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Abstract

Philadelphia’s Actual Value Initiative, adopted in 2013, creates a unique opportunity for us to test whether reassessments at short intervals to true market value and taxing by such values improve equity. Based on a difference-in-differences framework using parcel-level data matched with transactions in Philadelphia and 15 comparable cities, this study finds positive evidence on equity outcomes from more regular revaluations. The quality of assessment, as measured by the coefficient of dispersion, improves substantially after 2014, although the extent of improvement varies across communities. Vertical equity, measured by price-related differential, also improved, although it was still above the standard threshold. Cross-city comparisons confirm Philadelphia’s improvement in quality and equity of assessments after adopting the initiative. These results highlight the importance of regular reassessment in places where property values increase quickly, and they shed light on the disparate impacts of reassessment across income, property value, race, and gentrification status. The paper makes the case that the property tax, if designed well, can be an equitable tax instrument.

Key words: real property tax; valuation; assessment cycle; equity

JEL codes: H20, H31, H71, R51
1. Introduction

Although the property tax has long been criticized as the most unfair, even “the worst” tax (Jensen, 1931; Fisher, 1996; Cabral and Hoxby, 2012), it has persisted through today in the United States as the most important own-source revenue for many local governments. It is fair to say that local autonomy thrives when localities control their own mainstay revenue. For this important reason, improving the administration of the property tax is a perennial task for the public finance community. The negative reputation of the property tax is derived mainly from issues and challenges in property valuation, which demands up-to-date information about multiple aspects of properties and requires trained professional staff, thereby posing high costs in terms of technology and personnel. On top of these difficulties, property valuation is also susceptible to idiosyncratic errors in assessment. Property assessment, thus, is a complex, constantly evolving field.

Lags in property reassessment — or delays in estimating changes in the value of a property since the last assessment — and poor tax collection can adversely affect the horizontal and vertical equity of any local property tax system, as well as erode a local government’s revenue-raising capacity (Weber et al., 2010). Sudden and unexpected changes in tax bills from inaccurate assessments can leave capital-wealthy but liquidity-constrained households unable to pay their tax bills (Alm et al., 2016). Furthermore, the property tax is sometimes referred to as the “least fair” tax by the average American (ACIR, 1987; Fisher, 1996; Cabral and Hoxby, 2012): Property taxes are often found to be regressive, such that lower-value properties face higher assessments relative to their actual market values than higher-value properties (Berry et al., 2021; McMillen, 2013; McMillen and Singh, 2020). In particular, in jurisdictions where regular reassessment is not mandated by the state, fairness in taxation becomes a serious concern,
as house appreciation is less likely to be included in the assessed value owing to long lags in reassessment.

This study evaluates whether reassessments at short intervals to true market value and taxing by such values improve equity. In most states, real property tax law requires regular revaluation of properties. For example, counties in the state of Washington are required to annually update assessed values of all properties based on appropriate statistical data, and they are also required to physically inspect properties at least once every six years.¹ The state of Pennsylvania, however, is one of the few states that does not have statutorily mandated reassessments on a fixed cycle (Montarti and Weaver, 2007). In Philadelphia,² historical lags in property assessment have resulted in systematic inequities in the city’s property tax system. From the 1980s to 2012, Philadelphia did not conduct a comprehensive reassessment. As a result, the assessed value listed on most property tax bills was estimated to be 60 percent lower than true market values (Dowdall and Warner, 2012; Ding and Hwang, 2020). The quality of assessments was poor, and properties with similar market values were often listed with dramatically different assessed values (Gillen, 2008). As assessments were increasingly out of line with actual property values and the tax burden had become increasingly unequal with respect to wealth, Philadelphia adopted a property tax reform in 2013, known as the Actual Value Initiative (AVI). The AVI was not only the first comprehensive revaluation of all properties in the city in a 30-year window but also broke from the tradition of fractional assessment to reassess all properties at full market value. To improve the quality of property assessments, under the AVI, the city reassessed every property and changed in 2014 how tax bills were calculated. Philadelphia conducted another comprehensive revaluation in 2019.

¹ See dor.wa.gov/sites/default/files/legacy/docs/pubs/prop_tax/homeown.pdf.
² Throughout this paper, Philadelphia refers to the city of Philadelphia, rather than the metropolitan area.
The AVI requires more regular revaluations to address issues related to poor assessment quality and increasing inequity in property taxation in Philadelphia. As a policy shock, it provides a unique opportunity for us to answer our research question: Do regular short cycles of reassessment generate an equitable distribution of the tax burden among property owners? The consensus among scholars and practitioners is that annual reassessment best maintains equity and efficiency (Dowdall and Warner, 2012; Weber et al., 2010). Given the high costs of annual reassessments, however, a vast majority of assessing jurisdictions nationwide conduct reassessments less frequently. This overarching question in fact embeds several minor but not less important subquestions: What is the impact of regular comprehensive reassessments on properties across neighborhoods? Are more regular reassessments alone sufficient to achieve the equity goal? And if not, what other assessment practices could improve equity in property taxation? With empirical estimates on horizontal and vertical equity, we then consider the ramifications of assessment cycles on the efficiency of the cycles in terms of possible behavioral patterns of property owners.

Taking Philadelphia’s two recent reassessments as natural experiments, this paper uses parcel-level data matched with sales transactions in Philadelphia and 15 comparable cities across the nation to examine whether regular reassessments at short intervals to true market value and taxing by such values improve horizontal and vertical equity. Horizontal equity, measured by the coefficient of dispersion (COD) in this paper, measures the level of assessment uniformity: whether parcels with the same (or close) attributes would be assessed and taxed at equal amounts. Vertical equity, measured by the price-related differential (PRD), is concerned with the inequality in assessments for properties of varying values: whether less expensive properties are systematically assessed at higher ratios relative to their market values and thus bear a higher than
the fair share of property taxes than more expensive properties. The results suggest that before the AVI, the quality of Philadelphia’s property assessments was worse than almost all other cities in our sample and property taxes in Philadelphia were much more regressive than other cities, as well. Pursuant to the AVI, the comprehensive revaluation in 2014 (and again in 2019) led to marked improvement in assessment quality (horizontal equity), although the extent of improvement in uniformity was much smaller in disadvantaged communities.

The vertical equity of Philadelphia’s property tax system also improved after the city adopted the AVI. While a PRD between 0.98 and 1.03 is generally considered as the acceptable range, Philadelphia had a PRD as high as 1.42 pre-AVI, suggesting lower-priced homes were systematically assessed at a greater percent of their market values than high-value ones. The PRD declined to 1.28 in 2014 and further to 1.14 in 2019, showing a continued mitigation of assessment inequity post-AVI. Effective tax rates also experienced larger declines for properties in more disadvantaged communities, namely majority-Black or high-minority neighborhoods, low-income neighborhoods, or lower-income nongentrifying neighborhoods. Cross-city comparisons confirm that assessment quality in Philadelphia improved substantively against other cities after 2014, although Philadelphia’s PRD remained above the popular threshold.

Overall, our results highlight the importance of regular reassessments in cities that experienced large increases in property values (e.g., through gentrification) and shed light on the disparate impacts reassessment might have across income, property value, race, and gentrification. Thus, the paper makes the case that with regular reassessments, the real property tax can be an effective tax instrument, with facilitation by other practices or tax relief programs to ensure and maintain an equitable impact. This paper contributes to the literature on property taxation in a number of ways. First, the policy shock of the AVI allows us to identify the causal
effects of more regular reassessments on improving assessment quality and redistributing the property tax burden. This paper provides updated evidence on the (horizontal and vertical) equity effects of property revaluation after a long lapse in reassessments. Second, this study looks into the heterogeneity of the effects among properties in different neighborhoods and find that more regular reassessments provide greater benefit for property owners in more disadvantaged neighborhoods, although assessment accuracy does not necessarily improve as much. Finally, our research question cuts deep to the core of property tax administration — equity and efficiency. Conventional taxation theory has these two principles as holding a tradeoff. We argue that in terms of the property tax, equity and efficiency can move in unison — raising one will not lower the other, but rather the two will mutually reinforce through more frequent, regular property tax reassessments.

