

There are several programs in support of CleanBC:

- CleanBC Better Homes and FortisBC Heat Pump Loans

- Clean Energy Loan (Vancouver and area)
- On-Bill Financing (City of Nelson) for water and energy efficiency upgrades
- On-Bill Financing Penticton Home Energy Loan Program

The framework established through CleanBC is reflected in the 2021-22 mandate letter sent to BC Assessment (BCA), the Crown Corporation tasked with property assessments. The letter broadly requires that the "organization aligns operations with targets and strategies for minimizing greenhouse gas emissions and managing climate change risk," (BC Assessment, 2021).

Nova Scotia

Climate change is well supported in the province of Nova Scotia (NS) through Efficiency Nova Scotia, a program working to reduce reliance on oil for heating homes, resulting in more than 10% of the province's homeowners switching to heat pumps over the last five years (Government of Nova Scotia, 2022). In addition to various PACE programs throughout the province, NS also utilizes on-bill financing from Nova Scotia Power to finance heat pumps and clean energy loans for energy efficiency upgrades.

Nova Scotia's assessment organization, Property Valuation Services Corporation (PVSC) is responsible for assessing all property in the province as mandated under the Nova Scotia Assessment Act. There are two key areas of the Act that address land conservation or energy efficiency in real estate for assessment purposes: Sections 45B and 48.

Section 45B of the Nova Scotia Assessment Act - Conservation Property (2022) states that, *"conservation property shall be exempt from taxation under this Act or any other public or private Act of the Legislature authorizing a tax on the assessed value of the property," (Nova Scotia Assessment Act, 2022 p.29). This notion is further supported by the Conservation Property Tax Exemption Act which "encourages private landowners through a property tax exemption, to legally protect their ecologically significant lands,"* (Government of Nova Scotia, 2022).

Section 48 of the Nova Scotia Assessment Act - Energy Conserving Device (2022) states:

> *The assessment of a residential property shall not be increased during the period between an assessment and a general reassessment in respect of the increase in value to the residential property resulting from the installation of insulation or additional insulation or of the addition of or conversion to active energy conserving, power, or heat devices. (p.31)*

Local governments are also responding to the urgency of climate change. The Halifax Regional Municipality has approved a Climate Action Tax for 2022-2035, whereby property taxes for residential and commercial properties will increase an additional 3.0% to fund key climate action initiatives in the municipality, (on top of the 2.9% increase to property taxes), (Halifax Regional Municipality, 2022).

Ontario

In Ontario, there are two property tax incentives that are built into the property assessment framework. Once properties are classified as either conservation or managed forest by the Municipal Property Assessment Corporation (MPAC), they are eligible for property tax exemptions.

Privately owned conservation areas are subject to the Conservation Land Tax Incentive Program, which "recognizes, encourages, and supports the long-term private stewardship of Ontario's provincially important natural areas. Under the program, portions of your property that have eligible natural heritage features may qualify for a 100% property tax exemption," (Government of Ontario, 2022). There is also a Managed Forest Tax Incentive Program in Ontario, whereby landowners who get their property classified as Managed Forest pay 25% of the municipal tax rate set for residential properties (Government of Ontario, 2022).

In conclusion, there are a patchwork of methods used to tackle the green energy transition in Canada. Municipalities, provinces, and the assessment industry do not approach the issue similarly. There is not one standard or approach to how property taxation policies and the real estate sector can support climate change adaptation (Fair, 2022). Further, there does not appear to be any consultation or engagement between these actors on this topic. According to Chris Chopik of CMHC, the Appraisal Institute of Canada (AIC) has been "wrestling with this topic" for over a decade (Chopik, 2022). What we are witnessing are the very early stages of awareness around the possibilities and opportunities ahead. In this respect, Canada is lagging other countries like the United States of America and European states where concerted efforts have been made towards supporting the green energy transition in the real estate sector (Efficiency Canada, 2022; Resendes, 2022).

International Calls to Action

Reacting to a recent report from the Intergovernmental Panel on Climate Change (IPCC), the UN's Secretary General, Antonio Guterres, sounded the alarm (Dennis, 2022). Rapid action is needed to keep the promises made in the 2015 Paris Accord and avoid climate changes' most devastating impacts on our ecosystem, health, and livelihood. Timing is everything (Goulder, 2020) and associative action is most likely to provide positive results (Gills and Morgan, 2020).

Said associative action requires that a wide of range of actors, including governments, not for profit, Indigenous communities, businesses (etc.) participate and diverse approaches be used to mitigate the impact of climate change. Concerted and joint effort is required to address its human causes and impacts. This view was echoed by several of the experts we consulted. Both Connie Fair, former CEO of BCA and Land Title and Survey Authority (LTSA) and Russ Adams, VP Assets of PVSC, for instance, stressed the need for strategic alignment and coordination between all levels of government for any real progress (Fair, 2022 and Adams, 2022).

Urban centers, in particular, through their greenhouse gas emissions, are major contributor to climate change (United Nations, 2022). The International Energy Agency (IEA, 2021) estimates that cities (including their suburban sprawls), make up more than 70 % of annual global GHGs. And in Canada, nearly 3 out of 4 Canadians live in those urban centers, according to 2021 statistics (Statistics Canada, 2022). As aptly put by Hoornweg et al., "in a fast-approaching world with 9 billion people, 70 per cent of whom are expected to live in urban areas by 2050, cities must be efficient, [….] and emit far less GHGs," (Hoornweg, Sugar, and Trejos Gomez, 2020 p.43). Land use and the notion of retrofitting buildings and homes to increase energy efficiency have garnered support over the years. And yet, the IPCC notes low ambition in this area (IPCC, 2022, p. 41-22).

Studies continue to overlook the potential impact of climate change and energy transition policies on the assessment industry, valuation methods, and tax polices. This is evidenced by the IAAO's recent survey of Assessment Policy and Administration trends in the US and Canada (Dornfest, Rearich, and Brydin, 2018). Whilst it did capture business incentives and economic development programs that included new incentives for air pollution control equipment and wind/solar green energy initiatives, it largely ignored the broader context of climate change and energy policies.

The United States (US) offers tax incentives for energy efficiency upgrades. For example, the Internal Revenue Services (IRS, 2022) provides residential energy efficient property credits for a credit equal to the applicable percent of the cost of qualified property, on a sliding scale depending on the date the property is placed in service. In addition, the US enjoys a wide variety of PACE programs, EnergyStar federal residential tax credits for renewables and efficiency, financing energy efficient homes and a low-income home energy assistance program, to name a few examples (Energy.gov, 2022).

Whilst individual homeowner or business action is important, it is insufficient. According to Dixon and Eams, actions to be scaled up into a coordinated and purposive approach (Dixon and Eames, 2013). We argue that this is where property assessment practices and taxation policies have a unique role to play and can further the transition towards green energy use.

The European Union (EU) has been a leader in this domain, and much can be learnt from its approach to the green energy transition in the real estate sector. Through the introduction of an energy performance assessment for all buildings and homes, the EU has made the use of energy ratings in the sale or rent of properties a pillar of its Energy and Climate policy. Introduced in 2002, the uniform use of an energy requirement certificate (EPC) became a mandatory requirement for all member states in 2009. An EPC rating is assigned to each property and informs buyers and renters of the energy performance of their home or business.

Over the years since its implementation, EPCs have become more than a consumer and property owner information tool. The certification scheme has contributed to the monitoring of the energy performance of the building stock in each member country and has started to play a normative role around construction and building policy and regulatory frameworks across Europe (BPIE, 2014). It has become "without doubt a key enabler in making energy performance count in the market," (BPIE, 2014 p.47). In fact, according to the International Energy Agency, "energy certification of buildings is a key policy instrument for reducing the energy consumption and improving the energy performance of new and existing buildings," (IEA, 2010 p.7).

Its impact has become noticeable on the real estate market, rental industry and property prices across the European Union (European Commission, 2013). For instance, only a year after the introduction of energy efficiency labels in France, it was estimated that high efficiency houses (rated A & B on a A-G scale) were selling for approximately 14% and 27% higher than their equivalent in other brackets, (French Property, 2022). A longitudinal study on EPC and housing in Europe by The Tias Business School of Tilburg University confirms that "non-energy rated homes (energy performance label red; F and G) are being sold at a growing price discount." Tilburg University, 2021)

The Energy Efficiency Certification scheme, whilst promising, does not come without its own challenges. To begin, the cost of retrofitting property can be a heavy financial burden preventing many individual homeowners from moving forward. For this reason, financial incentives via rebates or tax credits can be instrumental in supporting the green energy transition. To mitigate the financial pressure of the retrofitting on homeowners, European countries such as Ireland or France have introduced grant schemes for energy retrofit as well as subsidies and tax reduction or exemption, (IEA, 2010 p.19).

Secondly, the energy performance certification process is complex, requiring the examination of many factors including but not limited to the construction material, building size and use, local climate and building design to name a few, (IEA, 2010 p.8). Such assessment requires in-depth and expert knowledge. Generally, consultants, building experts or environmental engineers are hired to conduct properties' energy assessments for EPCs. Two additional challenges to the EPC mechanism include the properties' energy performance assessment method and its implementation (IEA, 2010 p.4).

The Way Forward

Property assessment, in Canada, falls to the provincial or jurisdictional level. Each province is subject to the legislation of their individual assessment organization or government department and is responsible for producing their own assessment roll. Assessment rolls are produced at various cycles depending on the individual Assessment Act or governing legislation. Assessment organizations provide completed assessment rolls to local governments who rely on them for setting a property tax base for all properties in the jurisdiction. As such, assessment organizations and local taxing authorities already have solid mechanisms in place for information sharing and, therefore, potential coordination of efforts. It is clear, however, that the way forward must first be captured in a shared vision between all levels of government. The current siloed approach is not conductive to progress or innovation (Adams, 2022). Alignment between government goals, polices and (tax) incentives is needed (Fair, 2022). A strategic framework, reflecting the diversity of Canada's real estate and taxation landscape can and must be implemented. For any hope of success, it must start from the top level of government.

The federal government, however, cannot go it alone. Indeed, the complexity of the Canadian property assessment industry landscape means that partnerships and collaboration between assessment jurisdictions and the federal government are key to the discussion of EPCs or other energy efficiency measures. Assessment, taxation, and real-estate actors must come together, under federal government direction to develop a national legislative framework, supported by stronger incentives for individual property owners and the construction industry. With a Canada-wide directive and legislation in place, real estate organizations could then lead collaboration efforts and create partnerships between the public and private real estate sectors to make the impact of energy efficiency more tangible and visible to the public.

Canadian assessment organizations are data rich organizations, with skilled and knowledgeable staff. As a result, they are uniquely positioned to contribute to furthering the country's effort towards a green energy transition. Assessors, who are already efficient in property valuation, can be further trained to recognize energy efficiency and reflect these elements in assessments. Properties listed for sale by the real estate industry could also include energy rating information. With the right incentive, that information on energy efficiency could be provided by homeowners themselves (Resendes, 2022; Kuijper and Kathmann, 2023). Taxation actors can also translate energy efficiency in property tax savings and deduction, further incentivising the green energy transition. With a mechanism in place, taxpayers themselves can be encouraged to report energy efficiency home improvements (Kuijper and Kathmann, 2023).

Missing pieces include a lack of universal training for assessment, real estate and building professionals on how to recognize energy efficiency (Dollinger, 2022). The absence of a uniform energy efficiency rating and labeling further compounds our inability to move forward with concrete steps. Whilst several guides and certification programs are being utilized, including BuiltGreen, Step Guide, LEED, Passive House, Energy Star and R2000 (Clean BC, 2022), "the diversity in branding of those ratings creates confusion in the marketplace," (Chopik, 2022) and muddles the water for industry professionals. Finally, whilst it is clear that appetite for energy efficient or 'green' homes is growing, (Dollinger, 2022; Schorle, 2023; Resendes, 2022) further research is needed to fully understand the extent of that appetite, how it influences the real estate market and how it could shape local taxation policies.

In conclusion, this examination of how property assessment practices and taxations policies can support the green energy transition in Canada demonstrates how much work there is still left to do. Whilst there exist several gaps, there are also many opportunities for different levels of governments and real estate actors to collaborate and capitalize on what is already in place, to further the green energy transition. On that point, existing international efforts, such as European and American policies and practices, can help us understand what the way forward may look like and what some of the obstacles may be in Canada.

References

Amado, M et al. (2016). Energy efficient city: a model for urban planning. Sustainable Cities and Society 26, pp. 476-485.

BBC. (20 June 2020) Planting new forests can do more harm than good. Retrieved February 24, 2023, from https://www.bbc.com/news/science-environment-53138178

BBC. How farming can help to heal nature. Retrieved February 24, 2023 from https://www.bbc.com/future/bespoke/follow-the-food/how-farming-can-help-to-heal-nature.html

BC Assessment. 2021-22 Mandate letter. Retrieved March 1, 2023, from https://info.bcassessment.ca/about/Publications/2021-2022%20Mandate%20Letter.pdf

Buildings Performance Institute Europe (BPIE). (2014). Energy Performance Certificates across the EU. Retrieved July 17, 2022 from https://bpie.eu/wp-content/uploads/2015/10/Energy-Performance-Certificates-EPC-across-the-EU.-A-mapping-of-national-approaches-2014.pdf)

CBC. (25 April 2022). How Halifax plans to use property tax hike to tackle climate change. Retrieved March 9, 2023 from https://www.cbc.ca/news/canada/nova-scotia/halifax-climate-change-municipal-budget-property-tax-increase-1.6430026

Canadian Mortgage and Housing Corporation. CMHC green home. Retrieved May 30, 2022 from https://www.cmhc-schl.gc.ca/en/consumers/home-buying/mortgage-loan-insurance-for-consumers/cmhc-green-home

Energy.gov. Financing and incentives. Retrieved May 5, 2022, from https://www.energy.gov/energysaver/financial-incentives

Fesenfeld, L & Rinscheid, A. (2021). Emphasizing urgency of climate change is insufficient to increase policy support. One Earth, Vol 4, Issue 3, pp 411-424.

City of Toronto. Energy Retrofit Loans. https://www.toronto.ca/services-payments/water-environment/environmental-grants-incentives/energy-retrofit-loans/

Clean BC. Retrieved March 22 2023 from https://www.betterhomesbc.ca/faqs/how-does-the-bc-energy-step-code-compare-to-other-green-building-labeling-and-certification-programs-passivehouse-builtgreen-energy-star-r2000-leed/

Clean Energy Financing. Retrieved February 17, 2023, from https://cleanenergyfinancing.ca/

Cleantech. Canada: improving property tax system for green energy. Retrieved March 9, 2023, from https://cleantechlaw.com/2012/01/canada-improving-property-tax-system-for-green-energy/

CTV news. (19 October 2020). Alberta offers property tax exemption to energy companies frilling wells or building pipelines. Retrieved April 28, 2022 from https://calgary.ctvnews.ca/alberta-offers-property-tax-exemption-to-energy-companies-drilling-wells-or-building-pipelines-1.5151302

Dennis, B. (21 March 2022). U.N. secretary general says global climate target ‘is on life support. The Washington Post. Retrieved February 27, 2023 from https://www.washingtonpost.com/climate-environment/2022/03/21/15c-climate-guterres-life-support/

Dornfest, Alan S, Rearich, Jennifer, Bergen, T & Brydin, T. (September 25, 2018). Assessment Policy/Administration Trends in the US and Canada. Paper presented at IAAO 2018 Research Exchange. February 15, 2022, from https://library.iaao.org/fulltext/cp18090646.pdfhttps://researchexchange.iaao.org/conference/IAAO2018/schedule/63/

Efficiency Canada. The 2020 Model Building Codes. Retrieved February 26, 2023, from https://www.efficiencycanada.org/building-codes-2020/

Efficiency Canada. (17 November 2022). Canadian Energy Efficiency Scorecard highlights new opportunities in building codes and low-income programming. Retrieved February 24, 2023, from https://www.efficiencycanada.org/scorecard-2022-press-release/

Energy ratings and French house prices. Retrieved April 23, 2022, from https://www.french-property.com/news/french_property/energy_ratings_house_prices

European Commission. (April 2013). Energy performance certificates in buildings and their impact on transaction prices and rents in selected EU countries. Retrieved July 17 2022 from https://ec.europa.eu/energy/sites/ener/files/documents/20130619-energy_performance_certificates_in_buildings.pdf

Gills. B and Morgan. J. (2020). Global Climate Emergency: after COP24, climate science, urgency, and the threat to humanity. Globalization Vol 17, Issue 6, pp 885-902.

