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Latest Evidence from Philadelphia

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Assessment Frequency and Equity of the Property Tax: Latest Evidence from Philadelphia

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Abstract

Philadelphia's *Actual Value Initiative*, adopted in 2013, creates a unique opportunity for us to test whether improved reassessments at short intervals to true market value improve property tax 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 reassessments. The quality of property assessment improves substantially after 2014, although the extent of improvement varies across communities. Cross-city comparisons confirm Philadelphia's improvement in the quality and equity of property 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 property value and across neighborhood income, race, and gentrification status. The paper makes the case that the property tax, if designed well, can be an equitable tax instrument.

Keywords: real property tax, valuation, assessment cycle, equity

JEL codes: H20, H31, H71, R51

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1. Introduction

Although the property tax has long been criticized by some as the most unfair, even "the worst" tax (Cabral and Hoxby, 2012; Fisher, 1996; Jensen, 1931), the voice is strong and the evidence solid that the property tax could be a good tax (Youngman, 2016). The property tax has persisted through today in the United States as the most important own-source revenue for most 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 claims about the property tax are 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 (Advisory Committee on Intergovernmental Relations, 1987; Cabral and Hoxby, 2012; Fisher, 1996): 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 jurisdictions where

regular reassessment is not mandated by the state, fairness in taxation becomes a serious concern, as house value appreciation is less likely to be included in the assessed value, owing to long lags in reassessment.

This study evaluates whether better assessment practices and reassessments at shorter intervals to true market value improve property tax equity. In practice, some U.S. states do not mandate regular reassessment cycles — at least not short, regular cycles. In most states, the *real property tax law* requires regular property reassessment. For example, counties in Washington are required to annually update assessed values of all properties based on appropriate statistical data, and the counties are also required to physically inspect properties at least once every six years.[1] Pennsylvania, however, is one of the states that do not statutorily mandate reassessments on a fixed cycle (Montarti and Weaver, 2007). During long intervals between assessments, property values in urban centers diverge widely: Those in gentrifying districts and prime locations often appreciate quickly, whereas those in poor districts and less desirable locations rise very little, if at all (Ding et al., 2016; Guerrieri et al., 2013). 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.

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 single 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 (Ding and

[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.

Hwang, 2020; Dowdall and Warner, 2012). The quality of assessments was poor, and properties with similar market values were often listed with dramatically different assessed values (Gillen, 2008). As assessments became increasingly out of line with actual property values and the tax burden became increasingly unequal with respect to wealth, Philadelphia adopted a property tax reform in 2013, the *Actual Value Initiative* (AVI). The AVI was not only the first comprehensive reassessment 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. Under the AVI, the city reassessed every property and changed how tax bills were calculated. To solidify the improvements, Philadelphia conducted another comprehensive reassessment of residential properties for the 2019 tax year (and another in 2023, which is not examined in this paper).

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, the AVI provides a unique opportunity for us to answer our research question: *Do more regular, shorter cycles of reassessment and the resulting improved assessment practices 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. Therefore, the above overarching question in fact branches into three secondary questions: *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?*

It is essential to point out up front that in this paper, we are testing the entire bundle of programmatic improvements resulting from more regular reassessments instead of just the frequency of assessments. It is reasonable to assume that local governments and their assessors learn from previous assessments and improve their practices over time in normal circumstances.

With a focus on Philadelphia's two recent reassessments (2014 and 2019), this paper uses parcel-level data matched with transaction records 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 similar attributes and neighborhood amenities would be assessed and taxed at (close to) equal amounts. Vertical equity, measured by the price-related differential (PRD), is concerned with the inequality in assessments for properties of varying market 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.

Our empirical results suggest that before the AVI, the quality of Philadelphia's property assessments was worse than almost all the other cities in our sample and property taxes in Philadelphia were much more regressive than the other cities as well. Pursuant to the AVI, the comprehensive reassessment in 2014 (and again in 2019) led to marked improvements in assessment quality (i.e., improved horizontal tax 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 percentage 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 declined more for properties in 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 the other cities after 2014, although Philadelphia's PRD remained above the widely acceptable threshold.