2. Analytical Framework and Context

2.1. Property Assessment and Rationales

Value Assessment

Value assessment in property taxation determines the tax base of each property at some snap point of time via obtaining an as accurate as possible estimate of the market value of a property. Estimates are then converted into assessments either at 100 percent of market value or at a uniform percentage (assessment ratio) of the market value. The former is full value assessment, whereas the latter is a fractional assessment. As long as the estimates are accurate, the assessed value, $A$, matches the market value, $V$, providing a reliable tax base.

The purpose of obtaining accurate estimates of market value is to equitably distribute the burden of financing local public services, with the assessed value as a ratio of the total tax base.
The rationale for regular reassessment is that market value fluctuates. Although the value of properties trends up over time, the extent of change can be very uneven across neighborhoods, property types, and value ranges in a jurisdiction. It is a heterogeneous process on several dimensions. At the neighborhood level, amenities and typological features are one dimension. By housing type, some appreciate quickly, some slowly, and some do not grow or even depreciate. Along the range of housing prices (quality), the elasticity of demand and supply is another dimension to consider.

The property tax is a levy on the stock of household wealth. The heterogeneity of value changes over time demands regular reassessments to distribute the burden of public services on the basis of household wealth. Absent regular assessments, the distribution of the tax burden among properties will not be equitable, eroding the fairness of the tax and trust of the public in government.

**Assessment Cycles**

In this paper, we use the following working definitions of assessment cycles and this paper explores the relationship between the length of assessment cycles and a set of equity (uniformity) measures. Comprehensive assessment (mass appraisal) is conducted in discrete cycles by the year (valuation upon transaction or upon completion of new construction is different). The shortest cycle is annual, which offers the highest probability of match between market value \((V)\) and assessed value \((A)\), \(A \approx V\), which is the best for securing equity; thus, it is the ideal cycle. The *annual cycle* is taken as the default. There can be a parameter \(\rho\) before \(A\), \(\rho\), and \(0 < \rho \leq 1\). When a jurisdiction uses estimated market value as assessed value, \(\rho = 1\); when a jurisdiction uses a fractional assessment system, \(\rho < 1\).
We classify time between reassessments by three categories. The first category, a short cycle, refers to one that reassesses every two or three years. Short cycles are suboptimal relative to annual valuations, but the annual cycle is often not practicable for various reasons. For example, a small jurisdiction or one with inadequate resources cannot afford to assess each year. Uniformity of assessment from each comprehensive assessment can maintain most of its force within a reasonably short period; thus, a short cycle may maintain uniformity before a large inequity occurs. Short cycles arise as a compromise from the ideal cycle, often as the result of balancing the high cost of an annual cycle with uniformity of valuation.

The second category, a regular cycle, refers to assessments that are conducted once every four to six years. Although longer than a short cycle, these cycles are at least regular. The regularity of valuation between two assessments mitigates erosion to uniformity (equity) to a limited extent. These cycles often are adopted by small taxing jurisdictions, mainly for cost reasons.

Finally, a long or irregular cycle refers to assessment cycles that are longer than six years, beyond the length of a full economic cycle. These long cycles often become or drag into irregular, indefinitely long cycles. These are the scenarios that have often occurred, caused extreme inequity, and triggered the tag of the “worst tax.”

Under the U.S. federal system, states fall in at least two types — strong states and home rule states — in their relation with localities in the regulation of local taxation. The former type are Dillon-rule states that not only stipulate short or regular cycles but also strictly enforce the required cycle. Take Virginia, for example: the 1984 revision of the Virginia Code requires counties and cities to adopt a regular (fixed-length) cycle. The latter type allows local discretion,
without stipulating much regulation. New York is an example of home rule states, where local taxing jurisdictions decide their own assessment cycles.

The administration of the property tax has evolved toward regular, short, preferably annual reassessments, which are also what the states have mostly tried to promote since the second half of the 20th century. Among the rationales for the preferred cycles is a technical consideration: assessment is heavily subject to human judgment based on limited information, out of which errors are unavoidable. The technical errors capitalize into property values and, if not corrected in a timely manner, can erode tax equity for years.

2.2 Gaps in What Is Known

The academic literature has been thin on the administration of the property tax in general and on the effects of assessment cycles in particular. Among the few earliest studies, Geraci (1977) and Bowman and Mikesell (1990) identified some determinants of assessment equity, including characteristics of assessors, staffing of the assessor’s office, and tools for valuation. Mikesell (1980) examined the impact of assessment cycles on assessment quality. Using data from Virginia local tax assessing units in the years 1973 through 1976, he found that 68 percent of the units in regular cycles had better outcomes (higher uniformity or a 10 percent lower COD) compared with units in annual reassessment, and he found much smaller improvement in the latter group. He speculated that in states that require annual reassessments, revaluations were often just copying prior years’ numbers, probably with a flat percentage adjustment for all properties.

More recent research better accounts for potential simultaneity and omitted variable bias. Using cross-sectional data (1992) of assessing towns and cities in New York, Eom (2008) found
a positive relationship between assessment uniformity and frequent reassessment. Specifically, each additional year of lag in reassessment may lead to a 1.6 percent reduction in assessment uniformity, while an additional reassessment over the previous four years improves uniformity by 17.8 percent. However, there has not been more recent updated empirical evidence to support that annual reassessment should be the norm or that short and regular cycles are preferred. This paper fills the niche.

2.3 The Actual Value Initiative of Philadelphia

In 2013, after several years of public discussions and evaluations, Philadelphia adopted a comprehensive property tax reform, known as the Actual Value Initiative (AVI), which became effective for property tax bills in 2014. Under the AVI, Philadelphia conducted the first comprehensive reassessment since the 1980s for the market value of every property in the city. Consequently, the newly assessed values of properties under the AVI would more accurately reflect their market values. For example, from 2005 to 2013, the mean assessed value of single-family residential properties in Philadelphia remained almost flat, but after the full market value reassessment, the average assessed value almost tripled (Ding and Hwang, 2020). All properties were reassessed again at full market value in 2019.

Under the AVI, the city also changed the way it calculates tax bills (Ding and Hwang, 2020; Dowdall, 2015). Specifically, before 2013, the city used fractional assessment, at 32 percent (a predetermined ratio), so that less than one-third of a property’s estimated market value counted as assessed value, and the nominal tax rate was 9.771 percent. The AVI replaced fractional assessment with full market value assessment, with 100 percent of a property’s estimated value as assessed value to calculate tax bills. Claimed to be a revenue-neutral reform,
the AVI redistributed the tax burden in the city, and the nominal tax rate plummeted to 1.34 percent in 2014. Properties with no or small increases in market values since the 1980s benefited with lowered tax bills, whereas those with large appreciations in value received larger tax bills.

The effects of the two reassessments under the AVI are very clearly illustrated in Figure 1, where the dashed line marks the mean assessed values and the solid line marks the mean market values for single-family residential homes. Between tax years 2010 and 2013, there was very little change in the average assessed value for these properties; only new sales or properties under appeals were likely to be reassessed. Beginning in 2014, an almost three-fold increase in the assessed value considerably closed the difference between the average assessed value and the average market value. Absent comprehensive reassessments from 2014 through 2018 (there was a small increase in the tax rate in 2016 from 1.34 percent to 1.4 percent), the gap grew wider again, with assessed value decreasing slowly, likely because of appeals and market value increasing quickly. Then the second comprehensive full value reassessment in tax year 2019 closed some of the gap between the two values. Overall, the recent AVI tax reform in Philadelphia as a natural experiment offers the best and most representative case for our study.