Goulder, L. (Winter 2020. Timing Is Everything: How Economists Can Better Address the Urgency of Stronger Climate Policy. Review of Environmental Economics and Policy Vol 14, Number 1, pp 143-156.

Dixon, M & Eames, M. (2013) Scaling up: the challenges of urban retrofit. Building Research & Information 41:5, pp. 499-503.

Government of Alberta. Property Tax exemptions in Alberta: a guide. Retrieved May 20, 2022 from http://www.municipalaffairs.alberta.ca/documents/as/pte_guide_2005.pdf#:~:text=In%20Alberta%2C%20property%20tax%20exemptions%20can%20occur%20in,from%20property%20taxation%20is%20confirmed%20in%20section%20351.

Government of British Columbia. Energy Efficient Programs. Retrieved February 21, 2023, from ttps://www2.gov.bc.ca/gov/content/industry/electricity-alternative-energy/energy-efficiency-conservation/programs

Government of Canada. Canada's climate actions for a healthy environment and a healthy economy. Retrieved February 7, 2022, from https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/climate-plan-overview/actions-healthy-environment-economy.html

Government of Canada. Canada's greener home grant. Retrieved April 22, 2022, from https://www.nrcan.gc.ca/energy-efficiency/homes/canada-greener-homes-grant/23441

Government of Canada. (2022) Canada's greener home grant, Winter 2022 Update. Retrieved June 1, 2022 from https://www.canada.ca/en/natural-resources-canada/news/2022/01/canada-greener-homes-grant-winter-2022-update.html

Government of Ontario. Conservation Land Tax Incentive Program. Retrieved April 30, 2022 from https://www.ontario.ca/page/conservation-land-tax-incentive-program#:~:text=The%20Conservation%20Land%20Tax%20Incentive%20Program%20recognizes%2C%20encourages,may%20qualify%20for%20a%20100%25%20property%20tax%20exemption.

Government of Ontario. Managed forest tax incentive program. Retrieved April 30, 2022, from https://www.ontario.ca/page/managed-forest-tax-incentive-program

Government of Nova Scotia. Conservation Property Tax Exemption. Retrieved April 15, 2022, from Conservation Property Tax Exemption | Protected Areas | Nova Scotia Environment.

Government of Nova Scotia. Efficient Nova Scotia Program. Retrieved April 20. 2022 from https://www.efficiencyns.ca/

Greenwood, J & Whybrow, A. (1992) Property tax treatment of agricultural and forestland in Canada: Implications for land use policy. Property Tax Journal 11, pp 159-206.

Home energy efficiency in France. Retrieved April 23, 2022, from https://www.french-property.com/guides/france/building/renovation/energy-conservation/

Hoornweg, D, Sugar, L & Trejos Gomez, C. (May 2020). Cities and Greenhouse Gas Emissions: Moving Forward. Urbanisation 5, no. 1, 43-62.

International Association of Assessing Officers. (2019). Standard on Mass Appraisal of Real Property: A criterion for measuring fairness, quality, equity and accuracy, p. 1. https://www.iaao.org/media/standards/StandardOnMassAppraisal.pdf

MIT Climate Portal. (7 October 2021). Forests and climate change. Retrieved February 24, 2023, from https://climate.mit.edu/explainers/forests-and-climate-change

International Energy Agency. (22 July 2021). Empowering "Smart Cities" toward net zero emissions. Retrieved May 27, 2022, from https://www.iea.org/news/empowering-smart-cities-toward-net-zero-emissions

International Energy Agency. (2010). Policy Pathway: Energy Performance Certification of Buildings. https://www.iea.org/reports/policy-pathway-energy-performance-certification-of-buildings.

Intergovernmental Panel on Climate Change. (2022). 6th Assessment Report 2022.

https://www.ipcc.ch/report/ar6/wg2/downloads/report/IPCC_AR6_WGII_FinalDraft_FullReport.pdf

IRS. Energy Incentives for Individuals: Residential Property Updated Questions and Answers. Retrieved May 5, 2022, from https://www.irs.gov/newsroom/energy-incentives-for-individuals-residential-property-updated-questions-and-answers.

Kennedy, M, Frappé-Sénéclauze, T & Agar, B. (June 2020). Property Assessed Clean Energy in Canada: Design considerations for PACE programs and enabling legislations. Pembina Institute.

Halifax Regional Municipality. Budget. Retrieved October 22, 2022, from https://www.halifax.ca/city-hall/budget-finances/budget

Halifax Regional Municipality. Solar Projects. Retrieved October 30, 2022, from https://www.halifax.ca/home-property/solar-projects/about-solar-city

Nova Scotia Assessment Act. April 15, 2022 https://nslegislature.ca/sites/default/files/legc/statutes/assessment.pdf

NovaScotiaPACE https://novascotiapace.ca/pace-programs/

Pembina Institute. https://www.pembina.org/about/about-pembina

Personal communication between Carlos Resendes and Laura Maclean, October 3, 2022.

Personal communication between Connie Fair and Laura Maclean, October 13, 2022.

Personal communication between Ruth Dollinger and Laura Maclean, November 23, 2022.

Personal communication between Russ Adams and Laura Maclean, December 19, 2022.

Personal communication between Chris Chopik and Laura Maclean, December 23, 2022.

Personal communication between Marco Kuijper & Ruud Kathmann and Laura Maclean, January 2, 2023.

Personal communication between Patrick Schorle and Stephanie Vieille, February 23, 2023.

Tilburg University. (15 November 2021). The red energy performance label increasingly hurts home sales. https://www.tilburguniversity.edu/current/news/more-news/red-energy-performance-label-increasingly-hurts-home-sales

United Nations. Climate Action. Retrieved May 31, 2022 from https://www.un.org/en/climatechange/climate-solutions/cities-pollution#:~:text=Cities%20are%20major%20contributors%20to,cent%20of%20the%20Earth's%20surface.

United Nations. What is climate change? Retrieved May 31, 2022, from https://www.un.org/en/climatechange/what-is-climate-change

Statistics Canada. (Feb 2022). Canada's large urban centers continue to grow and spread. Retrieved June 1, 2022, from https://www150.statcan.gc.ca/n1/daily-quotidien/220209/dq220209b-eng.htm

World Future Council. (2012). How does agriculture contribute to climate change. https://www.worldfuturecouncil.org/how-does-agriculture-contribute-to-climate-change/

Zeidler, M. (May 17, 2019). New energy efficient buildings aren't enough, experts say — we have to retrofit the old ones, too. CBC News. Retrieved June 1, 2022, from https://www.cbc.ca/news/canada/british-columbia/green-buildings-retrofits-1.5150658

A Review of Vertical Equity Measures in Property Assessments

BY THE IAAO STATISTICAL TOOLS AND MEASURES TASK FORCE

1. Introduction

Assessment equity is a primary concern for municipalities that levy ad valorem taxes. Property taxes are a popular source for funding local services and are typically the largest source of municipal revenues. Assessment equity requires that assessment levels be fair for properties across price levels (vertical equity) and across properties with similar characteristics (horizontal equity). The Standard on Ratio Studies (IAAO, 2013) discusses the measurement of horizontal and vertical equity and its reporting requirements which the majority of jurisdictions adhere to.

1.1 Scope

This paper focuses on vertical equity measures. In addition to methods covered in the Standard on Ratio studies, this paper gives an overview of alternative methods such as Gini-based and nonparametric tests of vertical equity. A comparative study of performance is done on simulated datasets. The use of simulated datasets enables us to test each method against a known data-generating mechanism: because we know whether (and in what direction) vertical inequity truly exists in our data, we also know whether or not a given method draws the correct conclusion.

The IAAO Statistical Tools and Measures Task Force comprises **CARMELA QUINTOS**, Chair, and members **KRISTIE FOSTER**, **MOLLY HAYES**, **LUC HERMANS**, **MICHAEL McCORD**, **JOSHUA MYERS**, **VILMA VIELMA**, and **CORY YEMEN**. **SHAUN YORK** served as IAAO staff liaison.

The paper is organized so that the measurement and tests of vertical equity are grouped into five categories. The categories are based on the statistical approach to measurement, and within each category are tests for vertical equity. The categories and tests are:

1. regression models of assessed values on prices
   - Assessment-to-sales ratio regression on price (ASR; IAAO, 1978)
   - Paglin-Fogarty (Paglin and Fogarty, 1972) regression of assessed values (AV) on sales prices (SP)
   - Cheng (1974) regression of the log of AV on the log of SP
2. errors-in-variables (EIV) models
   - Kochin-Parks (Kochin and Parks, 1982) regression with AV as market proxy
   - Price-related bias (PRB) regression (Gloudemans, 2011)
   - Clapp (1990) instrumental variables regression
3. models based on inequality measures (distributional approach)
   - Kakwani Index (KI), introduced by Kakwani (1977) as the difference of Gini measures
   - Modified Kakwani Index (MKI) introduced by Fukushige, Ishikawa, and Maekawa (2012) as the ratio of Gini measurements
4. non-parametric tests
   - Kruskal-Wallis test, a non-parametric ANOVA based on group ranks
   - Spearman rank test, which tests the correlation of the ranks of assessments and prices
5. parametric tests
   - ANOVA F test, which relies on between- and within-group variability

Models in categories 1, 3, 4, and 5 are constructed under the assumption of no errors in variables and are referred as a group as non-EIV models.

The price-related differential (PRD), which measures the relationship between the weighted and unweighted mean of the assessment to sales ratio, is another commonly used index for vertical equity. The PRD does not have a standard statistical distribution, but it is included in our tables using both a bootstrap confidence interval and the fixed interval recommended by the IAAO.

Section 2 discusses the simulation set-up; Section 3 explains further the models described above and Section 4 discusses the simulation results. Tests in categories 1-3 are based on the T distribution and therefore their distances to the null distribution are directly comparable. A more general approach based on information theory could be used to compare test performance across all categories and is a subject for future research. All methods discussed in this paper test for global vertical equity. Section 5 illustrates, through an empirical example, the difference between global and local equity. The final section concludes with a recap of our findings.

1.2 Results Overview

The main points and results of the paper are:

1. ASR and PRB have at least some endogeneity bias by construction because the dependent and independent variables are related in each method. The more severe the endogeneity, the more the underlying relationship with market value will be masked or distorted. In the ASR, the sales price appears on both sides of the equation, whereas in the PRB, both AV and SP appear on both sides. The endogeneity by construction is likely worse in ASR than in PRB. PRB likely mitigates this concern due to the fact that the right side of the equation has both the numerator, AV, and the denominator, SP, of the ratio AV/SP in the form of the adjusted average of AV and SP. Sections 3.1 and 3.2 explain this issue. In any case, it is important to understand that measurement error is also a source of endogeneity. In the common EIV situation, any endogeneity by construction in PRB is potentially counteracted by its improved handling of the measurement error issue. ASR does not address measurement error so it also suffers from that source of endogeneity under the EIV scenario.

2. By construction, Paglin-Fogarty and Cheng regressions have regressivity bias, in that they are regressive when the sample used to construct the vertical equity test is also the estimating sample. This is because AV and SP appear on each side of the equation with a one-to-one relationship as measured by the slope coefficient. Regressivity occurs for the special case in which the estimating sample is used because the slope coefficient in the vertical equity regression is equal to the R-square and therefore bounded above by 1. This result is derived in McMillen-Singh (2022) and discussed in Section 3.1. Kochin-Parks would have a similar bias toward progressivity.

3. In the class of non-EIV models, which are tested with the T-score, the Paglin-Fogarty, Cheng, Kakwani Index, and Modified Kakwani Index scored highest and behave the same in that they all tend toward the same direction (i.e., they all tend toward vertical equity, regressivity, or progressivity in a given case). Their T-scores are also within range of each other. While the ASR behaves similarly to these four tests, its endogeneity problem prevents its preferred status.

4. In the class of EIV regression models, the Clapp test is preferable when considering the criteria investigated in this report. PRB and Clapp performed similarly in our tests because they are based on the premise that essentially a compromise between AV and SP should be used as the proxy for market value. The PRB has the endogeneity problem in its construction, and the Kochin-Parks test fails to detect the correct form of vertical inequity when horizontal inequity is present. The Kochin-Parks test was the only test (other than the PRD under the IAAO interval) to fail consistently in this set-up (scenario 6 across Cases A, B, and C in tables 4.1 – 5.3).

5. In the class of non-parametric and parametric tests, the Spearman rank test is preferable. While the Kruskal-Wallis and ANOVA F have correct size (probability of type I error) in line with the methods in 2 above, the tests cannot determine via a testing procedure the direction of vertical inequities. The non-parametric Spearman rank test also behaves like the four tests in 2 above, scored similarly, and should be included in a suite of tests for vertical equity.

6. Measurement error affects size and power. The class of EIV models behave differently than the non EIV models. The non-EIV models are constructed with the assumption of no errors-in-variables. They assume that arms-length prices are very good proxies for market value in that any errors that occur are insignificant. When measurement errors do exist as variance distortion from the true market value, the non-EIV models have incorrect size and uniformly tilt toward regressivity. In contrast, in cases where the EIV models also have incorrect size, they uniformly tilt toward progressivity. All the tests have the power to detect vertical inequity in the right direction when it exists in the data-generating process, regardless of the measurement error assumption. The

measurement error assumption, generated as variance distortion from the true market values, affects the size of the tests more so than their power. In other words, while the non-EIV tests, which assume no errors-in-variables, have incorrect size when the assumption fails, they do have the power to detect vertical inequity even in the presence of measurement errors. Similarly, the EIV tests, which are constructed assuming errors in variables, have incorrect size when there are no measurement errors but they do have the power to detect vertical inequities in the right direction.

7. Across all approaches, only the PRD, KI, MKI, and Spearman rank are index measures. An index is a single, composite score that represents the degree of a statistical quality of several distributions. The single score can have many properties, but a desirable property is that it be unitless. A unitless index enables comparison across datasets that could have been measured in different units, for example in thousands versus millions. Depending on the use of an index, another desirable property is that it be bounded. A bounded index enables determination of the strength of the relationship relative to its bounds. A well-known index is the Pearson correlation coefficient, which measures the strength of the co-movement between two series. It is unitless, so, e.g., a correlation of .8 has the same meaning regardless of whether it was measured with data in thousands or millions. The correlation coefficient is also bounded between -1 and 1. The closer the correlation estimate is to either boundary, the stronger the relation. For example, a .8 correlation between assessments and prices represent a stronger relation than a .5 correlation, regardless of the unit of measurement. At the bounds, the "perfect" relations exist and are measured: for example, a correlation of 1 is a perfect positive co-movement between two series. Both the PRD and MKI are unitless but unbounded indices. In contrast, the KI and Spearman rank indices are both unitless and bounded.