There has been significant heterogeneity across neighborhoods. Properties in majority-Black neighborhoods, high-minority neighborhoods, low-income neighborhoods, and nongentrifying neighborhoods saw a larger decrease in their assessment ratios and effective tax rates relative to those in other, more advantaged neighborhoods, suggesting a decrease in average property tax liability within disadvantaged communities. But assessment quality in these less advantaged communities became worse in the initial years after adopting the AVI. The results suggest that one comprehensive assessment cannot solve long-accumulated issues all at once. Rather, regular reassessments at short intervals, as well as improved quality of reassessment, are the key.

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 that reassessment might yield across income, property value, race, and gentrification status. Thus, this paper provides the latest evidence from a major city, which helps make the case that with regular reassessments, the property tax can be an effective and equitable tax instrument. When combined with other assessment practices and tax relief programs, local

jurisdictions can further ensure that the property tax does not cast inequitable impacts on different communities.

This paper contributes to the literature on property taxation in two key aspects. First, the policy shock of the AVI allows us to identify the causal effects of more regular reassessments and improved tax practices on improving assessment quality and redistributing the property tax burden. Thus, this paper provides updated evidence on the (horizontal and vertical) equity effects of property revaluations after a long lapse in reassessments. The second, and more novel, contribution of this study is that we examine heterogeneity in the effects of comprehensive property reassessment among properties in different types of neighborhoods. We find that more regular reassessments generate greater benefits for property owners in more disadvantaged neighborhoods, although assessment accuracy does not necessarily improve as much.

ANALYTICAL FRAMEWORK AND INSTIUTIONAL CONTEXT

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 estimate, as accurate as possible, of the market value of the 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 called *full value assessment* and the latter *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 with the range of housing prices (quality), the elasticity of demand and supply is another dimension to consider.

The real property tax is a levy on the stock of housing wealth. The heterogeneity of value changes over time and thus 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

This paper explores the relationship between the length of assessment cycles (and improved assessment practices) and a set of tax equity measures. Comprehensive property assessment (or mass appraisal) is conducted in discrete cycles by the year. The shortest cycle is annual, which offers the highest probability of match between market value (V) and assessed value (A), $A \cong V$.

There are also *short cycles* in which a jurisdiction reassesses every two or three years. While less likely than an annual cycle to accurately approximate market value (and thus suboptimal compared with annual reassessment), small jurisdictions, or ones with limited or inadequate resources, often cannot afford to reassess all properties each year. Some jurisdictions reassess on a *regular cycle*, which refers to reassessments that are conducted once every four to six years. While the regularity and uniformity of valuation erode between the two reassessment periods, these cycles often are adopted by small taxing jurisdictions, mainly for cost reasons. Last, a *long*

or *irregular cycle* refers to assessment cycles that are longer than six years, beyond the length of a full economic cycle. For a variety of reasons, these long cycles often become indefinitely long cycles, in which property is rarely, if ever, reassessed — except maybe at the time of sale. 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 relationship 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 (i.e., a 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.

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 jurisdictions with regular cycles had better outcomes (higher uniformity or a 10 percent lower COD) compared with those with annual reassessments, 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 the frequency of reassessments. Specifically, each additional year of lag in reassessment may lead to a 1.6percent 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 the claim that annual reassessment should be the norm or that short and regular cycles are preferred. This paper fills the niche.

The most recent literature provides updated evidence that property assessments have often turned out to be regressive, with low-priced properties being assessed at a higher value relative to their actual sale price than are high-priced properties (e.g., Berry, 2021). Atuahene (2018) found that property tax administration policies in Wayne County, Michigan, likely disproportionately impact African Americans, as measured by the incidence of unconstitutional assessments and property tax foreclosures. Avenancio-Leon and Howard (2019) documented a nationwide "assessment gap" under which Black and Hispanic homeowners face a 10 percent to 13 percent higher tax burden for the same bundle of public services. All these in fact point to outdated

assessments as a major driver of tax inequities and unfair tax burdens within and across jurisdictions.