While the AVI requires the city to reassess all properties more regularly, it does not necessarily change the administration of property assessment practices or the quality of assessments. In other words, while a comprehensive reassessment should render the assessed values closer to true market value, it does not necessarily make assessments more equitable, and its effectiveness is still an empirical question.
3. Data and Methodology

3.1 Methodology

This study intends to isolate the effect of the AVI on the level of horizontal and vertical equity of residential property assessments by comparing the assessment outcomes before and after the adoption of the AVI in Philadelphia with those of a national sample of peer cities. Here, properties (sales) in Philadelphia are considered as the treatment group because they became subject to regular revaluation under the AVI post-2014. Properties in peer cities that did not experience such a policy shock are considered as the comparison group. The two-way, property-level, difference-in-differences (DID) model can be specified as:

\[
Y_{ijt} = \beta_0 + \beta_1 \cdot TREAT_j + \beta_2 \cdot POST_t + \beta_3 \cdot TREAT_j \cdot POST_t + \Theta \cdot TRACT_j + \lambda \cdot YEAR_t + \epsilon_{ijt}
\]  

(1)

in which \(Y_{ijt}\) represents the outcome measure for property \(i\) in tract \(j\) and in year \(t\). \(TREAT_j\) is the dummy variable that represents properties in Philadelphia (the treatment group). \(POST_t\) is the time dummy and is assigned a value of one for the post-2014 period. \(TREAT_j \cdot POST_t\) is the two-way interaction of the treatment and the time dummies. While both \(TREAT_j\) and \(POST_t\) are omitted in the estimation because we include the tract and yearly fixed effects in our model, we can still identify the effects of AVI by estimating the coefficient, \(\beta_3\), of the interaction term, \(TREAT_j \cdot POST_t\). \(TRACT_j\) and \(YEAR_t\) are vectors of tract- and year-fixed effects.

To evaluate the heterogeneity in the effects of the AVI across neighborhoods that differ by income, racial composition, and gentrification status (for the definition in this paper, see footnote 15), we employ the following model using data from Philadelphia only.

\[
Y_{ijt} = \beta_0 + \beta_1 \cdot NBHD_j + \beta_2 \cdot POST_t + \beta_3 \cdot NBHD_j \cdot POST_t + \Theta \cdot TRACT_j + \lambda \cdot YEAR_t + \epsilon_{ijt}
\]  

(2)
in which \( NBHD \) represents the different types of neighborhoods (by race, income, or gentrification status) and the coefficient of the interaction, \( \beta_3 \), captures the change in the outcome measures post-AVI in the corresponding type of neighborhoods relative to the change in the reference group. In other words, \( \beta_3 \) measures how the AVI impacts properties in a particular type of neighborhood differently from other neighborhoods. All other terms are as defined in equation (1) above.

### 3.2 Measures of Horizontal and Vertical Equity

Horizontal equity (i.e., assessment uniformity) is concerned with assessment differentiation between parcels with the same (or close) attributes. Thus, a uniform assessment, with all properties of equal value being assessed and taxed at equal amounts, achieves horizontal equity. Vertical equity is concerned with the treatment of properties over the range of values. Applying different assessment ratios to properties of varying values results in vertical inequity. For example, a system in which less expensive homes are systematically assessed at higher sales ratios than more expensive homes is *regressive*, while a system in which the assessment ratio increases as property value increases is *progressive*. When the ratio is consistent across home values, a property tax system is considered equitable.

The assessment ratio \( (R) \) is defined as the assessed value of a property to the actual sale price of the property (assessed value \( [A_i] \) divided by market value \( [V_i] \) in the year the property is sold): \( R_i = \frac{A_i}{V_i} \), in which \( V_i \) can be proxied by the recorded sales price of each property. This measure could capture both horizontal and vertical equity, with the major limitation that it does not directly measure any deviation from the desired threshold.
The International Association of Assessing Officers (IAAO) has suggested acceptable thresholds as industry standards for horizontal equity and vertical equity in property assessment. Here, we discuss two measures, coefficient of dispersion (COD) for horizontal equity and price-related differential (PRD) for vertical equity, that are most often used in the literature. Taken together, the COD and the PRD characterize the degree of assessment equity in a particular housing market.

**Measure of Horizontal Equity**

The most common measure to assess horizontal equity is the COD, which measures the average percent deviation of an individual parcel $i$’s assessment ratio from the target (or median) assessment ratio in a jurisdiction. The calculation of the COD of a sample of sales transactions can be expressed as:

$$COD_i = \frac{|R_0 - R_i|}{R_0} = |1 - R_i|$$  \hspace{1cm} (3)

where $R_0$ is the target assessment ratio in the taxing jurisdiction. In an ideal scenario, every property would be assessed exactly at its market value, and thus each property would have an $R_i$ of “1.” So we use a value of “1” for $R_0$, and then the mean COD is computed as the average COD across all properties. Higher values of COD indicate less uniformity in assessment, while lower COD values suggest relatively uniform assessments, and thus imply that a property tax system is horizontally equitable.

According to the *IAAO Standard on Ratio Study* (2013), a reasonable COD for single-family homes is between 5 percent and 15 percent, conditional on the age of the property and neighborhood type, and the target COD for residential properties in “older, heterogeneous areas”
such as Philadelphia should be 15 percent or less. Accordingly, we also created a dummy variable that equals 1 if a sale has a COD of 15 percent or less.

To measure the actual tax burden for property owners, we use the effective tax rate as another outcome, which is calculated as the tax amount divided by the market value of the property proxied by sales price of arm’s length transactions.

**Measure of Vertical Equity**

While there is a general consensus that the COD is an appropriate measure to examine horizontal equity, there is no such consensus over how to test the vertical equity of a property tax system. We use the PRD as the primary measure of vertical equity, which is calculated by taking the mean assessment ratio for all parcels in the sample and dividing it by the weighted mean ratio, where the weight is the sale price. This calculation can be expressed as:

$$ PRD = \frac{\frac{1}{N} \sum \frac{A_i}{V_i}}{\frac{\sum A_i}{\sum V_i}} \tag{4} $$

A PRD of 1 thus implies an absence of vertical inequity in property assessment in a particular geography: Assessments would be perfectly uniform across home values if the weighted mean is equal to the unweighted mean. A PRD greater than 1 suggests the presence of assessment regressivity, in which higher-value properties are assessed at lower ratios, and higher

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3 As Eom (2008) notes, there is a nonlinearity inherent in the COD — it is much easier to decrease a COD from 30 percent to 20 percent than from 15 percent to 5 percent.

4 There are some important limitations with the PRD in measuring vertical equity, because PRD tends to be estimated downward because of right-lying outliers that skew the distribution (Almy et al., 1978; Gloudemans, 1999; Carter, 2016). A number of strategies to evaluate the vertical equity of a tax system have been proposed (see Paglin and Fogarty, 1972; Cheng, 1974; Almy et al., 1978; Bell, 1984; Sunderman et al., 1990; and Kochin and Parks, 1982).
values of PRD indicate greater regressivity. A PRD less than 1 instead suggests the presence of assessment progressivity, in which lower-value properties are assessed at lower ratios.

The IAAO Standards (2013) suggest a PRD between 0.98 and 1.03 as the acceptable range. This range is asymmetric around 1 because there is an upward bias in the denominator, which does not affect the numerator. A PRD above 1.03 is generally considered regressive, i.e., favoring high-valued homes, while a PRD below 0.98 is deemed progressive, which favors low-valued homes.