8. The PRD performs well in our simulation study when conclusions are drawn based on a bootstrap interval, but it performs the worst when conclusions are based on the standard IAAO interval (where a PRD less than 0.98 indicates progressivity and a PRD greater than 1.03 indicates regressivity; IAAO, 2013).

2. Simulation Study

Accurately assessing the degree of inequity inherently present using a given set of methods requires the use of data that is constructed in such a way that both the level and location of the inequity is known. This section describes the data-generating mechanisms used to construct such a dataset for this exercise. A real-world dataset could not have been used, because without knowledge of the actual degree of horizontal inequity and vertical inequity in a dataset, one is not able to judge whether a given method of detection is correctly accepting or falsely rejecting the null hypothesis.

The vertical equity tests are constructed from the simulated datasets generated under different scenarios of vertical and horizontal inequity. We performed our experiment on three different datasets with varying relationships among assessed values, sales prices, and market values. The purpose of these three cases is to find patterns in the behavior of the tests. (Note that this exercise is not the same as estimating the size and power of a test. To get an estimate of the size and power of a test, steps 2 and 3 listed below must be repeated several thousand times, tabulating the number of times the simulated data leads to acceptance or rejection of the null hypothesis. The power estimate is the proportion of simulated samples in step 3 that correctly lead to rejection. The significance level, or size, is the proportion of the simulated samples in step 2 that falsely lead to rejection.)

The steps to the simulation study are:

1. Specify how the test is carried out. This includes indicating how the test statistic is calculated and how the significance level is specified.

2. Determine the behavior of the test under the null hypothesis. The null hypothesis used throughout is vertical equity. Generate random samples from the distributions specified by the null hypothesis. Calculate the test statistics from the simulated data and determine if the null hypothesis is correctly accepted or rejected.

3. Determine the behavior of the test under the alternative hypothesis. The alternative hypothesis used throughout is vertical inequity in the direction of regressivity or progressivity. Generate random samples from the distributions specified by the alternative hypothesis. Calculate the test statistics from the simulated data and determine if the null hypothesis is incorrectly accepted or correctly rejected.

Details on the simulated data are discussed in Section 2.1 which follows. Test scenarios are discussed in Section 2.2. There are six scenarios set up with different types of vertical and horizontal inequities and these are laid out in tables 1 and 2 below.

2.1 Simulated Dataset and Data Generation Process

The dataset used in this exercise was randomly generated according to a given set of parameters in order to create natural variation. The relationship between various property characteristic data fields was generated in order to be realistic. Each property received a simulated true market value that forms the basis of the generation of the assessed values and the sale price. Assessed values and sales prices were generated from market value with three different types of variances and are labeled as Cases A, B, and C. Within each case, six different scenarios were set up for the Sale Price and the Assessed Value in order to simulate a series of possible combinations of horizontal and vertical inequity. Thus, a total of 18 (3*6) cases provide a view of the effect of price and AV distortion on tests for vertical equity when data is generated with horizontal equity/inequity and vertical equity/inequity.

It was important that this dataset look as much like a real-world dataset as possible. It includes fields for Parcel ID (eight digit numeric), Neighborhood (numbered 1 through 12, each simulated to contain properties with similar sizes and ages), Living Area (mean of 2187 square feet), Year Built (mean of 1945), as well as the Market Value, Sale Price, and the six Assessed Values corresponding to the six experimental scenarios.

Table 1 describes the different scenarios of horizontal and vertical inequity that were generated.

Table 1. Simulation Scenarios

Scenarios	General Description	Degree of Horizontal Inequity	Degree of Vertical Inequity
Scenario 1	No Horizontal or Vertical Inequity	None	None
Scenario 2	Progressive Vertical Inequity and No Horizontal Inequity	None	Roughly 30% linear progressive change in value over the range of the market values
Scenario 3	Regressive Vertical Inequity and No Horizontal Inequity	None	Roughly 30% linear regressive change in value over the range of the market values
Scenario 4	No Vertical Inequity and Horizontal Inequity	Age-based horizontal inequity: 90% of market value in first and fourth quartile of age and 110% in the second and third quartiles of age.	None
Scenario 5	Progressive Vertical Inequity and Horizontal Inequity	Age-based horizontal inequity: 90% of market value in first and fourth quartile of age and 110% in the second and third quartiles of age.	Roughly 30% linear progressive change in value over the range of the market values
Scenario 6	Regressive Vertical Inequity and Horizontal Inequity	Age-based horizontal inequity: 90% of market value in first and fourth quartile of age and 110% in the second and third quartiles of age.	Roughly 30% linear regressive change in value over the range of the market values

The degree of vertical and horizontal inequity was chosen so as to be both realistic and measurable. Note that the actual degree of horizontal or vertical inequity in Scenarios 2, 3, 5, and 6 may be impacted by the presence of both individually generated quantities. It was important that the type of inequity mirror something found in the real world. It was also important that a method, if largely unbiased, would be able to accurately detect such an inequity. The question we must now answer is how many types of different errors exist in the detection of vertical and horizontal equity under these data scenarios for each method of detection.

2.2 Detecting Type I and Type II Errors

The size and power of a test are referred to as the type I and type II errors respectively. A type I error (false positive) occurs when a true null hypothesis is rejected; in our case, this is when a given method indicates that either regressive or progressive vertical inequity exists when in fact it does not. A type II error (false negative) occurs when a false null hypothesis is not rejected; in our case, this is when a given regression-based method indicates that it cannot be concluded that a form of vertical inequity exists when in fact either regressive or progressive vertical inequity does exist. A form of type III error occurs when a false null hypothesis is rejected but the wrong conclusion is made; in our case, this is when vertical inequity of certain direction exists but the method indicates that the vertical inequity is in the other direction (for example, if the vertical inequity is progressive and the method indicates that the vertical inequity is regressive).

For the sake of explainability, we discuss type I, II, and III errors in light of Scenarios 1, 2, and 3, which are the cases of vertical equity, progressive vertical inequity, and regressive vertical inequity, respectively. Scenarios 4, 5, and 6 repeat Scenarios 1, 2, and 3 with the addition of horizontal inequity, expressed as additional variability of the assessed value estimate of market value. Thus, the types of errors are tested in pairs with one scenario containing horizontal equity and the second scenario containing horizontal inequity.

The paired scenarios are summarized in table 2.1.

Table 2. Scenarios used to Detect Type I and II Errors

Type of Error	Type of Vertical Redistribution	Type of Horizontal Redistribution	
		Horizontal Equity (HE)	Horizontal Inequity (HI)
Type I Error - Size	Vertical Equity (VE)	Scenario 1	Scenario 4
		VE, HE	VE, HI
Type II Error - Power	Vertical Inequity - Progressivity (VIP)	Scenario 2	Scenario 5
		VIP, HE	VIP, HI
Type II Error - Power	Vertical Inequity -Regressivity (VIR)	Scenario 3	Scenario 6
		VIR, HE	VIR, HI

Type I errors can be made in Scenarios 1 and 4 when the method concludes that statistically significant vertical inequity of a given direction exists. Type II errors can be made in Scenarios 2, 3, 5 and 6 when a method indicates that no statistically significant vertical inequity exists. Type III errors can be made in Scenarios 2, 3, 5, and 6 when a method indicates that there is statistically significant vertical inequity but in the wrong direction.

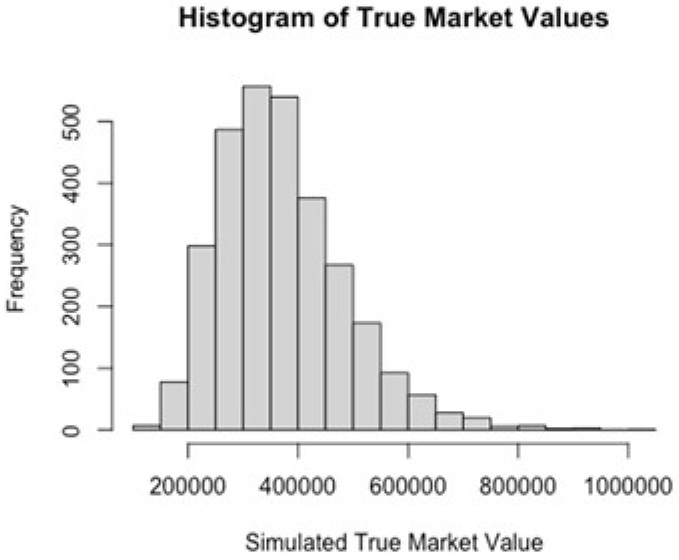
2.3 Errors in Variables Assumption and the Market Proxy

All of these types of errors result from the bias present in the method itself, which could arise from how the method is constructed or from the choice of the market value proxy. Each method of vertical inequity detection contains a choice for the market value proxy inside of its overall form. If assessed value is chosen as the market value proxy, as is the case with the Kochin-Parks regression-based method, then the method will be biased toward progressivity to the degree that the assessed value tends to be variable around the true market value. If sale price is chosen as the market value proxy, as is the case with the ratio-vs.-sale price and Cheng regression-based methods, then the method will be biased toward regressivity to the degree that the sale price tends to be variable around the true market value. If some combination of assessed value and sale price is used as the market value proxy, as is the case in the PRB and Clapp regression-based methods, then the method will be biased toward regressivity the degree to which the sale price tends to be a more unreliable indicator of market value than the assessed value, and the method will be biased toward progressivity the degree to which the assessed value tends to be a more unreliable indicator of market value than the sale price.

In order to isolate and measure the extent of the bias problem, the assessed values (AV) and sale prices (SP) were generated from a set of true market values (MV) that were generated from a log-normal distribution with mean of log(350,000) and standard deviation of 0.3. Figure 1 shows a histogram and summary statistics of MV.

Figure 1. Histogram (a) and summary statistics (b) of MV

a



b

Min	1st Quartile	Median	Mean	3rd Quartile	Max
103,066	289,352	355,831	371,893	436,193	1,012,216

Three draws each with 3,000 sample points create the base for the three cases under the EIV assumption. The simplest way to generate prices distorted from MV is to draw from the MV distribution with a different variance. Three cases are considered, each with a different variance of SP relative to AV. The performance of EIV models is biased toward regressivity or progressivity to the extent that AV or SP dominates the behavior of the market proxy. Similarly, the performance of the regression and Gini tests will be affected depending on the uncertainty of price around the true market value.

Case A in table 2.2 has SP generated with larger variance than that of AV, Case B has SP generated with variance equal to that of AV (such that they are equally good estimators for MV), and Case C has SP generated with lower variance than that of AV. More complicated scenarios, such as effects of outliers or non-linearities, are not considered here. The simplest case of variance distortion captures the base case and will illustrate the natural bias of the estimators if it exists. Note that within each of the cases below, we can analyze the size and power characteristics given in table 2.1. Thus, the six scenarios are embedded within Cases A, B, and C, giving a total of 3*6 = 18 cases.

Table 2.2. Data-Generating Process when Prices are Measured with Errors (Mean = log(350,000))

Case	Standard Deviation			Market Proxy Implication
	MV	SP	Base AV*	
A	0.3	0.3/12	0.3/15	Prices are worse estimates of MV than AV
B	0.3	0.3/15	0.3/15	Prices and AV are similar estimates of MV
C	0.3	0.3/20	0.3/15	Prices are better estimates of MV than AV

** AV is further perturbed from the base AV to reflect progressivity, regressivity, and horizontal inequity as described in Table 1.*

This set of true market values was not just useful in generating the set of assessed values and sale prices according to a reasonably accurate process model, but can also be used to quantify the degree of bias due to the choice of the market value proxy itself. The true market value, which is known through this simulation, can be substituted for the market value proxy in each method in order to quantify the degree of bias present in the method itself, because using the true market value as the proxy eliminates the bias derived from the choice of market value proxy. The amount of bias present in the method itself can be affected by issues such as that method's handling of outliers or small sample size situations, but these cases are not considered in our report. The use of the simulated true market value in the determination of the market value proxy can help to determine a good estimate of how much vertical inequity each method detects in terms of the scale used in that method. There are different schools of thought on how to perform this substitution, however, and Sections 4.1 and 4.2 describe how the results differ for the regression-based tests.

3. Measures of Vertical Equity

In this section we discuss five methods to measure and test for vertical inequity:

1. regression models of assessed values on prices,
2. EIV models,
3. models based on inequality measures,
4. non-parametric tests, and
5. parametric tests.

Common to all these tests is that they allow testing of vertical equity using p-values from a standard statistical distribution. For comparison, we also show the PRD results in terms of the IAAO [0.98, 1.03] interval (where a PRD less than 0.98 indicates progressivity and a PRD greater than 1.03 indicates regressivity; IAAO, 2013) and in terms of a bootstrap interval.

Throughout the paper we use the following variable definitions:

Abbreviation	Definition
AV	Assessed Values
SP	Sales Prices
MV	Market Values
R	Ratio defined as AV/SP

In practice, the AV and SP are known quantities. Sales prices are assumed to reflect arms-length transactions. The assessed value can be an appraisal or estimated from sales prices using mass appraisal methods. The market value is unknown. A key distinguishing feature of each model is how the unknown market value is treated. All methods are constructed with AV and SP, which are available data, while the model formulation dictates the treatment of the unknown market value.

Tables 3.1 and 3.2 summarize the various approaches considered in this paper. Methods 1-3, presented in Table 3.1, can be further grouped together as vertical equity tests based on the T-test of a regression coefficient, which assume normality of the data. Methods 4-5, presented in Table 3.2, are based on other test statistics, such as the difference between means or correlation between variables, with varying levels of assumptions on the underlying data.