3.3 Data

Data used in this study primarily are obtained from two sources, in addition to data from the U.S. Census Bureau (the 2009–2013 American Community Survey and U.S. Census TIGER/Line Shapefiles). The first source is the publicly available administrative parcel-level data from the City of Philadelphia’s Department of Revenue (DOR), the Philadelphia Department of Records, and the Office of Property Assessment (OPA). The parcel-level tax files contain annual assessed values, characteristics of each parcel (e.g., property type: residential or commercial, single-family, condo, or multifamily), tax amount, as well as exemptions and abatements, all from 2010 to 2019. Each parcel has a unique identifier that enables us to match units across data sets. We also used real estate transfer data compiled by the Philadelphia Department of Records,5 which were merged to respective parcels; thereby, we have information on assessments and taxes for properties that were transferred during the study period. Using ArcGIS, we also conducted a spatial join to link property-level data to Philadelphia’s census tracts.

5 These are available through OpenDataPhilly at www.opendataphilly.org/.
The administrative data from Philadelphia are compared with control group data from CoreLogic Solutions, the latter of which were used to construct a transaction and assessment data set for our control group of comparable cities for the 2012–2015 period. The selection criteria are: (1) the 30 largest U.S. cities and one smaller peer city, Pittsburgh, from Pennsylvania based on its similarities to Philadelphia; (2) cities with consistent and reasonable counts of observations in the data set during our sample period; (3) cities that conducted no comprehensive overhaul of their assessment system based on our knowledge during our sample period. Applying these criteria, we narrowed down to 15 cities. They are Baltimore; Charlotte, NC; Columbus, OH; Dallas; Denver; El Paso, TX; Fort Worth, TX; Houston; Oklahoma City; Phoenix; Pittsburgh; Portland, OR; San Antonio; Seattle; and Washington, D.C. A few other major cities, such as New York, Chicago, and Los Angeles, were not selected, primarily because of either limited coverage during the study period or a significant number of observations with missing values in their assessment or sales data.

We made a few additional decisions in creating the final sample of residential properties for our analysis. First, the analysis focuses only on arm’s length transactions of single-family residential properties. Arm’s length transactions generally refer to market-rate sales involving buyers and sellers with no previous relationship (rather than, for example, sales between relatives or foreclosure auctions). Prices from arm’s length transactions thus should better reflect true market values, since buyers and sellers in these transactions are more likely to be seeking a price that maximizes their own self-interest. We focused on single-family home sales primarily because of the higher volume of sales within this property class compared with other types of

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6 Unfortunately, CoreLogic Solutions only offered this data set to us through 2015.
7 In addition to the two decisions discussed in the text, we also limited each property parcel to one transaction per month to remove duplicates. If there were multiple transactions of the same property parcel in a month, we only included the transaction with the highest price.
residential units, such as multifamily residential and condo units. Additionally, single-family homes have a higher within-class uniformity than other property classes.

Second, sales with a missing value for the sales price, extremely low or high prices (those with assessed values below $1,000 or above $2,000,000), or with extremely high or extremely low assessment ratios were excluded from the analysis. The sales prices for 4.8 percent of sales are missing in Philadelphia; another 26.9 percent of sales have sales prices below $1,000. These observations were excluded to mitigate the bias induced by these outliers. In addition, a small share of sales transactions suffer from the issue of invalid transactions, as a 2018 audit report of the Philadelphia OPA highlighted, for which we can conclude quite confidently that either the sale price is not valid, the assessment does not reflect current market conditions, or the property data underlying the assessment is far from accurate. Because it is impossible to verify the validity for millions of sales over multiple years, we followed the IAAO-recommended maximum trimming limits and excluded sales with assessment ratios above 3.0 or below 0.1 (about 5 percent on each side), which represent a further 9.1 percent of transactions. After trimming, the statistics provide a more logical and meaningful basis to come to informed policy recommendations and tax administration practices.

8 Sales prices were recorded as $1 in 20.1 percent of sales, meaning these were not arm’s length sales. Our trends were robust to alternative exclusion thresholds.
9 By the 2018 audit report of Philadelphia OPA: “Some, if not many, of the sales as identified as valid by the City are not truly valid. This makes it impossible to continue the analysis without considering further action to yield a clearer insight regarding assessment accuracy.”
10 The IAAO Standard states it is appropriate to set maximum trimming limits of no more than 10 percent (20 percent in extreme circumstances with small samples). We use an acceptable level of trimming — about 10 percent of observations — to drop the outliers, while making sure the final sample still allows for a meaningful analysis and reflects actual overall performance.
11 And the share of sales with invalid or small sales prices or with particularly large or small assessment ratios decreases slightly over time during the study period. Thus, our results are likely an underestimate of the AVI’s impact.
These data cleaning procedures were followed also for the control cities. The data are made up of single-family properties, with duplicate month-property records cleaned; extreme sales prices were removed; the same boundaries of assessment ratio values were trimmed; and sparse tracts were removed. We also removed cities with sparse or inconsistent amounts of data across years and focused on the years 2012–2015 in order to retain the 15 selected cities.

Our final sample has 156,171 sales transactions during the 2010 to 2019 period in Philadelphia for our baseline regression. For the cross-city regression, there are 704,899 observations for the control group and 54,683 for the treatment (Philadelphia) of single-family home transactions during the 2012–2015 period.

4. Impact of AVI on Equity: Descriptive Analyses

4.1 Horizontal Equity

Table 1 provides summary statistics of single-family residential properties in Philadelphia by year from 2010 to 2019, where columns (1) to (4) are contextual information and columns (5) to (9) are analytical indexes derived from the first four. The number of transactions and mean sale price were both low through 2012 as part of the sluggish recovery from the Great Recession. The market began to warm up in 2013 and has been improving since, with transactions and sale prices smoothly trending up. From 2010 through 2013, the mean assessment ratio stayed in the mid-50s, with the CODs also in the mid-to-high-50s, almost four times the acceptable level of 15 percent set by the IAAO for “old, heterogeneous areas” like Philadelphia. The percentage of CODs below 15 percent was in the single digits, and the PRD was way above the IAAO threshold.
Adopted as a response to increasing inequity in property taxation, the AVI seemed to have done what it is supposed to do. The average assessment ratio more than doubled, increasing to 119 percent in 2014. That is, the AVI led to increased assessed values in general, and an average greater than 100 percent suggests that at least a significant share of assessments were higher than their actual sale prices. The average COD decreased by a quarter from 55 percent in 2013 to 41 percent in 2014 — horizontal equity saw a huge improvement. The share of assessments with a COD below 15 percent quadrupled from about 8 percent to 33 percent. These indices showcase a substantive amelioration of horizontal equity in property assessment due to the full valuation reform.

On the basis of the reassessment in 2014, the second reassessment in 2019 generated continued improvement. The absolute error of the average assessment ratio decreased from near 20 percent (19.3 percent in 2014) to about 9 percent in 2019. This adjustment could be explained, among other reasons, as institutional learning from repeated reassessments within a short window of time.\textsuperscript{12} The mean COD improved a further 9 percentage points (from 41 percent to 32 percent), confirming the benefit of reassessment in a short interval, although it remained more than double the threshold of 15 percent. The share of CODs within the threshold, however, dropped by 4 percentage points, for which we do not have a good explanation, except that the city has a lot to learn while it is still in the exploratory stage toward regular cycles of assessment after a three-decade lapse.