Table 3.1. Regression T-Tests for Vertical Equity

Method	Model	T-Test	Market Value Proxy
1. Regressions of AV on SP			
ASR	$R = a_0 + a_1\,SP + \varepsilon$	$a_1 = 0$	SP
Paglin and Fogarty	$AV = a_0 + a_1 SP + \varepsilon$	$a_1 = 0$	SP
Cheng	$log\,(AV) = a_0 + a_1 log\,(SP) + \varepsilon$	$a_1 = 0$	SP
2. Errors-in-Variables			
Kochin and Parks	$log\,(SP) = \beta_0 + \beta_1 log\,(AV) + \varepsilon$	$\beta_1 = 1$	AV
Price-Related-Bias (PRB)	$\frac{R - median(R)}{median(R)} = \beta_0 + \beta_1 log_2(Value) + \varepsilon$ where $Value = 0.5\left(\frac{AV}{median\,(R)} + SP\right)$	$\beta_1 = 0$	$0.5\left(\frac{AV}{median\,(R)} + SP\right)$
Clapp	First stage: $log\,(AV) = b_0 + b_1 IV + e$ where IV = -1 when both AV and SP are in the lower 1/3 of their distributions, 1 when both AV and SP are in the upper 1/3 of their distributions, and 0 otherwise. Second stage: $\log\,(SP) = \beta_0 + \beta_1 \widehat{log\,(AV)} + \varepsilon$ where $\widehat{log\,(AV)}$ is the prediction from the first stage regression.	$\beta_1 = 1$	IV
3. Inequality Indexes			
Kakwani Index (KI)	$2var(CF_N)ShareDiff = \Upsilon_0 + \Upsilon_1 CF_N + \varepsilon$ where $ShareDiff = \left(\frac{Share_{AV}}{mean(Share_{AV}} - \frac{Share_{SP}}{mean(Share_{SP})}\right)$	$\Upsilon_1 = 0$	SP
Modified Kakwani Index (MKI)	First stage: $\frac{Share_{SP}}{mean(Share_{SP})} = g_0 + g_1 CF_N + \varepsilon$ Second stage: $\frac{Share_{SA}}{mean(Share_{SA})} = \Upsilon_0 + \Upsilon_1\left(\widehat{\frac{Share_{SP}}{mean(Share_{SP})}}\right)$ where $\left(\widehat{\frac{Share_{SP}}{mean(Share_{SP})}}\right)$ is the prediction from the first stage regression.	$\Upsilon_1 = 0$	SP

Table 3.2. Non-parametric and Parametric Tests for Vertical Equity

Method	Test Statistic	Distribution and Assumptions	Market Value Proxy
4. Nonparametric			
Kruskal-Wallis	$KW = \frac{12\sum_{j=1}^{k} R_j^2/n_j}{n(n+1)}$ where k is the number of price groups, n_j the number of ratios in the jth roup, and the R_j sum of the ranks in the jth group.	χ_{k-1}^2 No assumption on data distributions	SP
Spearman Rank Correlation	$\rho = 1 - \frac{6\sum_i d_i^2}{n(n^2-1)}$ where d_i is the difference in ranks of each observation, and is the total number of observations. More generally, it is the correlation of the ranks of two variables.	Approximate around the correlation coefficient r: $t = r\sqrt{\frac{n-2}{1-r^2}}$ No assumption on data distributions	SP
5. Parametric			
ANOVA	$F = \frac{Between\ Group\ Variance}{Within\ Group\ Variance}$	$F_{k-1, n-k}$ F distribution with k-1 and n-k degrees of freedom. Ratios are from a normal distribution with equal variance	SP

3.1. Regression Models of Assessed Values on Prices

In this model class, the tests for vertical equity regress some functional form of AV on some functional form of the level of SP. These tests measure the slope of the simple linear regression line. The null hypothesis is vertical equity as reflected by a flat line between the dependent variable and the independent variable. A line with a significant slope coefficient indicates an increasing or decreasing relationship to the price level, thereby indicating vertical inequity in either the progressive or regressive direction.

Models set in the standard regression framework are:

Assessment Ratio Regression (ASR) - Introduced by IAAO (1978), the model regresses the assessment-to-sales ratio R on sales prices. The interpretation of vertical equity is based on the value of the slope coefficient a_1 where a value zero ($a_1 = 0$) designates no vertical inequity. Regressivity is indicated by a negative value ($a_1 < 0$) and progressivity by a positive value ($a_1 > 0$).

Endogeneity Bias. By construction, with sales price being on the left and right sides of the equation, the ASR model suffers from measurement error. The ASR regression is

$$AV/SP = a_0 + a_1 SP + \varepsilon,$$

which can be rewritten as

$$AV = a_0 SP + a_1 SP^2 + \varepsilon SP.$$

The error term is correlated with the independent variables.

Paglin-Fogarty Regression – Introduced by Paglin and Fogarty (1972), the model regresses assessment on prices. There is vertical equity when $a_1 = 1$. When $a_1 < 1$ then vertical inequity is present as progressive inequity. Regressive inequity is diagnosed when $a_1 > 1$.

Regressivity Bias. As noted by McMillen and Singh (2022), when AV is estimated from SP and the regression is run with the in-sample estimates of AV on prices from which it was estimated from, then the slope coefficient in the Paglin-Fogarty regression is the R^2 and therefore biased to be less than 1 (regressivity) since $0 \leq R^2 \leq 1$. In other words, if one runs

$$AV = a_0 + a_1 SP + \varepsilon$$

and AV is an estimate of price, $\widehat{SP}$ from a regression using SP then $\widehat{a_1}$ is the R^2 which is bounded above by 1.

Cheng Regression – Introduced by Cheng (1974), the model extends the Paglin-Fogarty framework by acknowledging that assessments and prices are non-linear, and not taking this into account can distort

T-tests on the slope coefficient. The model regresses the log of assessments on the log of prices. The interpretation of vertical equity and the slope coefficient is the same as in the Paglin-Fogarty framework.

Regressivity Bias. As noted by McMillen and Singh (2022), regressivity bias will exist for this regression when AV is estimated from SP and the sample data used to test for vertical equity is the same as the estimation sample.

3.1.1 Assumption on Market Values and Prices

Models set in the standard regression framework assume that arm-length prices are proxies of market values. Prices are taken as the best available encoding of market value information. In the regression formulation, errors of prices and market values are taken to be negligible in the sense that the prices reflect informed buyers and sellers and discrepancies between prices and market values are unknown, unmeasurable, and random.

Thus, these models only use some functional form of prices as the independent variable—i.e., the ratio regression and Paglin-Fogarty use sale prices while Cheng (1974) uses log of prices. In contrast, EIV models (also called measurement error models) would additionally assume a helper equation on the independent variable to tease out the error between prices and market value, that are assumed significant, or use a market value proxy. Such models are covered in the following section.

3.2 Errors-in-Variables Models

Assumptions governing prices, assessed values, and the true market value differentiate these models from the rest that are covered in this paper.

3.2.1 Assumption on Market Value and Prices

These models consider the measurement error in arms-length prices with respect to the true market value to be significant enough so that either an instrumental variable or a market proxy are used. When independent variables are measured with error, the result is that the slope coefficients in the regression equation are inconsistent and therefore biased. The solution is to find a market value proxy or to use a different framework from the standard regression framework. The standard regression framework discussed in the previous section assumes *no* measurement errors in the independent variable.

Models set in the errors-in-variables framework are:

Kochin-Parks Regression – Introduced by Kochin and Parks (1982), this model uses AV as a market proxy for market value. The regression is the Cheng model with the independent and dependent variables reversed. They argue that AV is a predictor of prices and belongs on the left-hand side of the equation. There is vertical equity when $\beta_1=1$. When $\beta_1 < 1$ then vertical inequity is present as progressive inequity. Regressive inequity is diagnosed when $\beta_1>1$.

Price-Related Bias (PRB) – Introduced by Gloudemans (2011), this model also approaches the EIV problem by introducing a market proxy, but unlike Kochin-Parks, the left-hand side variable is a function of the assessment ratio *R*. The right-hand side is the proxy, which is constructed as a weighted average of AV normalized by the median of *R* and sales prices. There is vertical equity when $\beta_1= 0$. When $\beta_1< 0$ then vertical inequity is present as regressive inequity. Progressive inequity is diagnosed when $\beta_1> 0$.

Endogeneity Bias. This was noted as well by McMillen and Singh (2022). The dependent and independent variables are functions of R, AV, and SP so there exists a relationship between them. This relationship will somewhat mask the true underlying relationship that is generated by the data-generating process.

Clapp IV Regression – Introduced by Clapp (1990), the approach moves out of the standard regression framework to solve the EIV problem. An instrumental variable is constructed from the first stage regression of AV and SP and used in the second stage regression with the log of price as the dependent variable. There is vertical equity when $\beta_1=1$. When $\beta_1< 1$ then vertical inequity is present as progressive inequity. Regressive inequity is diagnosed when $\beta_1> 1$. There is loss of information in this method since concordant information at the center third of the distribution is not used at the first stage.

3.3 Inequality Indices

Inequality indices measure the extent to which a distribution deviates from a perfectly equal (uniform) distribution. Inequality measurement is a non-parametric approach in the sense that there are no assumptions on the distribution of the data. There are several measures of inequality in the literature, however, few of them have a regression equivalent. The Gini-based measures of inequality are considered in this paper because they have a regression equivalent. The advantage is that inference using the standard T-test for vertical equity is possible.

3.3.1 Vertical Equity Definition and Measurement

Although Gini-based inequality measures have a regression equivalent, the approach is significantly different from those considered in the previous two sections. The basic difference is in how equity is defined, and therefore measured. In the Gini framework, equity is measured in terms of a property's share of assessment versus its share of prices. A share in assessment is calculated as a property's assessment divided by the total assessment in that jurisdiction. Similarly, a share in price is calculated as a property's price divided by total prices in that jurisdiction. Vertical equity occurs when, for all properties, the shares of assessments equal the shares in prices. Regressivity occurs when lower-priced properties have a higher share of assessment than their share of prices. Progressivity occurs when lower-priced properties have a lower share of assessment than their share of prices.

3.3.2 Gini-Based Inequality Measures

The notation we use to calculate Gini indices are: $Share_{SP}$, a property's price divided by the total price in a jurisdiction; $Share_{AV}$, a property's assessed value divided by the total assessed value in a jurisdiction; and CF_N, cumulative frequency as a share of total number of properties N when prices are ranked in ascending order.

Kakwani Index (KI) – Introduced into the property assessment literature in Quintos (2020), the KI measures progressivity or regressivity by comparing the difference in the shares of assessments, $Share_{AV}$, to the shares of prices, $Share_{SP}$, as price level increases. From the regression in table 3.1, the slope coefficient Υ_1 measures the response of the difference in AV and SP shares as price level increases (CF_N). Therefore, the sign of is the indicator for vertical equity or inequity:

Vertical equity exists when $\Upsilon_1 = 0$

Regressivity exists when $-1 \leq \Upsilon_1 < 0$

Progressivity exists when $0 < \Upsilon_1 \leq 1$.

Note that KI is bounded between [-1, 1]—technically, the bounds range from -2 to 2, but such values would only occur when the assessment and/or price distributions fall above the equality line (an unrealistic situation that would require highly left-skewed data, when prices are typically right-skewed).

Modified Kakwani Index (MKI) - Introduced into the property assessment literature in Quintos (2020), the MKI measures progressivity or regressivity by comparing the ratio of the shares of assessments, $Share_{AV}$, to the shares of prices, $Share_{SP}$, as price level increases. It can be interpreted as an instrumental variable procedure like Clapp with the first-stage regression being on CF_N, the cumulative frequency count of properties sorted in ascending order of prices. From the regression in table 3.1, the slope coefficient γ_1 measures the response of the shares in AV on SP shares, where the shares in SP are predicted from its response as price level increases (CF_N is calculated after sorting prices in ascending order). The distance of γ_1 from 1 is the indicator for vertical equity or inequity:

Vertical equity exists when $\gamma_1 = 1$

Regressivity exists when $\gamma_1 < 1$

Progressivity exists when $\gamma_1 > 1$.

Unlike KI, the MKI has the interpretation of an elasticity measure.

3.3.3 Assumption on Market Values and Prices

The approach based on inequality measures assumes that arms-length prices are reflective of market values. Measurement errors that exist are either negligible and not measurable in the sense that they are unknown and/or random.

To the extent that measurement errors exist in prices, the method remains robust so long as the errors do not have a significant effect on the ranks of prices and the true market values. As seen in the regression, the cumulative frequency depends on the order of prices and not prices themselves. So long as the true market value retains the same rankings as prices — i.e., high market value and high prices, low market value and low prices — then the procedure remains robust to measurement errors.

3.4 Non-parametric Tests

Methods considered in this section are calculated test statistics or coefficient indicators for vertical equity that do not require any assumptions on the distribution of the data. They are not set in a regression framework, so the inconsistency on slope coefficients that measurement errors would cause is not an issue here. The null and alternative hypotheses are as follows.

Null: Properties are appraised at the same level across price groups.

Alternative: Properties are not appraised at the same level across price groups.

No measurement error is assumed, so arms-length sales prices are used as proxy for the true market value. The methods considered here are:

Kruskal-Wallis Test – Prices are ranked and grouped into deciles. Assessment-to-price ratios are pooled and ranked in ascending order. The Kruskal-Wallis test determines whether differences in the average ranks across price groups are sufficiently large to indicate systematic differences in appraisal levels. The test can only determine no vertical equity under the alternative hypothesis; however, graphs can help determine the direction (regressivity or progressivity) of the inequity.

Spearman's Rank Correlation – This method measures the strength and direction of association between the ranks of the prices and the ranks of the assessed values. The Spearman's rank correlation coefficient, denoted by ρ is equivalent to the Pearson correlation coefficient calculated on the ranks of two variables rather than the values themselves.

Vertical equity exists when $\rho = 0$

Regressivity exists when $-1 \leq \rho < 0$

Progressivity exists when $0 < \rho \leq 1$

Spearman rank correlation is bounded between [-1, 1].

3.5 Parametric Tests

Methods considered in this section are calculated test statistics or coefficient indicators for vertical equity that assume a normal data distribution. They are not set in a regression framework. The null and alternative hypotheses are as follows.

Null: Properties are appraised at the same level across price groups.

Alternative: Properties are not appraised at the same level across price groups.

No measurement error is assumed so that arms-length sales prices are used as proxy for the true market value.

ANOVA F Test – The one-way ANOVA checks for the variability of group means and the associated variability in observations within that group. The F-statistic is the ratio of the explained variance divided by the unexplained variance. Like the Kruskal-Wallis test, the test can only determine vertical inequity under the alternative hypothesis. Supporting measurements and graphs can help determine the direction of that inequity.

4. Simulation Results

In this section we show the results of the methods on the simulated data. We start with the no EIV assumption.

4.1 No Errors-in-Variables Assumption

Recall that in the data-generating process, the AV is generated from the MV distribution. Thus, in estimating the performance of the tests under a true relationship, the MV is substituted with either prices or the market proxy in the construction of the test. The performance of the EIV models differ based on how the substitution of MV is done; the performances of the other tests are unaffected.

4.1.1 Setting the Sale Price as Market Value

Note that the true MV is unknown to the modeler; in practice, the modeler constructs the test statistics using prices. However, for this investigation we replace price with our known, simulated MV in order to assess how tests perform when there is no EIV.

Table 4.1 below shows test performance when prices behave like MV (i.e., prices are not measured with error). These results show that PRD (when based on the bootstrap interval), ASR, Paglin-Fogarty, Cheng, KI, MKI, and the Spearman Rank test perform the best, getting all cases correct with no Type I, II, or III errors detected. These seven tests are robust to horizontal inequities in all scenarios. Notably, Kochin-Parks, PRB, and Clapp are the only tests with incorrect size (a Type I error) under Scenarios 1 and 4 (shaded gray in table 4.1). The reason for this incorrect size is explained in Section 4.1.2. Finally, PRD based on the IAAO interval shows the worst performance.