Figure 2, showing the density of the CODs for residential sales in 2013, 2014, and 2019, illustrates more finely how assessment accuracy improved from reassessments at short intervals. In 2013, the density peaked at 0.6, with the whole distribution being far right from zero. The first

\textsuperscript{12} Needless to say, there are other contributors, including repeal-induced assessment adjustments due to the sharply increased housing prices during that period relative to the largely unchanged assessments from 2014 to 2019.
revaluation (in 2014) shifted the distribution to the left, which suggests a significant improvement in horizontal equity across properties. Then, the second reassessment (in 2019) shifted the tail of the distribution further to the left, confirming the results from the statistical analyses above. Clearly, assessment accuracy in Philadelphia has been improving following the two comprehensive assessments since the AVI was adopted in 2014.

We can also look at the effective tax rate to determine how these trends in assessment accuracy take shape in actual taxes paid. The bottom left panel of Figure 3 graphs the mean effective tax rate over time. Post-AVI, around the same time that averages in the assessment ratio increased and the CODs and the PRDs decreased, the average effective tax rate declined. Contrary to these other metrics, the citywide average effective tax rate did not experience as dramatic of a change between 2013 and 2014, but it has still steadily declined since 2013.

Figure 4 compares trends from 2012 to 2015 between Philadelphia and the control group of 15 cities. The mean values of assessment ratio, the COD, percentage of CODs below 15 percent, and the PRD of the control group are smooth over this four-year period; Philadelphia’s metrics trend similarly to the control group pre-AVI for all values except the PRD but diverge from the control group post-AVI. Philadelphia’s assessed value and proportion of acceptably accurate assessments both jumped more than twofold in 2014, whereas the control group experienced a lower assessment ratio and only a slight improvement in acceptably accurate assessments. Philadelphia’s mean COD and mean PRD both fell drastically in 2014, whereas those measures each fell only very slightly in the control group.

In Figure 5, we map the COD by census tract in Philadelphia for 2013, 2014, and 2019. The left panel shows the COD in 2013, with most tracts having high CODs. The middle panel, for 2014, shows substantive improvement from the 2014 reassessment, but the CODs in over half
of the tracts were still quite high, especially in areas close to the downtown urban core. The right panel, for 2019, shows moderate COD values across the city, indicating huge improvement overall and a decline of the intense cross-tract variation in COD values. We can infer that even with the AVI, one comprehensive assessment cannot solve long-accumulated issues all at once; regular reassessment at short intervals, as well as improved quality of reassessment, is the key.

Overall, assessment accuracy improved after the AVI was adopted in 2014. As shown in Table 1, despite the improvement in the average COD in Philadelphia following the first full market reassessment in 2014, as well as the second full market reassessment in 2019, there was still significant variation in CODs. This pattern implies that each comprehensive reassessment results in a level shift — but not necessarily a trend shift — in measures of horizontal equity. That is, each reassessment better equalizes properties of similar assessed value, but it does not seem to systematically alter assessment practices such that there are significant improvements to reduce the variation of assessed values from the mean.

4.2 Heterogeneity in Assessment Quality Post-AVI

To evaluate how the quality of assessment changed over time for properties in more disadvantaged communities, we break all the sales into multiple groups based on tract-level characteristics. Specifically, we categorize all neighborhoods in Philadelphia by median income (in quartiles), share of White residents (in quartiles), property value (in quartiles), majority race
(Black, White, and other), and gentrification status (gentrifying, nongentrifying, and nongentrifiable). Figure 6 shows trends in the average COD across neighborhoods, suggesting that before the AVI was implemented, tracts that were higher income, higher value, non-Black, and gentrifying were more likely to have a higher COD, meaning tracts with these characteristics were more likely to have less accurate value assessments. After the AVI, however, these trends flip. Sales in lower-income, lower home value, majority-Black and nongentrifying tracts had higher CODs than those in other neighborhoods; that is, tracts with these characteristics were more likely to have less accurate assessed values after the AVI.

Although this correlative trend cannot be deemed a direct result of the implementation of the AVI, the distinction in trends across groups may suggest that changes surrounding the AVI had a particularly negative impact on assessment quality immediately following the policy’s implementation for already vulnerable groups (i.e., homes in majority-Black, nongentrifying, lower-home value, and lower-income tracts). Nonetheless, the gap in the average COD across groups appears to be converging after the adoption of the AVI, especially in more recent years.

### 4.3 Vertical Equity

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13 Based on data from the 2009–2013 5-year American Community Survey, tracts are categorized by tract majority race, where a tract is majority White (47 percent of observations) if the population is more than 50 percent non-Hispanic white, majority Black (35 percent of observations) if it is more than 50 percent Black (defined as Hispanic Black or non-Hispanic Black), and other (18 percent of observations) if it is neither majority White nor majority Black as they are defined above.

14 Ding and Hwang (2020) define a gentrifiable tract as one in which the median household income was below that of the city in 2000, a gentrifying tract as one which is gentrifiable and experienced both (1) an increase in either its median gross rent or median home value above the respective city average and (2) an increase in its share of college-educated residents from 2000 to 2013 above the average city increase, and a nongentrifying tract as one that is gentrifiable but does not satisfy both requirements to be considered gentrifying.
Philadelphia’s PRD in 2010 through 2013 was between 1.39 and 1.42, clearly above the threshold of 1.03, indicating that assessments were highly regressive in the city (Table 1 and Figure 3, bottom right panel). In other words, lower-priced homes were systematically assessed at a greater percent of their market value. The long period with no reassessments and disparities in Great Recession–induced price crashes across submarkets should help explain such high levels of regressivity. The differential effects of the Great Recession on the various submarkets could also have exacerbated the quality of assessment. The PRD decreased to 1.28 in 2014, indicating a marked improvement under the AVI, but it remained regressive. The 2019 reassessment decreased the PRD further to 1.14, showing a continued mitigation of assessment inequity.

To put the results for Philadelphia into a comparative context, the 2013 PRD of the peer cities ranges from 0.97 in Phoenix to 1.30 in Pittsburgh (Table 2). The PRD for Pittsburgh was only slightly lower than that for Philadelphia, likely because these two cities are in the same state, and it does not require regular revaluations. All cities in the control group had smaller changes in their PRD from 2013 to 2014 than did Philadelphia, with a control group average change of -0.009 (a maximum decrease of -0.051 in Columbus City and a maximum increase of 0.034 in Baltimore, compared with a decline of 0.081 in Philadelphia). Pittsburgh had almost no change in its PRD (from 1.30 in 2013 to 1.31 in 2014). Philadelphia’s improvement in PRD obviously outstripped any other city in the control group, most likely because of the adoption of the AVI. Of course, assessment inequity in Philadelphia until 2014 was still more regressive than most of the other cities.

Collectively, the above descriptive results using the most common equity measures suggest there was some improvement in the vertical uniformity of the property tax system.
following reassessment. Despite that improvement, vertical inequality remains significantly above the acceptable level.

5. Impact of the AVI on Horizontal Equity: Regression Results

This section summarizes the regression results of the short-term impact of the AVI on horizontal equity. The AVI’s effect is captured by the coefficient of the interaction variable \((PHIL \times POST)\), representing the change in the value of the corresponding outcome measure post-AVI of a property in Philadelphia. As defined earlier, the control group consists of residential property sales in our 15 comparison cities. None of these cities experienced significant changes in their property tax systems during the study period (2012–2015). Based on the observations only in Philadelphia, we further evaluate the disparate impact of the AVI on properties in different types of neighborhoods.

5.1. Effects of AVI on Horizontal Equity of Assessments

As shown in Table 3, we find that the AVI led to a significant improvement in horizontal equity in residential property assessments. The adoption of the AVI in Philadelphia leads to a decrease of 11.0 percentage points in the COD for an average property.\(^{15}\) In other words, the average COD results confirm that, compared with cities without similar comprehensive changes in their assessment system, the adoption of more regular reassessments generally makes assessments more uniform across properties of similar values.