Table 4.1 Type I, II, and III Errors Under True relationship of AV and MV
No Errors-in-Variables (SP behaves like MV)
MV replaces SP in the construction of the tests

Method	True: Vertical Equity		True: Progressivity		True: Regressivity		No. Correct
	Scenario 1: HE	Scenario 4: HI	Scenario 2: HE	Scenario 5: HI	Scenario 3: HE	Scenario 6: HI	
PRD	**1.00014**	**0.99927**	**0.98855**	**0.98859**	**1.01204**	**1.01092**	
IAAO Interval	Vertical Equity	Vertical Equity	*Vertical Equity*	*Vertical Equity*	*Vertical Equity*	*Vertical Equity*	**2**
Bootstrap Interval	Vertical Equity (0.99955, 1.00076)	Vertical Equity (0.99810, 1.00038)	Progressivity (0.98769, 0.98943)	Progressivity (0.98723, 0.98987)	Regressivity (1.01112, 1.01300)	Regressivity (1.00966, 1.01222)	**6**
COD	**0.05282**	**0.10592**	**0.06172**	**0.10808**	**0.06044**	**0.10759**	
ASR	Vertical Equity	Vertical Equity	Progressivity	Progressivity	Regressivity	Regressivity	**6**
Paglin-Fogarty	Vertical Equity	Vertical Equity	Progressivity	Progressivity	Regressivity	Regressivity	**6**
Cheng	Vertical Equity	Vertical Equity	Progressivity	Progressivity	Regressivity	Regressivity	**6**
Kochin-Parks	*Progressivity*[I]	*Progressivity*[I]	Progressivity	Progressivity	Regressivity	*Progressivity*[III]	**3**
PRB	*Progressivity*[I]	*Progressivity*[I]	Progressivity	Progressivity	Regressivity	Regressivity	**4**
Clapp	*Progressivity*[I]	*Progressivity*[I]	Progressivity	Progressivity	Regressivity	*Vertical Equity*[II]	**3**
KI	Vertical Equity	Vertical Equity	Progressivity	Progressivity	Regressivity	Regressivity	**6**
MKI	Vertical Equity	Vertical Equity	Progressivity	Progressivity	Regressivity	Regressivity	**6**
Kruskal-Wallis	Vertical Equity	*Progressivity*[I]	Progressivity	Progressivity	Regressivity	Regressivity	**5**
Spearman Rank	Vertical Equity	Vertical Equity	Progressivity	Progressivity	Regressivity	Regressivity	**6**
ANOVA	Veritcal Equity	*Vertical Inequity*[I]	Vertical Inequity	Vertical Inequity	Vertical Inequity	Vertical Inequity	**5**

4.1.2 Setting the Market Value Proxy as the Market Value

In this set of results, the market value proxy for each method is set by substituting MV for both the assessed value and the sale price, not just for the sales price as done in the previous section. This matters in the PRB and Clapp methods, which make a compromise between assessed value and sale price in the determination of the market proxy. The PRB and Clapp methods were developed on the assertion that the use of both assessed value and sale price reduces the bias that arises from choosing either the assessed value or sale price alone as the market value proxy.

Recall that the regression, Gini, non-parametric, and parametric tests assume that arms-length prices equal the market value. These tests do not specifically take into account the condition that prices are measured with error. In contrast, the EIV models of Kochin-Parks, PRB, and Clapp assume that prices are measured with error. Kochin-Parks selects AV as the market proxy while the PRB and Clapp use both AV and sale prices for a market proxy.

Table 4.2 displays the results of setting the EIV models' market value proxies to MV. The PRB and Clapp score all 6 here, whereas they scored 4 in table 4.1. *In other words, to get the correct size in Scenarios 1 and 4, sales prices and assessed values are assumed to behave like MV. The PRB and Clapp obtain the correct size under a different null condition as those imposed to generate table 4.1.*

Table 4.2 Type I, II and III Errors Under True relationship of AV and MV
No Errors-in-Variables (SP, AV behave like MV)
MV replaces SP, AV in the construction of the tests

Method	True: Vertical Equity		True: Progressivity		True: Regressivity		No. Correct
	Scenario 1: HE	Scenario 4:	Scenario 2: HE	Scenario 5: HI	Scenario 3: HE	Scenario 6: HI	
Kochin-Parks	Vertical Equity	Vertical Equity	Vertical Equity[II]	Vertical Equity[II]	Vertical Equity[II]	Vertical Equity[II]	2
PRB	Vertical Equity	Vertical Equity	Progressivity	Progressivity	Regressivity	Regressivity	6
Clapp	Vertical Equity	Vertical Equity	Progressivity	Progressivity	Regressivity	Regressivity	6

4.2 Errors-in-Variables Assumption

In this set of results, we use the set of prices distorted from market values. As shown in table 2.2, the simplest distortion is a different variance from MV. *By keeping the price distortion simple, we can study the baseline behavior or bias of the tests when measurement error exists.*

Because the true data generating process has measurement errors, the EIV models are constructed in the form as they are written, without replacement of AV or SP by MV. Similarly, because we are assuming measurement errors in price, the other tests—regression, Gini, non-parametric and parametric tests—are constructed in the form as they are written with sales prices. Now SP is not replaced by MV; instead SP is used, which is distorted (or measured with error) from MV using table 2.2 variances.

Note that the three errors-in-variables models, the PRB, Clapp, and to a lesser extent Kochin-Parks, are constructed under the framework of measurement errors. Thus, the degree to which they achieve correct size indicates how well their method does in addressing measurement errors. In contrast, the other tests are not constructed under the measurement errors assumption. Thus, the degree to which they fail to achieve the correct size will depend on the type of error introduced and the structure of the tests.

4.2.1 Higher Measurement Error in Prices than in AV

Table 5.1 shows the set of results that refer to Case A in table 2.2 where prices have a larger variance distortion from MV as compared to AV's distortion from MV. PRB and Clapp methods perform the best, getting 5 of the 6 scenarios correct. In the detection of size in scenarios 1 and 4, the EIV methods tend toward progressivity when they reject the null, whereas the other methods all tend toward regressivity.

Table 5.1 Type I, II, and III Errors Under True relationship of AV and MV
Case A Errors-in-Variables
Tests are constructed without replacing AV or SP by MV

Price is a worse estimator of MV than AV

Method	True: Vertical Equity		True: Progressivity		True: Regressivity		No. Correct
	Scenario 1: HE	Scenario 4: HI	Scenario 2: HE	Scenario 5: HI	Scenario 3: HE	Scenario 6: HI	
PRD	1.007	1.00617	0.99528	0.99549	1.01902	1.01808	
IAAO Interval	Vertical Equity	Vertical Equity	*Vertical Equity*	*Vertical Equity*	*Vertical Equity*	*Vertical Equity*	2
Bootstrap Interval	*Regressivity* (1.00592, 1.00805)	*Regressivity* (1.00471, 1.00760)	Progressivity (0.99413, 0.99640)	Progressivity (0.99386, 0.99701)	Regressivity (1.01779, 1.02030)	Regressivity (1.01649, 1.01978)	4
COD	0.08556	0.12323	0.09136	0.1264	0.09092	0.12581	
ASR	*Regressivity*[I]	*Regressivity*[I]	Progressivity	Progressivity	Regressivity	Regressivity	4
Paglin-Fogarty	*Regressivity*[I]	*Regressivity*[I]	Progressivity	Progressivity	Regressivity	Regressivity	4
Cheng	*Regressivity*[I]	*Regressivity*[I]	Progressivity	Progressivity	Regressivity	Regressivity	4
Kochin-Parks	*Progressivity*[I]	*Progressivity*[I]	Progressivity	Progressivity	Regressivity	*Progressivity*[III]	3
PRB	Vertical Equity	*Progressivity*[I]	Progressivity	Progressivity	Regressivity	Regressivity	5
Clapp	Vertical Equity	*Progressivity*[I]	Progressivity	Progressivity	Regressivity	Regressivity	5
KI	*Regressivity*[I]	*Regressivity*[I]	Progressivity	Progressivity	Regressivity	Regressivity	4
MKI	*Regressivity*[I]	*Regressivity*[I]	Progressivity	Progressivity	Regressivity	Regressivity	4
Kruskal-Wallis	*Regressivity*[I]	*Regressivity*[I]	Progressivity	Progressivity	Regressivity	Regressivity	4
Spearman Rank	*Regressivity*[I]	*Regressivity*[I]	Progressivity	Progressivity	Regressivity	Regressivity	4
ANOVA	*Vertical Inequity*[I]	*Vertical Inequity*[I]	Vertical Inequity	Vertical Inequity	Vertical Inequity	Vertical Inequity	4

4.2.2 Similar Measurement Error in Prices and AV

Table 5.2 shows Case B, where prices and assessed values are distorted from MV with the same variance. In this case, all tests fail in detecting the true size of the test at the 5% level. However, as in the previous tables, all the tests except Kochin-Parks and PRD based on the IAAO interval have the power to detect the true direction of vertical inequity.

Table 5.2 Type I, II, and III Errors Under True relationship of AV and MV
Case B Errors-in-Variables
Tests are constructed without replacing AV or SP by MV

Price and AV are comparable estimators of MV

Method	True: Vertical Equity		True: Progressivity		True: Regressivity		No. Correct
	Scenario 1: HE	Scenario 4: HI	Scenario 2: HE	Scenario 5: HI	Scenario 3: HE	Scenario 6: HI	
PRD	1.00419	1.00399	0.99299	0.99244	1.01647	1.01525	
IAAO Interval	Vertical Equity	Vertical Equity	*Vertical Equity*	*Vertical Equity*	*Vertical Equity*	*Vertical Equity*	2
Bootstrap Interval	*Regressivity* (1.00334, 1.00506)	*Regressivity* (1.00265, 1.00532)	Progressivity (0.99197, 0.99402)	Progressivity (0.99103, 0.99383)	Regressivity (1.01532, 1.01762)	Regressivity (1.01383, 1.01657)	4
COD	0.07468	0.11523	0.0808	0.11665	0.07967	0.11814	
ASR	*Regressivity*[I]	*Regressivity*[I]	Progressivity	Progressivity	Regressivity	Regressivity	4
Paglin-Fogarty	*Regressivity*[I]	*Regressivity*[I]	Progressivity	Progressivity	Regressivity	Regressivity	4
Cheng	*Regressivity*[I]	*Regressivity*[I]	Progressivity	Progressivity	Regressivity	Regressivity	4
Kochin-Parks	*Progressivity*[I]	*Progressivity*[I]	Progressivity	Progressivity	Regressivity	*Progressivity*[III]	3
PRB	*Progressivity*[I]	*Progressivity*[I]	Progressivity	Progressivity	Regressivity	Regressivity	4
Clapp	*Progressivity*[I]	*Progressivity*[I]	Progressivity	Progressivity	Regressivity	Regressivity	4
KI	*Regressivity*[I]	*Regressivity*[I]	Progressivity	Progressivity	Regressivity	Regressivity	4
MKI	*Regressivity*[I]	*Regressivity*[I]	Progressivity	Progressivity	Regressivity	Regressivity	4
Kruskal-Wallis	*Regressivity*[I]	*Regressivity*[I]	Progressivity	Progressivity	Regressivity	Regressivity	4
Spearman Rank	*Regressivity*[I]	*Regressivity*[I]	Progressivity	Progressivity	Regressivity	Regressivity	4
ANOVA	*Vertical Inequity*[I]	*Vertical Inequity*[I]	Vertical Inequity	Vertical Inequity	Vertical Inequity	Vertical Inequity	4

4.2.3 Lower Measurement Error in Prices than in AV

Table 5.3 shows Case C, where prices are distorted from MV with less variance than AV. The PRB performs the best with 5 out of the 6 cases correct. As with the previous tables, under scenarios 1 and 4, the EIV models find progressivity when they falsely reject the true null of vertical equity while the non-EIV models find regressivity. PRD under the IAAO interval performs the worst.

Table 5.3 Type I, II, and III Errors Under True relationship of AV and MV
Case C Errors-in-Variables
Tests are constructed without replacing AV or SP by MV

Price is a better estimator of MV than AV

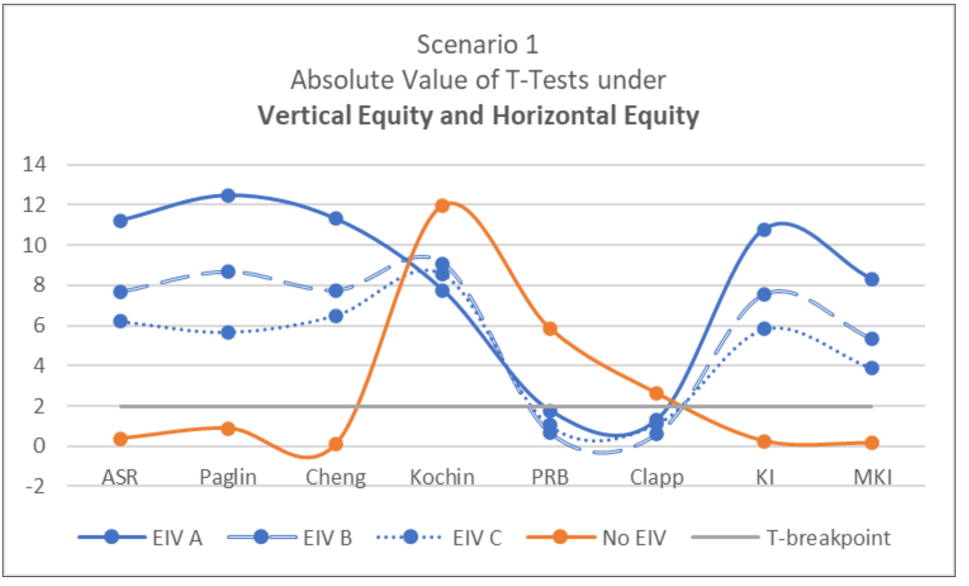
Method	True: Vertical Equity		True: Progressivity		True: Regressivity		No. Correct
	Scenario 1: HE	Scenario 4: HI	Scenario 2: HE	Scenario 5: HI	Scenario 3: HE	Scenario 6: HI	
PRD	1.00297	1.00260	0.99131	0.99042	1.01421	1.01401	
IAAO Interval	Vertical Equity	Vertical Equity	*Vertical Equity*	*Vertical Equity*	*Vertical Equity*	*Vertical Equity*	2
Bootstrap Interval	*Regressivity* (1.00218, 1.00375)	*Regressivity* (1.00142, 1.00386)	Progressivity (0.99037, 0.99222)	Progressivity (0.98902, 0.99176)	Regressivity (1.01317, 1.01521)	Regressivity (1.01267, 1.01536)	4
COD	0.06505	0.11078	0.07418	0.11408	0.07341	0.11363	
ASR	*Regressivity*[I]	*Regressivity*[I]	Progressivity	Progressivity	Regressivity	Regressivity	4
Paglin-Fogarty	*Regressivity*[I]	*Regressivity*[I]	Progressivity	Progressivity	Regressivity	Regressivity	4
Cheng	*Regressivity*[I]	*Regressivity*[I]	Progressivity	Progressivity	Regressivity	Regressivity	4
Kochin-Parks	*Progressivity*[I]	*Progressivity*[I]	Progressivity	Progressivity	Regressivity	*Progressivity*[III]	3
PRB	Vertical Equity	*Progressivity*[I]	Progressivity	Progressivity	Regressivity	Regressivity	5
Clapp	*Progressivity*[I]	*Progressivity*[I]	Progressivity	Progressivity	Regressivity	Regressivity	4
KI	*Regressivity*[I]	*Regressivity*[I]	Progressivity	Progressivity	Regressivity	Regressivity	4
MKI	*Regressivity*[I]	*Regressivity*[I]	Progressivity	Progressivity	Regressivity	Regressivity	4
Kruskal-Wallis	*Regressivity*[I]	*Regressivity*[I]	Progressivity	Progressivity	Regressivity	Regressivity	4
Spearman Rank	*Regressivity*[I]	*Regressivity*[I]	Progressivity	Progressivity	Regressivity	Regressivity	4
ANOVA	*Vertical Inequity*[I]	*Vertical Inequity*[I]	Vertical Inequity	Vertical Inequity	Vertical Inequity	Vertical Inequity	4

4.3 Recapitulation of Results

The Gini and regression-based tests have the commonality of being based on the T-score. These tests use the T-test to determine acceptance or rejection of the null hypothesis. The behavior of the tests relative to the critical value can be a measure of its strength. The graphs below show the absolute value of the T-tests for all 18 cases. The graphs below in Figures 2.1 and 2.2 are the T-scores used to conclude the results already given in tables 4.1 and 5.1-5.3.

The orange curves are the T-scores under the No EIV assumption in table 4.1 while the blue curves are under the EIV assumption. Under the EIV assumption the three blue curves are the three cases A, B and C representing different variances between prices and assessed values. The grey line is the value 1.96 which is the normal critical value at 95% significance. *Points above the grey line reject the null; points below the grey line accept the null.*

Figure 2.1 Summary of Test Performance (Size of Test)
Scenarios 1 and 4 under Vertical Equity



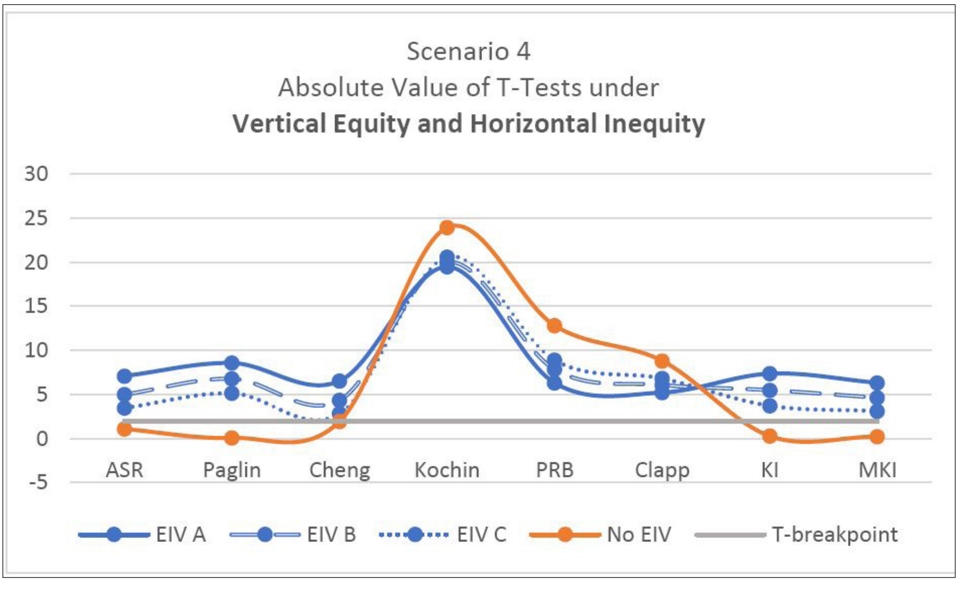
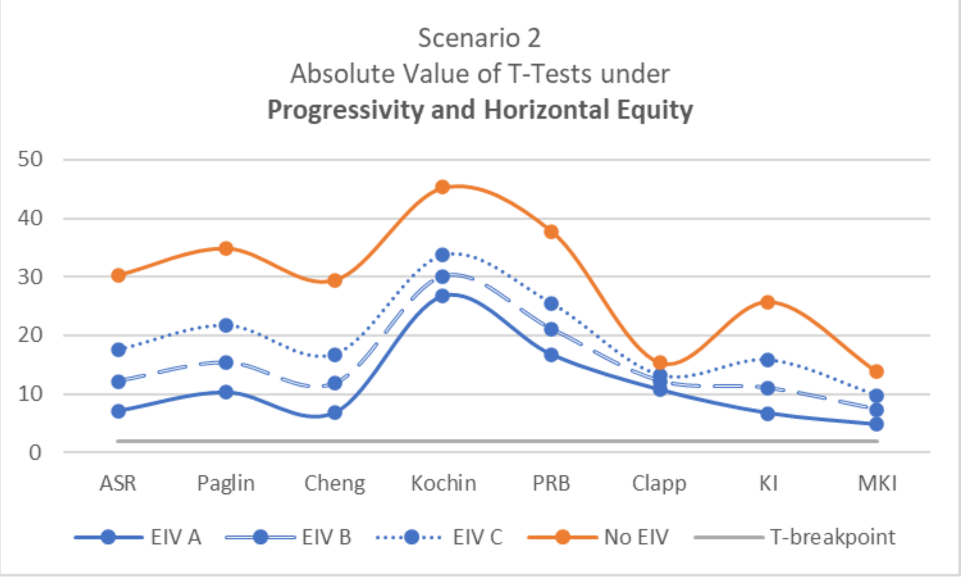
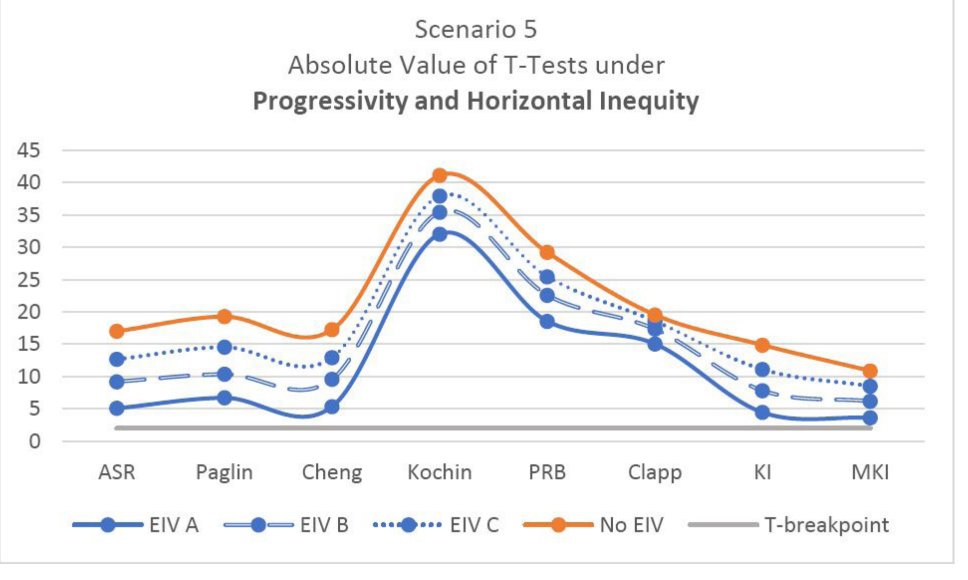
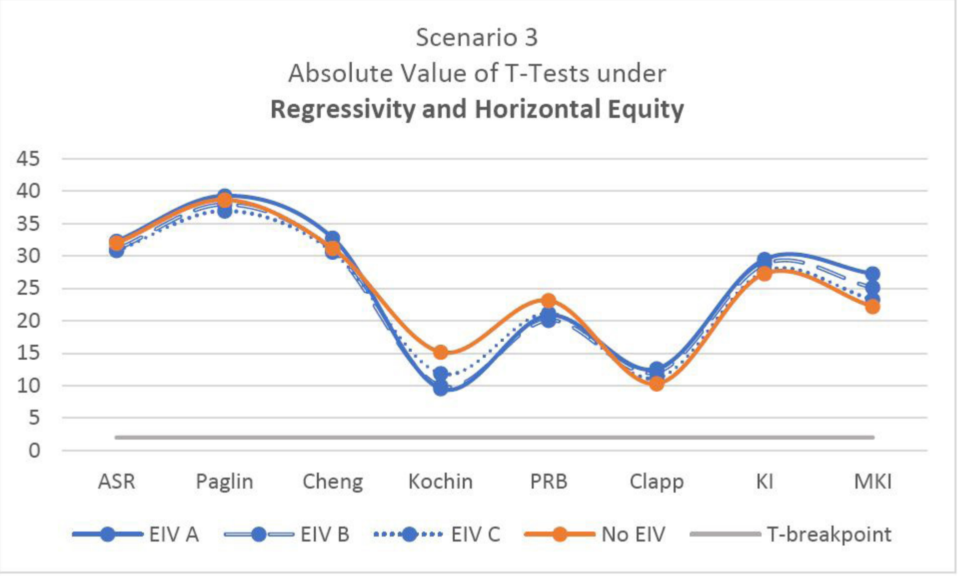


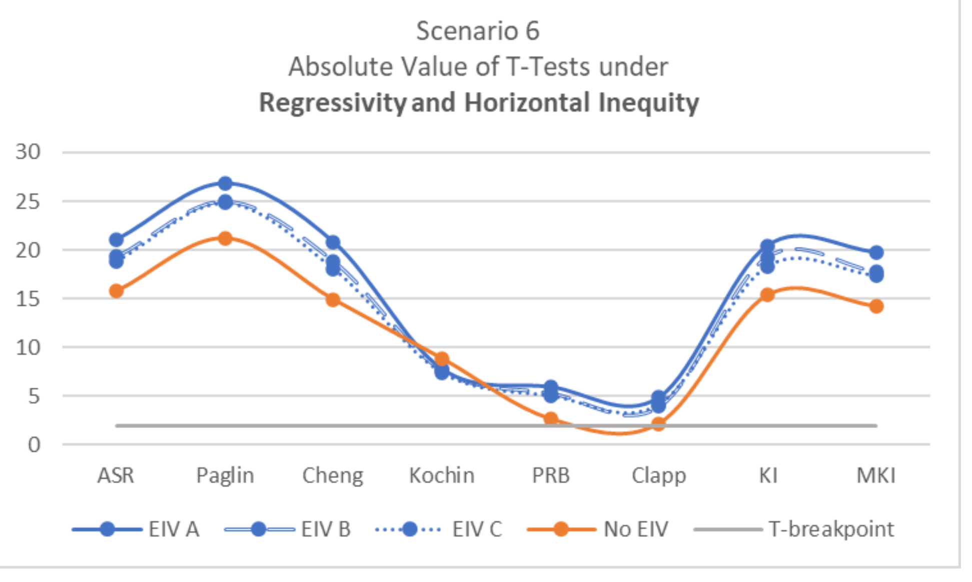
Figure 2.2 Summary of Test Performance (Power of Test)
A. Scenarios 2 and 5 under Progressivity





B. Scenarios 3 and 6 under Regressivity



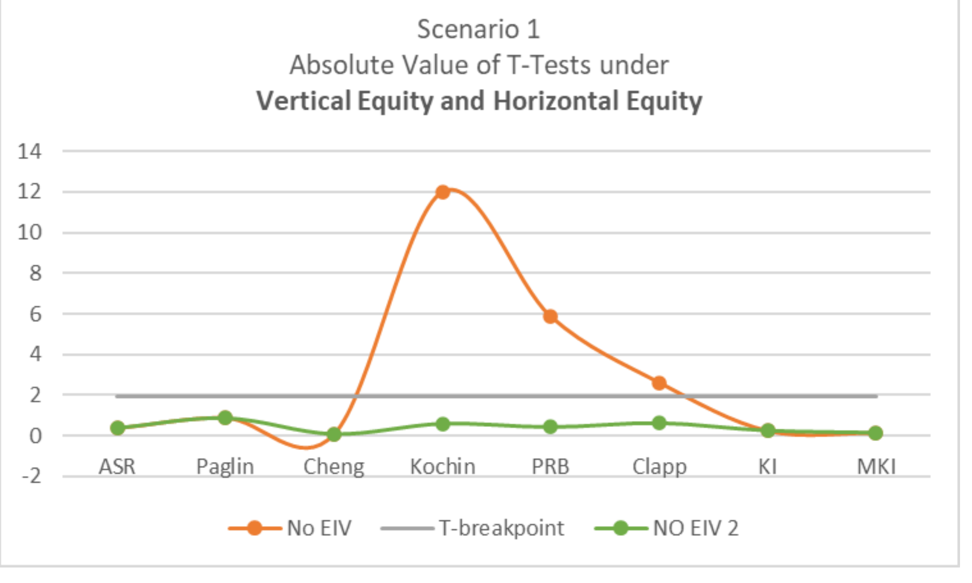


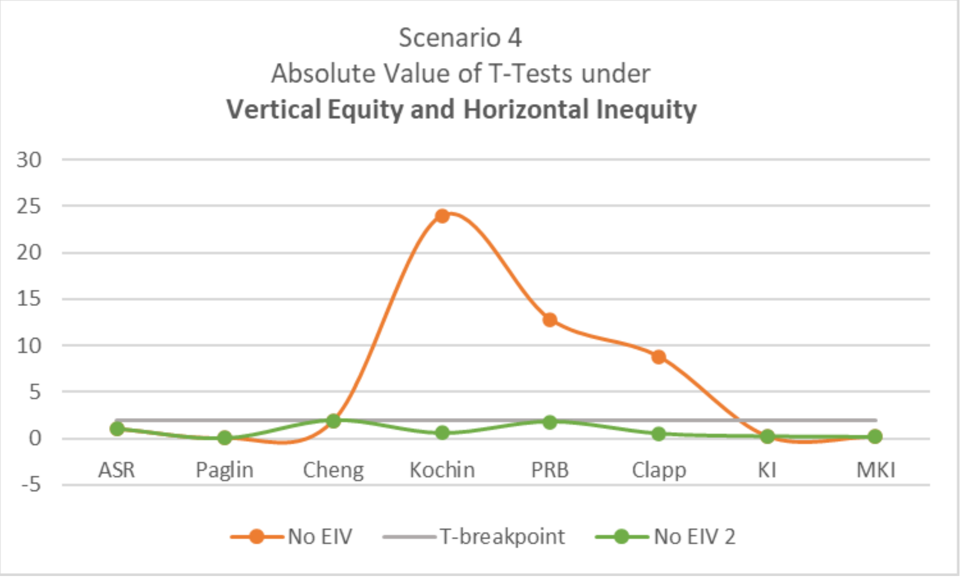
The shape of each curve in figures 2.1 and 2.2 illustrate how different the EIV models are from the non-EIV models. The curves tend to have peaks or troughs where the EIV models' (Kochin-Parks, PRB, and Clapp) values are plotted, and tend to flatten out where the values for the non-EIV models (ASR, Paglin-Fogarty, Cheng, KI, and MKI) are plotted. This is because the T-scores observed in the non-EIV models are similar to each other (although the regression tests generally show higher T-scores for both size and power than the Gini tests), and are often distinct from the T-scores observed in the EIV models.

Finally, it is important to highlight the difference between the No EIV results of table 4.1 and table 4.2 for Kochin-Parks, the PRB and Clapp methods. Recall that the only difference was in the substitution of the market value in the testing regressions. table 4.1 substituted MV for SP everywhere in the equations including for the Kochin-Parks, PRB, and Clapp regressions. In contrast, table 4.2 substituted MV for the assumed market value proxy in the following ways: for the PRB, MV substitutes for *Value* = .5 $\left(\frac{AV}{median(R)}+SP\right)$; for Clapp, MV substitutes for both AV and SP in the construction of IV; for Kochin-Parks, MV substitutes for AV on the right-hand side of the equation. *Note that for a single true MV to be used for the market value proxy in all three of these cases, it is implied that AV = SP.* In other words, the market value proxies will behave like the one true MV if and only if AV = SP.