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\(^{15}\) Results from the tract-level regressions are quite consistent with the property-level results, and the magnitude is even larger.
When the outcome variable is the dummy of whether the COD of a sale is below 15 percent, the results are quite consistent: The probability of having a COD below 15 percent increases by 25.8 percentage points after the adoption of the AVI. These results confirm that the AVI not only helps improve average assessment accuracy but it also markedly improved the proportion of properties with acceptably accurate assessment levels. When the assessment ratio is used as the outcome variable, the results are quite consistent; the AVI helps improve horizontal equity by bringing the assessment ratio closer to one.

5.2. Heterogeneity in AVI’s Effect on Horizontal Equity

In Table 4, we find that the impact of the AVI on horizontal equity varies significantly across neighborhoods in Philadelphia. Overall, the results suggest the assessment ratio decreased after the adoption of the AVI in disadvantaged neighborhoods (majority Black, low-income, lower property value neighborhoods, as well as lower-income nongentrifying neighborhoods). All these suggest tax assessments became fairer across neighborhoods, as assessments in these neighborhoods experienced smaller increases (or larger declines) relative to sales prices after the adoption the AVI than those in other neighborhoods.

The improvement in the uniformity of assessments, however, was smaller in these more disadvantaged neighborhoods: The improvement in CODs was much smaller in majority-Black, low-income, or lower property value neighborhoods, relative to other neighborhoods. For example, there was a larger variation of assessment values from sales prices in majority-Black neighborhoods, and quality of assessments in those neighborhoods even became slightly worse.

16 Note that here, tracts are categorized by the “majority Black,” or simply “Black,” binary variable, in which a tract is Black (35 percent of observations) if it is more than 50 percent Black (defined as Hispanic Black or non-Hispanic Black), and it is non-Black (65 percent of observations) if it is not majority Black as defined above.
post-AVI: The percent of sales with a COD below 15 percent decreased by 24.9 percentage points in majority-Black neighborhoods relative to non-Black neighborhoods.

When we use yearly dummies instead of one POST dummy, the results confirm that the uniformity in assessment, as measured by the COD, becomes relatively worse in majority-Black neighborhoods, especially in the initial years after the AVI was adopted. The assessment ratio and the COD in majority-Black neighborhoods experience a relatively larger increase immediately after the adoption of the AVI (2014 and 2015) than in later years. This could be partly explained by the generally larger variation of assessment among low-value properties. This may also be attributed to the methodology, data reporting, or other aspects of the property valuation practices that may affect the quality of property assessments. While property tax horizontal uniformity has improved over time, the change in the COD in majority-Black neighborhoods from the pre-AVI level was still significantly larger than that in majority-White neighborhoods as of 2019 (by 22 percent). Similar patterns can be found for properties using other measures of neighborhood disadvantages, such as lower-income neighborhoods, high-minority neighborhoods, neighborhoods with lower property values, or nongentrifying neighborhoods. It is concerning if such an assessment system makes low-income and predominantly minority neighborhoods more vulnerable. More research is warranted regarding additional interventions to mitigate potential disparate impacts of more frequent reassessment.

5.3. Effects of the AVI on Horizontal Equity of Property Owners’ Tax Burdens

In terms of the actual tax burden for property owners, compared with other cities, the effective tax rate did not experience significant changes after the adoption of the AVI, as shown
in Table 3. This is consistent with the claim by the city government that the AVI is largely a revenue-neutral policy.

However, the impact of the AVI on tax burdens varies significantly across neighborhoods (Table 4). In fact, properties in majority-Black neighborhoods, high-minority neighborhoods, low-income neighborhoods, and nongentrifying neighborhoods saw a larger decrease in their effective tax rate relative to those in other more advantaged neighborhoods. Taken together with the PRD results presented above, these results suggest the AVI generally makes property taxes more equitable in Philadelphia. This is especially evident in the model using yearly dummies, which suggests the effective tax rate declines over time post-AVI in majority-Black neighborhoods relative to the non-Black ones (from -0.334 percentage point in 2014 to -0.753 percentage point in 2019). The results suggest that while property owners in less advantaged neighborhoods experienced patterns of worsening uniformity of assessment, the improvement in tax burden for property owners in the same neighborhoods continued even after the adoption of the AVI.

In addition to improving the quality of assessments, the regressivity of the property tax can also be mitigated by well-targeted tax relief programs. For example, the AVI was adopted together with two major programs: one to mitigate tax increases for owner-occupied homeowners (the Homestead Exemption program) and one for long-term homeowners who were likely to face sharp increases in property tax bills after the reassessments (the Longtime Owner Occupants Program or LOOP). The Homestead Exemption program should make property taxation more progressive, since the amount of the exemption is fixed regardless of the value of the property; thus, homeowners of lower-value properties enjoy larger benefits from the

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17 The Homestead Exemption program, the biggest single mitigation program, is available for all owner-occupied primary residences in Philadelphia, regardless of the homeowner’s income or length of tenure in their residences.
program. In contrast, certain tax programs may increase the regressivity of property taxes. For example, Philadelphia has an abatement program that was enacted in 1997, under which new construction or major rehabilitation projects are entitled to a 10-year tax abatement on the value of the newly constructed or rehabilitated improvements.

6. Conclusion

Despite decades of property tax revolts, local governments continue to rely heavily on property taxes. Property assessment, however, is a complex and constantly evolving field and there has been no consensus on whether property values should be regularly reassessed to assure the equity of the real property tax. In practice, many U.S. states do not mandate regular revaluation cycles — at least not short, regular cycles. During long intervals between assessments, property values in urban centers diverge widely: Those in wealthy districts and prime locations appreciate quickly, whereas those in poor districts and less desirable locations rise very little, if at all. Recessions could also exacerbate the quality of overall property assessment when assessments do not keep up with sharper declines in property values in harder-hit areas. Thus, taxes that are levied at the same rate but are based on outdated valuations may hurt low-income homeowners.

The empirical results show generally positive evidence of regular revaluations, although impacts appear to vary across neighborhood types. The quality of assessments in Philadelphia, as measured by the COD, improves significantly after the revaluation in 2014. The tax burden for properties in less advantaged neighborhoods was also reduced after the AVI was introduced, although an alternative vertical equity measure presents mixed results. These results highlight the importance of regular reassessment in cities experiencing significant increases in property values.
(i.e., gentrification) and shed light on the disparate impacts that reassessment might have across income, property value, race, and gentrification.

While our findings suggest that more regular reassessments do improve vertical and horizontal equity, such a program does not address all the challenges of property assessment or property tax administration. The quality of assessment of Philadelphia properties, although significantly improved post-AVI, is still far above the acceptable threshold. This could be explained by variations in assessment methodologies or issues related to quality control, data collection, and data cleaning for property transactions.

Discussions of city- and state-level revaluation policy changes have been in the works for some time. At the national level, regular revaluation of properties has been required by the real property tax law in most states. At the state level, a 2010 study of county assessment practices in Pennsylvania recommended that the Pennsylvania General Assembly consolidate property assessment law into a uniform statewide system and require more frequent reassessment at an interval of four years (Weber et al., 2010). Such changes could not only improve assessment quality and equity across all counties in Pennsylvania but also lower the administrative costs of reassessment, simplify processes to mitigate human error, and comply with the state constitution’s uniformity clause.