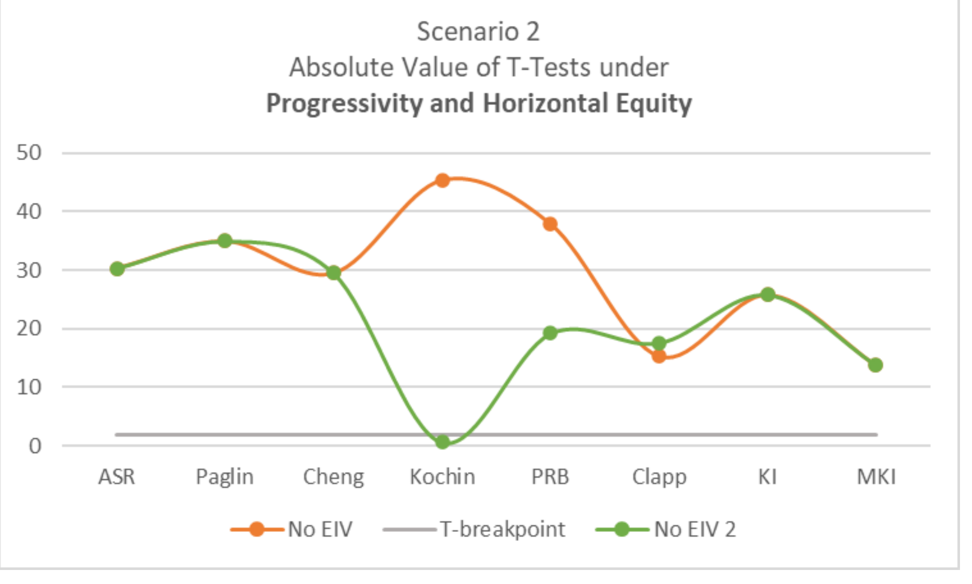
Figure 3 shows the differences between tables 4.1 and 4.2. The orange curves, labeled "No EIV", show table 4.1 results (and were also graphed in Figures 2.1 and 2.2). The green curves, labeled "No EIV 2", graph T-scores of table 4.2. The PRB and Clapp T-scores of table 4.2 behave similarly to the other methods' T-scores (either all above or all below the T-breakpoint), with the exception being the Kochin-Parks T-scores of table 4.2, which continue to behave differently from the other measures. This can be seen from the flattening out of the green curve compared to the orange curve. The similarity in behavior of tables 4.2 and 4.1 comes from the implied assumption that AV = SP in table 4.2, and from the fact that simulated data distorts AV from SP by a variance distortion only. A bigger difference between the orange and green curves could be observed if AV is perturbed more from SP (and MV) through outliers or higher skew. This should be the subject of future research. In all cases, the orange and green curves depend on one's interpretation of how the size and power of the test is calculated for EIV models.

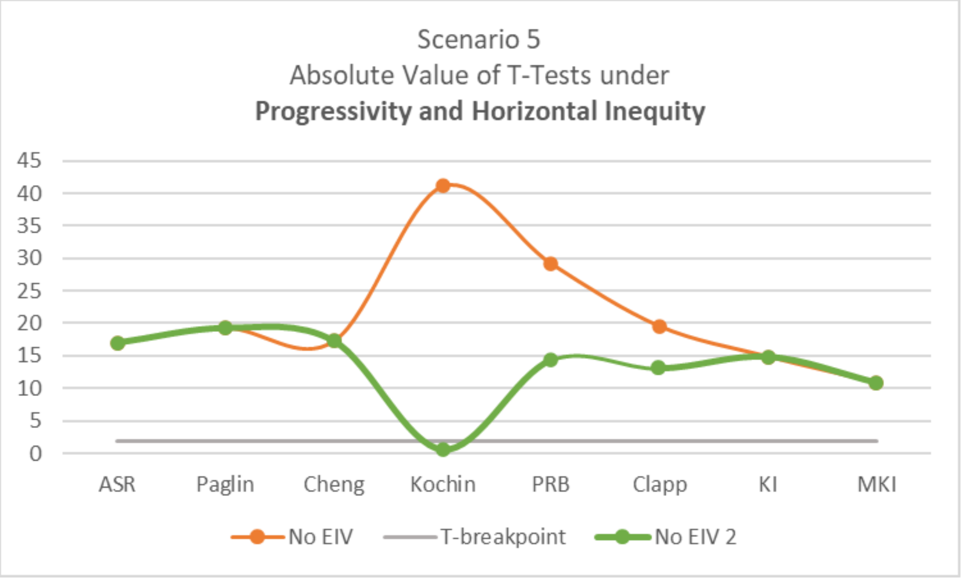
Figure 3. Test Performance when MV Replaces SP (No EIV)
Versus when MV replaces Market Proxy (No EIV 2)
Scenarios 1 and 4 under Vertical Equity



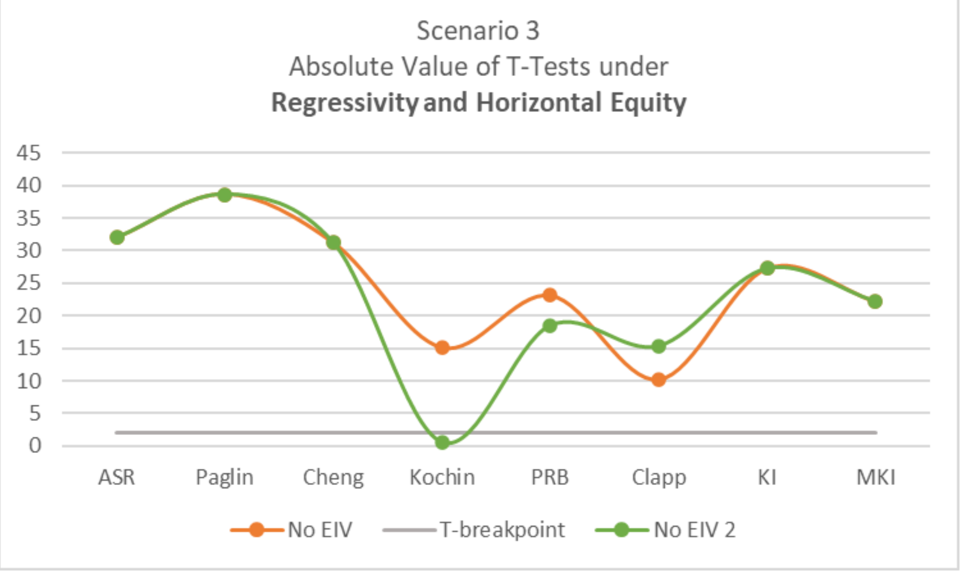


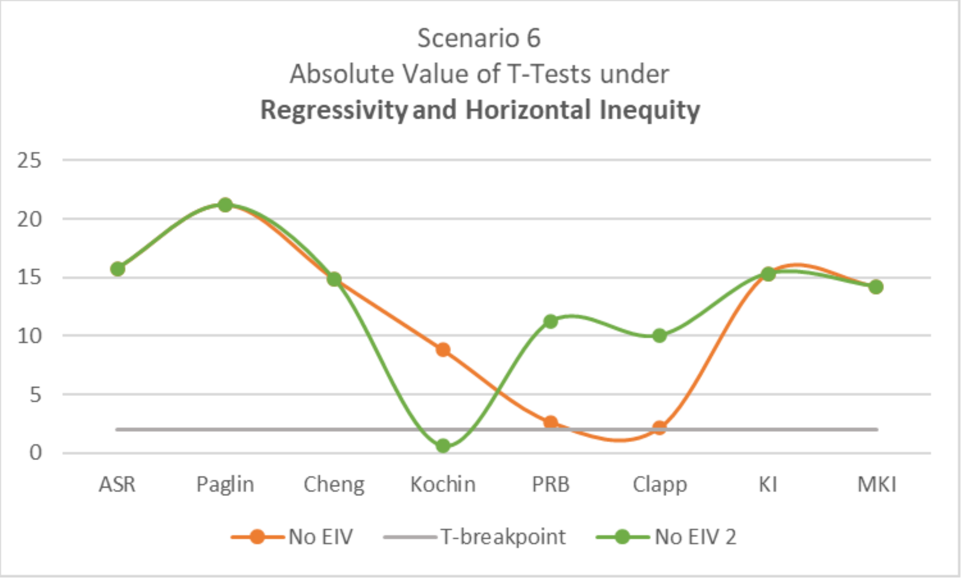
B. Scenarios 2 and 5 under Progressivity





C. Scenarios 3 and 6 under Regressivity





5. Local versus Global Vertical Equity: An Application of GWR

This section provides an empirical application and comparison of the various methods explored in previous Sections to examine both horizontal and vertical equity performance on a sales transaction dataset.

5.1 Description of Empirical Data

The data set is derived from the Ulster University House Price Index (UUHPI; an established property market index dating back to 1984) over the period 2021 for the Belfast housing market, which is based on a robust sample of achieved sales price transactions obtained from estate agents on a quarterly basis. This sample encompasses approximately 40% of all recorded property transactions across Northern Ireland. Because the data collection process encompasses the triangulation of three different data sources, robust testing and validation procedures are undertaken to remove duplicates and ensure reliability. The study area is the geographic extent of Belfast, which is the capital city of Northern Ireland and is a dense urban form representing a high proportion of the country's property sales transactions. House prices are, on average, the highest countrywide, although they can vary greatly across the city by property type.

In total, 5,374 transactions are used in the study after undergoing a data mining and cleansing exercise to remove outliers, with a data merge undertaken to obtain the X, Y coordinates using a GIS platform. The independent variables contained within the study are based on the structural characteristics of the properties, including the era of construction, property typology, property size, number of bedrooms, number of reception rooms, and whether the property has a garage. The variables contained within the analysis and their descriptions are presented in table 6. Where applicable, the categorical variables are transformed into their binary state to indicate the absence or presence of a categorical effect that may be expected to shift the outcome (Kleinbaum et al., 1988).

Table 6. Variables and Descriptions for the Belfast Data

Variables	Description	Type
Sales Price	Achieved sales price	C
Ln(Price)	Logarithm of sales price	C
Floor Area	Size of property in meters square (m2)	C
Type	Property type; for example 1 if Detached (a detached dwelling single family); 0 otherwise.	B
Age	The age of the property in defined categories. For example, 1 if built before 1919; 0 otherwise.	B
Bedrooms	Number of bedrooms; = 1 if Beds 1; otherwise 0	B
Bathrooms	Number of bathrooms; = 1 if Baths 1; otherwise 0	B
Half Bathrooms	Number of bathrooms; = 1 if Baths 1; otherwise 0	B
Stories	Number of stories; =1 if two-storey; otherwise 0.	B
Garage	If the property has a garage =1; otherwise 0.	B
X	Coordinate for absolute location	C
Y	Coordinate for absolute location	C
Zipcode_2	Last 2-digit zip code for where the property is located. For example; =1 if PC2, otherwise 0.	B
Location	Where the property is located across the city. For example, = 1 if suburban; otherwise 0.	B

In total, three logarithmic OLS fixed-effects MRA models are developed based on the property level characteristics with the inclusion of locational attributes. Within this analysis, the semi-log linear fit is applied within the modelling framework due to the skewed nature of the sales price distribution and for computational efficiency and interpretability, providing useful interpretations of the independent variable coefficients in terms of their elasticity. The semi-log specification is as follows:

$$LnY = \beta_0 + \beta_1.X_1 + \beta_2.X_2 \dots . \beta_n.X_n + \varepsilon$$

where LnY is the dependent variable (log of sale price), are the independent variables, are parameters to be estimated, and ε is the error term.

Three MRA models are specified to reflect the varying degree to which assessment jurisdictions have access to different types of data for mass appraisal. MRA Model 1 includes all property attributes and the lowest delineated location, using zip-code-level dummies, with Model 2 applying a more aggregated spatial identifier. Model 3 removes some of the property attribute information, which may be missing from the general sales information collected by assessment offices.

5.1.1 GWR regression model

Geographically weighted regression (GWR) has become a mainstream spatial modelling approach within real estate analysis examining spatial (and/or temporal) variations in market pricing as a consequence of both neighborhood and locational factors. Thus, GWR is a non-parametric approach applied to mitigate the issues of spatial heterogeneity and autocorrelation, as it permits coefficients to vary continuously. GWR is represented by the following formula as outlined by Fotheringham et al. (2002:61):

$$y_i = \beta_0\,(x_i,y_i) + \sum \beta_k\,(xi,y\mathrm{i})\,x_{ik} + \varepsilon_i$$

where is the i-th sale, β_0 is the model intercept, β_k is the k-th coefficient, x_{ik} is the k-th variable for the i-th sale, ε_i is the error term of the i-th sale, and $(xi,y\mathrm{i})$ are the x-y coordinates of the i-th regression point.

GWR measures the relationships around each regression point i, where each set of regression coefficients is estimated by weighted least squares using kernel densities. In this study, an nXn spatial weights matrix is constructed to indicate the weight applied to each observation, assigned relative to the subject based on geographic distance:

$$w_{ij} = \exp [- (|d_{ij}| / b^2)]$$

where w_{ij} is the weight applied to the j-th property at regression point i, d_{ij} is the geographical distance in kilometers between regression point i and j, and b is the geographical bandwidth.

The bandwidth in GWR specifies the radius of the weighting function, which is either fixed, based on absolute distance, or adaptive (fluctuating based on a predetermined number of nearest neighbors). An optimal bandwidth can be found by maximizing the model goodness-of-fit. The analysis examined various spatial weighting functions (bi-square, moving window, and adaptive spatial kernel) for minimizing nearest neighbors using Akaike information criterion (AIC) optimization. For this data, the optimal approach applied a bi-square adaptive spatial kernel that was optimized to minimize the corrected AIC (AICc) with a minimum percentage of neighbors set at 10% and a maximum percentage of neighbors set at 15%.

5.2 Equity Results

Table 7 shows the results of the vertical equity tests run on the output of the GWR and three MRA models. All the tests detect global regressivity except for Kochin-Parks.

Table 7. Vertical Equity Results

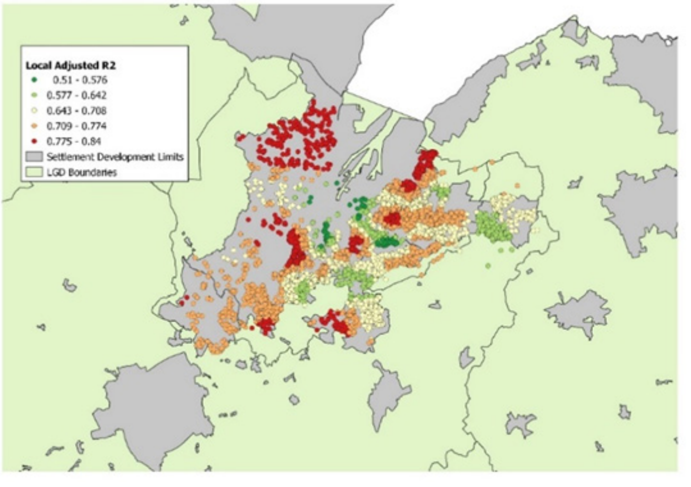
Focus:	GWR	Conclusion	MRA 1	Conclusion	MRA 2	Conclusion	MRA 3	Conclusion
Median Ratio	1.0289		1.0164		1.0288		1.0410	
COD	20.3280		23.3991		25.9938		28.973	
PRD	1.0627	Regressive	1.0570	Regressive	1.0883	Regressive	1.1197	Regressive
PRB	-0.1467	Regressive	-0.1133	Regressive	-0.2009	Regressive	-0.2779	Regressive
Paglin-Fogarty	0.8182	Regressive	0.7672	Regressive	0.7214	Regressive	0.6800	Regressive
Cheng	0.8206	Regressive	0.8860	Regressive	0.7620	Regressive	0.6686	Regressive
Kochin-Parks	0.9815	Progressive	0.8182	Progressive	0.9211	Progressive	0.9494	Progressive
Bell	1.0061	Regressive	1.1763	Regressive	0.9978	Regressive	0.8829	Regressive
ASR	-5.08E-07	Regressive	-5.16E-07	Regressive	-8.03E-07	Regressive	-10.87E-06	Regressive
Clapp	1.1004	Regressive	1.1888	Regressive	1.2464	Regressive	1.4524	Regressive
Modified Clapp (B-S)	1.0327	Regressive	1.1141	Regressive	1.1972	Regressive	1.3646	Regressive
KI	-0.04851	Regressive	-0.04691	Regressive	-0.06595	Regressive	-0.09123	Regressive
MKI	0.85117	Regressive	0.85609	Regressive	0.79767	Regressive	0.72012	Regressive
N	5,374		5,374		5,374		5,374	
Kruskal-Wallis	763.98	Regressive	339.25	Regressive	917.04	Regressive	1601	Regressive
Spearman Rank	-0.35166	Regressive	-0.23346	Regressive	-0.37039	Regressive	-0.52174	Regressive

5.3 Mitigating Inequities via GWR

Natural progression within tax inequality research is to apply more spatially weighted local modelling frameworks to assess the varying nature of tax inequity across the administrative housing market structure. Whilst the differing measures (ratios) provide a basis for evaluating the presence of inequities over the entire tax jurisdiction, they do not allow for the extraction of variation throughout a particular region. The GWR moves beyond a conditional mean estimate by providing local regression parameter descriptive statistics of the coefficient estimates, which can be used to identify differential effects on value. While approaches such as the modified Clapp-Birch-Sunderman (Birch and Sunderman, 2013) method apply dummy variables for each of the individual neighborhood areas to obtain their gross vertical inequity slope estimates, the model does not describe the spatial variation of the vertical inequity, with the result that neighborhoods' coefficients are likely to under-represent regressivity and progressivity, which may be cancelling each other out. Moreover, in GWR, the localized parameter estimates reveal the geographically varying nature of both horizontal and vertical inequity. Thus, it provides the basis for vertical inequity measurements to vary *within* neighborhoods or assessment jurisdictions, providing intra-neighborhood tax assessment.

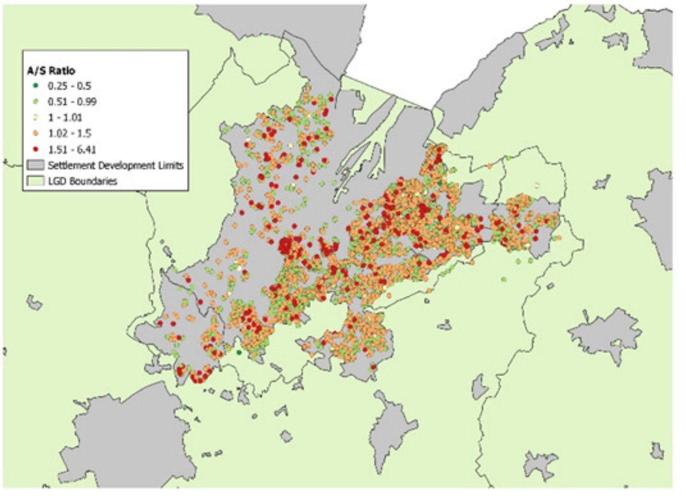
Examination of the GWR technique shows improvements within the level of explanation or goodness of fit relative to the other MRA models. Scrutiny of the localized R2 statistic provides a basis for assessing model performance and where it is deficient, i.e., where further omitted variable bias and model misspecification may still be present, which can aid assessors in allocating resources to these areas to increase estimation accuracy. For example, Figure 4 below shows clustering and high levels of model performance in particular areas, but also areas where the model performs more poorly, which may be attributable to sub-markets characterized by more heterogeneous stock and horizontal inequity.

Figure 4. GWR model performance



In addition, when examining the vertical inequity estimates across the quartiles, minimum, and maximum, the modified Clapp model LnA estimate clearly exhibits both progressivity and regressivity. The minimum estimate of 0.4603 and first quartile estimate of 0.8926 show the presence of progressivity, while the third quartile (1.1401) and maximum statistic (1.784) display regressivity. This is further exemplified by Figure 5 below where the ratios demonstrate there to be clear clusters of progressive and regressive inequity in assessment.

Figure 5. Assessment-to-sales ratios



The GWR enhancement also permits the coefficients to fluctuate, providing a coefficient value at each assessed property. This allows a granular analysis of the effects of spatial variation on value and therefore can improve practitioners' understanding of the horizontal—and thus vertical—inequity estimation error. This provides a representation for assessors to establish which of the property attributes are associated with inequity by location—and also where these characteristics are *not* associated with inequity. This is vitally important for policy as assessors can isolate the characteristics and location to enhance their taxation assessment and diagnose where inequity is originating.

The significance of locally weighted regression approaches is therefore that by isolating exact locations, any neighborhood-level assessment practices or adjustments that underlie these tax inequities can be targeted and addressed. The adoption of the locally weighted approach helps isolate exactly which properties are causing valuation inequity so assessors can save time and money addressing them. Also, since GWR allows coefficients to vary over space, it does not assume that these new variables are impacting equity to the same degree and magnitude. In this way, GWR provides a relatively adoptable and feasible method to identify intra-neighborhood and cross-neighborhood inequity that spans existing aggregation borders, arguably allowing for a more informed depiction of a spatially referenced vertical inequity tax allocation.

5.3.1 GWR: Pros and Cons

The adoption of GWR as a method to mitigate inequities has its advantages and disadvantages, enumerated below.

Advantages:

I. GWR can more accurately identify local submarket fluctuations, leading to ratio studies that are more uniform, equitable, and accurate, which can help assessment jurisdictions save costs associated with inequity.

II. It greatly reduces the amount of time it takes to create multiple sub-models or a flexible global model.

III. GWR can reduce the number of variables needed for mass appraisal exercises. This is because much of the variation the extra variables would need to "explain" in a global model is avoided using the moving window. This can be very beneficial for assessment jurisdictions with limited data or data collection restraints.

IV. It provides a means for visually demonstrating on a map how inaccuracy or coefficients and models behave by location. Equally, it can show where the model explanation is superior or inferior, which can then be used for targeted assessment. This also provides the basis for establishing what determinants are more (or less) value-significant.

V. The approach can be executed using free and open-source software commonly taught in universities (e.g., Python, R).

VI. It can even be used to identify locations and magnitudes of inequity.

Disadvantages:

I. GWR has the potential to run into issues with a high volume of variables, particularly dummy variables that can produce errors or biases.

II. The standard GWR approach is limited in terms of interactive variables.

III. The technique requires accurate coordinates of absolute location for each property, and not all assessment jurisdictions have access to such data.

IV. Model explainability is more complicated and less transparent to taxpayers than for a single linear model. Instead of just using the coefficients (adjustments) from a model to explain the total appraised value "line item receipt"-style, in GWR one must calculate a spatial weights matrix for the new properties for the prediction loop that uses weighted averages of coefficients.

V. GWR requires an in-house specialist, such as a geospatial analyst or spatial econometrician, with the appropriate expertise to build and maintain the model.

VI. GWR can have issues with predictions at boundaries based on the adaptive bandwidth

6. Summary and Recommendations

This paper compares the performance of different measures of vertical equity using simulated data. The goal of the paper is to detect the basic tendency of a test to correctly or falsely reject the null hypothesis. To accomplish this, simulated data was constructed so that the true relationships are controlled. In scenarios where there are measurement errors in the use of prices, distortions are of the basic form, i.e., variance distortions, to capture the tendency of the tests toward regressivity or progressivity.

While more simulation studies that allow for other types of distortions such as outlier effects, nonlinearities, small samples, etc. could produce additional observations and possibly affect our conclusions, the results that would hold true regardless would be that (1) ASR and PRB have at least some endogeneity bias by construction with the ASR likely having more bias than the PRB, and (2) the methods belong to two classes: those with no measurement error assumption (non-EIV models) and those which assume measurement errors exist (the EIV models). Because these tests are constructed under different assumptions and operate under a different null (model conditions under the null are different), their behaviors are different.

We do not recommend one particular test over another but rather that a suite of tests be reported to support the existence or absence of vertical equity. The tests of Paglin-Fogarty and Cheng, as well as Gini-based (distributional) tests, the Spearman Rank test, and the Clapp test are good candidates. It is important to note that Paglin-Fogarty and Cheng methods are subject to regressivity bias when assessed values are estimated from a regression. Other methods not addressed in this paper, including other distributional methods such as entropy-based approaches, should be investigated for future research.

7. References

Birch, J. and M. Sunderman. 2013. Regression modeling for vertical and horizontal property tax inequity. *Journal of Housing Research*, 23(1): 89-104.

Cheng, P.L. 1974. Property taxation, assessment performance, and its measurement. *Public Finance* XXIX: 268-284

Clapp, J.M. 1990. A New Test for Equitable Real Estate Tax Assessment. *Journal of Real Estate Finance and Economics*, 3: 233-249.

Fotheringham, A.S., Brunsdon, C., and M. Charlton. 2002. Geographically weighted regression: The analysis of spatially varying relationships. John Wiley & Sons, Chichester.

Fukushige, M., Ishikawa, N., and S. Maekawa. 2012. A modified Kakwani measure of health inequality. *Health Economics Review*, 2 (1): 10.

Gloudemans, R.J. 2011. The coefficient of price-related bias: A measure of vertical equity. *Fair+Equitable*, 9 (8); 3-8

IAAO, 2013. Standard on Ratio Studies. Kansas City, MO: IAAO.

IAAO, 1978. Improving Real Property Assessment: A Reference Manual. Kansas City, MO: IAAO.

Kakwani, N.C. 1977. Measurement of tax progressivity: An international comparison. *Economic Journal*, 87: 71- 80.

Kleinbaum, D.G., Kupper, L.L. and H. Morgenstern. 1982. Epidemiologic Research. Epidemiologic Research Principles and Quantitative Methods. Belmont, California.

Kochin, L.A. and R.W. Parks 1982. Testing for assessment uniformity: A reappraisal, *Property Tax Journal*, 3(1): 27-54.

McMillen, D. and R. Singh. 2022. Measures of vertical inequality in assessments, Lincoln Institute of Land Policy, working paper.

Paglin, M. and M. Fogarty. 1972. Equity and the property tax: A new conceptual focus. *National Tax Journal* 25(4):557-565.

Quintos, C. 2020. A Gini measure for vertical equity in property assessments. *Journal of Property Tax Assessment and Administration*, 17:2, 33-61.

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Few, S. 2010. "BI Has Hit the Wall." Visual Business Intelligence, a blog by Stephen Few. September 9. http://www.perceptualedge.com/blog/?p=820 (accessed Jan. 20, 2011).

Book

Overshot, D., and R. Pray. 2010. 2011 National Construction Estimator, 59th ed. Carlsbad, CA: Craftsman Book Company.

Chapter in a book

Englebert, E.A. 1969. "Political Aspects of Real Estate Taxation in Relation to Metropolitan Growth and Planning." In Land and Building Taxes: Their Effect on Economic Development, edited by A.P. Becker, 51-62. Madison: University of Wisconsin Press.

Dissertation

Choi, M. 2008. "Contesting Imagnaires in Death Rituals during the Northern Song Dynasty," Ph.D. diss., University of Chicago.

Government report

Internal Revenue Service. 2010. *Tax-exempt Status for Your Organization* (Publication 557). Washington, DC: U.S. Department of the Treasury.

Journal article

McMillen, D.P., and R.N. Weber. 2008. "Thin Markets and Property Tax Inequities: A Multinomial Logit Approach." National Tax Journal 61(4): 653-671.

Legal materials

United States v. Smith, 182 F.2-D 305 (2-D Cir. 1953).

FAA Modernization and Reform Act of 2012. Public Law 112-95, 126 Stat. 11, 112th Cong. (February 14, 2012). http://www.faa.gov/about/office_org/headquarters_offices/apl/aatf/legislative_history/media/faa_modernization_reform_act_2012_plaw-112publ95.pdf.

Magazine or newspaper article

Bergen, K. 2011. "Illinois Department of Revenue Denies Tax Exemptions for 3 Hospitals," Chicago Tribune, August 17. http://articles.chicagotribune.com/2011-08-17/business/ct-biz-0817-hospital-tax-20110817_1_charity-care-provena-covenant-medical-center-tax-exempt-status (accessed Aug. 26, 2011).

Online database

Lincoln Institute of Land Policy. (n.d.) Significant Features of the Property Tax, online database. http://www.lincolninst.edu/subcenters/significant-features-property-tax/.

Personal communication (letter, memorandum, email)

Morton, M. 2010. Letter from Morton (General Counsel for Revenue Operations, West Virginia

Department of Revenue, Charleston, WV) to C. Kent (Vice President Business and Economic Research, Marshall University, Huntington, WV), June 14.

Presentation

O'Connor, P.M. 2004. "Basics of Non-linear Modeling." Paper presented at Broadening Your Horizons, 8th Annual Integrating GIS & CAMA 2004 Conference of the International Association of Assessing Officers and the Urban & Regional Information Systems Association, Austin, TX, March 28-31.

Plimmer, F., and G. McGill. 2003. "Land Value Taxation: Betterment Taxation in England and the Potential for Change." Paper presented at FIG Working Week, Fédération Internationale des Géomètres, Paris, France, April 13-17.

Press release

U.S. Census Bureau News. 2012. "New Residential Sales in December 2011," press release, January 26. http://www.census.gov/construction/nrs/ (accessed Feb. 20, 2012).

Proceedings

Moore, J.W. 1995. "The Market-Correlated Stratified Cost Approach." In Proceedings of the 61st Annual Conference of the International Association of Assessing Officers, 223-236. Chicago: IAAO.

Reports

Center for Business and Economic Research. 2011. Property Tax Exemptions of Nonprofit Organizations in West Virginia: Survey Results, prepared for Sub-Committee on Local Finance and Property Taxation of the Governor's Tax Modernization. Huntington, WV: Marshall University.

Brown, M. 2005. Statewide Property Tax Equalization Study. Indiana Fiscal Policy Institute Report No. 24. http://www.indianafiscal.org/report.pdf (accessed Nov. 3, 2010).

Technical standard

International Association of Assessing Officers. 2013. Standard on Ratio Studies. Kansas City, MO: IAAO.

USPAP

The Appraisal Foundation (TAF). 2012. Uniform Standards of Professional Appraisal Practice, 2012—2013 ed. Washington, DC: TAF.

Website

International Property Tax Institute. 2012. "IPTIpedia." http://wiki.ipti.org/index.php?title=Main_Page (accessed July 1, 2012).

U.S. Census Bureau. 2010. "American Community Survey: 2005—2009." http://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml.

Working Paper

Bahl, R., and J. Martinez-Vazquez. 2007. "The Property Tax in Developing Countries: Current Practice and Prospects." Working paper, Lincoln Institute of Land Policy, Cambridge, MA.

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