At the city level, the Philadelphia City Council recommended in 2019 that the OPA overhaul its leadership, partner with private firms to increase assessment accuracy and appraisal services, and reform its quality control methods (Clarke, 2019). The Office of the Controller also advised that OPA targets its efforts on the geographic areas that are most disproportionately tax burdened — North, Southwest, and West Philadelphia (Rhynhart, 2019). It also recommended readdressing land valuations, improving the transparency of assessment methods, and examining
the true impact of the current tax exemptions and abatements aimed to protect vulnerable homeowners. The city also hired consultants in 2019 to evaluate the city’s property assessment system (J.F. Ryan Associates, Inc., 2018). Based on recommendations from the evaluation, the city initially planned to implement a new assessment system in 2020, which has been delayed because of the COVID-19 crisis. Approaches such as these city- and state-level policy proposals may help fill the equity gaps that the AVI hasn’t managed to mitigate in Philadelphia’s property tax system.

This paper provides updated evidence on the equity effects (horizontal and vertical) of property revaluation on the distribution of the tax burden among owners along the income spectrum after a long lapse in reassessments. The paper makes the case that the real property tax can be well maintained as an effective tax instrument, although other practices or tax relief programs might be necessary to ensure an equitable impact. Despite conventional taxation theory holding equity and efficiency as tradeoffs, the evidence presented supports the idea that equity and efficiency can improve in unison, such that each reinforces the other through more frequent, regular property tax reassessments. As a case study, this empirical research contributes to debates on the design of property taxation systems. The results can help researchers and policymakers understand the complicated relationship between property sales, assessments, and property taxes.
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Figure 1: Mean Sales Prices and Mean Assessments of Single-Family Residential Properties in Philadelphia, 2010–2019

Source: Authors’ calculations using data on property assessments, tax payment history, and sales transactions from the City of Philadelphia’s Department of Revenue, Department of Records, and Office of Property Assessment.
Figure 2. Philadelphia Coefficient of Dispersion (COD) Distribution in 2013, 2014, and 2019

Source: Authors’ calculations using data on property assessments, tax payment history, and sales transactions from the City of Philadelphia’s Department of Revenue, Department of Records, and Office of Property Assessment.
Figure 3: Mean Assessment Ratio, Coefficient of Dispersion, Effective Tax Rate, and Price-Related Differential, Philadelphia

Source: Authors’ calculations using data on property assessments, tax payment history, and sales transactions from the City of Philadelphia’s Department of Revenue, Department of Records, and Office of Property Assessment.
Figure 4: Measures of Horizontal Equity and Vertical Equity, Philadelphia vs. Control Group of Cities, 2012–2015

Source: Authors’ calculations using data on property assessments, tax payment history, and sales transactions from the City of Philadelphia’s Department of Revenue, Department of Records, and Office of Property Assessment, and national control city data from CoreLogic Solutions.
Figure 5. Average Coefficient of Dispersion (COD) in Philadelphia by Neighborhood in 2013, 2014, and 2019

Source: Authors’ calculations using data on property assessments, tax payment history, and sales transactions from the City of Philadelphia’s Department of Revenue, Department of Records, and Office of Property Assessment, and U.S. Census TIGER/Line Shapefiles.
Figure 6. Coefficient of Dispersion (COD) Trends by Neighborhood Characteristics

Source: Authors’ calculations using data on property assessments, tax payment history, and sales transactions from the City of Philadelphia’s Department of Revenue, Department of Records, and Office of Property Assessment, and 2009-2013 American Community Survey data.

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## Table 1: Descriptive Statistics for Sales in Philadelphia

| Year | # of Sales | Mean Sale Price | Mean Assessment | Mean Tax Amount | Mean AR | Mean COD | Mean Effective Tax Rate |
|------|------------|-----------------|-----------------|-----------------|--------|----------|------------------------|
| 2010 | 12,596     | $137,884        | $51,640         | $1,179          | 0.53   | 0.57     | 0.07                   | 1.42 | 1.34% |
| 2011 | 11,363     | $133,575        | $53,694         | $1,329          | 0.56   | 0.54     | 0.09                   | 1.39 | 1.55% |
| 2012 | 12,029     | $140,307        | $55,774         | $1,413          | 0.56   | 0.55     | 0.07                   | 1.41 | 1.61% |
| 2013 | 13,381     | $145,997        | $57,369         | $1,492          | 0.55   | 0.55     | 0.08                   | 1.39 | 1.62% |
| 2014 | 13,517     | $165,434        | $154,299        | $1,655          | 1.19   | 0.41     | 0.33                   | 1.28 | 1.41% |
| 2015 | 15,756     | $164,414        | $149,106        | $1,622          | 1.15   | 0.40     | 0.33                   | 1.27 | 1.35% |
| 2016 | 18,455     | $172,862        | $148,670        | $1,679          | 1.08   | 0.38     | 0.34                   | 1.25 | 1.31% |
| 2017 | 20,040     | $187,057        | $148,588        | $1,694          | 0.99   | 0.36     | 0.31                   | 1.25 | 1.19% |
| 2018 | 20,102     | $196,348        | $147,089        | $1,700          | 0.91   | 0.36     | 0.25                   | 1.22 | 1.11% |
| 2019 | 18,932     | $202,013        | $161,284        | $1,855          | 0.91   | 0.32     | 0.29                   | 1.14 | 1.06% |

*Source:* Authors’ calculations using data on property assessments, tax payment history, and sales transactions from the City of Philadelphia’s Department of Revenue, Department of Records, and Office of Property Assessment.
Table 2: Descriptive Statistics in Philadelphia and Peer Cities

|                  | Total Sales | Mean Sales | Mean Assessment | Mean AR | Mean COD Below 15% | Pet COD | PRD | Mean Effective Tax Rate |
|------------------|-------------|------------|----------------|---------|-------------------|--------|-----|-------------------------|
|                  | 2013       | 2014       | 2013           | 2014    | 2013              | 2014   | 2013| 2014 | 2013 | 2014 | 2013 | 2014 | 2013 | 2014 |
| Philadelphia     | 13,381     | 13,517     | $145,997       | $165,434| $57,369           | $154,299| 0.55| 1.19 | 0.55| 0.41 | 0.08 | 0.33 | 1.39 | 1.28 |
|                  |            |            | 1.62%          | 1.41%   |
| Baltimore        | 8,144      | 5,629      | $153,624       | $138,851| $149,504          | $131,912| 1.26| 1.27 | 0.52| 0.54 | 0.25 | 0.21 | 1.29 | 1.34 |
|                  |            |            | 2.95%          | 2.93%   |
| Charlotte        | 15,196     | 13,828     | $209,967       | $226,544| $197,080          | $195,958| 1.05| 0.96 | 0.26| 0.24 | 0.50 | 0.49 | 1.12 | 1.11 |
|                  |            |            | 1.37%          | 1.27%   |
| Columbus         | 17,731     | 13,084     | $135,482       | $148,748| $134,761          | $141,799| 1.24| 1.13 | 0.40| 0.30 | 0.41 | 0.48 | 1.24 | 1.18 |
|                  |            |            | 2.78%          | 3.25%   |
| Dallas           | 12,505     | 9,420      | $263,046       | $263,703| $230,791          | $226,348| 0.94| 0.89 | 0.24| 0.23 | 0.42 | 0.41 | 1.07 | 1.04 |
|                  |            |            | 2.54%          | 2.43%   |
| Denver           | 12,336     | 10,038     | $332,432       | $368,169| $274,531          | $276,218| 0.84| 0.76 | 0.21| 0.27 | 0.40 | 0.22 | 1.02 | 1.01 |
|                  |            |            | 0.58%          | 0.52%   |
| El Paso          | 4,273      | 2,833      | $150,385       | $148,010| $149,543          | $145,510| 1.06| 1.04 | 0.21| 0.20 | 0.54 | 0.53 | 1.07 | 1.06 |
|                  |            |            | 3.40%          | 2.86%   |
| Fort Worth       | 11,301     | 5,825      | $165,997       | $159,691| $150,785          | $137,366| 0.96| 0.90 | 0.20| 0.21 | 0.53 | 0.49 | 1.06 | 1.05 |
|                  |            |            | 2.77%          | 2.60%   |
| Houston          | 25,053     | 24,668     | $238,696       | $254,692| $207,874          | $226,551| 0.93| 0.94 | 0.22| 0.22 | 0.45 | 0.46 | 1.07 | 1.05 |
|                  |            |            | 2.56%          | 2.52%   |
| Oklahoma City    | 11,893     | 12,047     | $147,955       | $157,418| $141,558          | $156,444| 1.07| 1.09 | 0.25| 0.19 | 0.59 | 0.75 | 1.11 | 1.09 |
|                  |            |            | 1.29%          | 1.25%   |
| Phoenix          | 29,385     | 17,531     | $206,105       | $215,219| $113,231          | $124,470| 0.53| 0.57 | 0.48| 0.44 | 0.03 | 0.03 | 0.97 | 0.98 |
|                  |            |            | 0.72%          | 0.70%   |
| Pittsburgh       | 3,508      | 3,154      | $142,009       | $160,418| $116,743          | $125,583| 1.07| 1.03 | 0.40| 0.39 | 0.28 | 0.26 | 1.30 | 1.31 |
|                  |            |            | 2.55%          | 2.09%   |
| Portland         | 11,242     | 10,210     | $331,552       | $348,896| $296,005          | $324,654| 0.94| 0.97 | 0.18| 0.17 | 0.51 | 0.58 | 1.05 | 1.04 |
|                  |            |            | 1.34%          | 1.30%   |
| San Antonio      | 14,543     | 9,333      | $174,423       | $194,937| $158,143          | $174,734| 0.95| 0.93 | 0.21| 0.20 | 0.50 | 0.52 | 1.04 | 1.04 |
|                  |            |            | 2.50%          | 2.43%   |
| Seattle          | 10,358     | 8,129      | $473,597       | $512,510| $371,149          | $389,338| 0.83| 0.79 | 0.25| 0.25 | 0.26 | 0.22 | 1.06 | 1.04 |
|                  |            |            | 0.97%          | 0.87%   |
| Washington, D.C. | 6,862      | 5,331      | $546,066       | $546,573| $449,642          | $450,541| 0.88| 0.87 | 0.24| 0.23 | 0.38 | 0.39 | 1.07 | 1.05 |
|                  |            |            | 0.76%          | 0.68%   |

*Source:* Authors’ calculations using data on property assessments, tax payment history, and sales transactions from the City of Philadelphia’s Department of Revenue, Department of Records, and Office of Property Assessment, and national control city data from CoreLogic Solutions.
### Table 3. Summary of Coefficients of the Interaction Terms (Peer City Comparison)

| Source: Authors’ calculations using data on property assessments, tax payment history, and sales transactions from the City of Philadelphia’s Department of Revenue, Department of Records, and Office of Property Assessment, and national control city data from CoreLogic Solutions. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Assessment Ratio** | **COD** | **COD_pct15** | **Effective Tax Rate** |
| **Coef.** | **Std. Err.** | **t** | **P>|t|** | **Coef.** | **Std. Err.** | **t** | **P>|t|** | **Coef.** | **Std. Err.** | **t** | **P>|t|** | **Coef.** | **Std. Err.** | **t** | **P>|t|** |
| Treat | -0.338 | 0.013 | 26.910 | 0.000 | 0.045 | 0.006 | 8.230 | 0.000 | -0.343 | 0.007 | 48.420 | 0.000 | -0.028 | 0.024 | 1.160 | 0.265 |
| Post_14 | -0.062 | 0.024 | 2.540 | 0.023 | -0.032 | 0.011 | 3.000 | 0.009 | 0.000 | 0.014 | 0.010 | 0.992 | -0.165 | 0.048 | 3.460 | 0.004 |
| Treat*Post_14 | 0.706 | 0.024 | 28.880 | 0.000 | -0.110 | 0.011 | 10.190 | 0.000 | 0.258 | 0.014 | 18.680 | 0.000 | -0.014 | 0.048 | 0.290 | 0.775 |
Table 4. Summary of the Coefficients of the Interaction Terms (Philadelphia Properties Only)

| Source: Authors’ calculations using data on property assessments, tax payment history, and sales transactions from the City of Philadelphia’s Department of Revenue, Department of Records, and Office of Property Assessment. |
## Table 5. Summary of the Coefficients of the Interaction Terms (Year 2013 as Reference, Philadelphia Properties Only)

| AR            | Coef. | Std. Err. | t   | P>t | COD            | Coef. | Std. Err. | t   | P>t | COD_pct15 | Coef. | Std. Err. | t   | P>t | Effective Tax Rate | Coef. | Std. Err. | t   | P>t |
|---------------|-------|-----------|-----|-----|---------------|-------|-----------|-----|-----|-----------|-------|-----------|-----|-----|-------------------|-------|-----------|-----|-----|
| Black NBHD*2010 | -0.009 | 0.018     | -0.490 | 0.623 | -0.019 | 0.011 | -1.750 | 0.081 | 0.002 | 0.11 | 0.180 | 0.854 | -0.142 | 0.059 | -2.390 | 0.017 |
| Black NBHD*2011 | -0.004 | 0.015     | -0.280 | 0.778 | -0.005 | 0.009 | -0.590 | 0.554 | -0.007 | 0.009 | -0.730 | 0.485 | -0.068 | 0.049 | -1.380 | 0.169 |
| Black NBHD*2012 | -0.004 | 0.012     | -0.310 | 0.755 | 0.001 | 0.008 | 0.070 | 0.942 | -0.017 | 0.009 | -1.900 | 0.058 | -0.030 | 0.041 | -0.740 | 0.460 |
| Black NBHD*2014 | 0.059  | 0.025     | 2.340 | 0.020 | 0.334 | 0.029 | 11.630 | 0.000 | -0.273 | 0.021 | -12.840 | 0.000 | -0.334 | 0.067 | -5.010 | 0.000 |
| Black NBHD*2015 | 0.022  | 0.023     | 0.960 | 0.336 | 0.314 | 0.028 | 11.190 | 0.000 | -0.276 | 0.021 | -13.240 | 0.000 | -0.401 | 0.058 | -6.850 | 0.000 |
| Black NBHD*2016 | -0.031 | 0.022     | -1.420 | 0.158 | 0.297 | 0.025 | 11.910 | 0.000 | -0.284 | 0.022 | -13.190 | 0.000 | -0.478 | 0.058 | -8.240 | 0.000 |
| Black NBHD*2017 | -0.071 | 0.022     | -3.210 | 0.001 | 0.277 | 0.021 | 13.390 | 0.000 | -0.263 | 0.019 | -13.670 | 0.000 | -0.547 | 0.059 | -9.290 | 0.000 |
| Black NBHD*2018 | -0.106 | 0.021     | -4.990 | 0.000 | 0.244 | 0.016 | 14.880 | 0.000 | -0.204 | 0.015 | -13.220 | 0.000 | -0.588 | 0.063 | -9.330 | 0.000 |
| Black NBHD*2019 | -0.207 | 0.022     | -9.540 | 0.000 | 0.220 | 0.018 | 12.070 | 0.000 | -0.237 | 0.017 | -13.670 | 0.000 | -0.753 | 0.077 | -9.780 | 0.000 |

**Source:** Authors’ calculations using data on property assessments, tax payment history, and sales transactions from the City of Philadelphia’s Department of Revenue, Department of Records, and Office of Property Assessment.