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 as high as 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 in calculating 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 AVI was adopted together with two other major tax programs: One was to mitigate tax increases for owner-occupied homeowners (i.e., the Homestead Exemption program)[3] and the other was for long-term homeowners who were likely to face sharp increases in property tax bills after the reassessment (i.e., the Longtime Owner Occupants Program, or LOOP). The Homestead Exemption program should make the property tax a little 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 program. These two new programs may have a direct impact on a property's effective tax rate, but they are not expected to affect tax assessments directly.

The effects of the 2014 and 2019 reassessments under the AVI are 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 threefold 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 widened 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 policy shock of the recent AVI tax reform in Philadelphia offers the best and most representative case for our study.

[3] 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.

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

DATA AND METHODOLOGY

Measuring Horizontal and Vertical Tax Equity

There are two dimensions of real property tax equity — horizontal equity and vertical equity. Horizontal equity, or assessment uniformity, is concerned with assessment differences between parcels with the same (or close) attributes. If all properties of equal value are assessed and taxed at equal amounts, then the tax system achieves horizontal equity. Vertical equity is concerned with the treatment of properties over a range of values. For example, if lower-valued homes have a higher assessed value relative to their market value (i.e., have a higher assessment ratio) than more valuable homes, this system would be considered regressive. Put it another way, a system in which assessment ratios decrease with property values is regressive, while a system in which assessment ratios increase with property values is progressive.

One metric that captures elements of both horizontal and vertical equity is the assessment ratio (*AR*), which is defined as the *ratio* (R_i) of 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):

$$R_i = \frac{A_i}{V_i} \qquad (1)$$

in which V_i can be proxied by the recorded sales price of each property. The major limitation of the assessment ratio is that it does not directly measure any deviation from the desired threshold,

nor does it fully distinguish between horizontal and vertical equity. Thus, the International Association of Assessing Officers (IAAO) suggests using separate measures for vertical and horizontal equity, and the IAAO provides acceptable ("recommended") thresholds as industry standards for horizontal equity and vertical equity in property assessment.

To measure horizontal equity, we will use the coefficient of dispersion (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 sales transaction can be expressed as:

$$COD_i = \frac{|R_0 - R_i|}{R_0} = |1 - R_i| \qquad (2)$$

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 COD of a jurisdiction or a neighborhood is then computed as the average COD across all properties within the corresponding geography. Higher COD values 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 International Association of Assessing Officers' (IAAO, 2013) *Standard on Ratio Study*, 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.[4] Accordingly, we also created a dummy variable that equals 1 if a sale has a COD of 15 percent or less.

[4] As Eom (2008) noted, 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.

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.

To measure vertical equity, we will use the price related differential (PRD),[5] 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:

$$PRD = \frac{\frac{1}{N}\sum_1^n \frac{A_i}{V_i}}{\frac{\sum_1^n A_i}{\sum_1^n V_i}} \qquad (3)$$

A PRD of 1 thus implies 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 values of PRD indicate greater regressivity. A PRD lower than 1 instead suggests the presence of assessment progressivity, in which lower-value properties are assessed at lower ratios. The IAAO (2013) suggests 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.

Taken together, the COD and the PRD characterize the degree of assessment equity in a particular housing market.

[5] 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; Carter, 2016; Gloudemans, 1999;). 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).

Methodology

This study begins by showing descriptive trends in assessment quality and tax equity before and after the adoption of the AVI. Specifically, we show these trends both for Philadelphia before and after the systematic reassessments in 2014 and 2019, as well as these trends for Philadelphia and a group of 15 comparison cities that did not experience a similar systematic reassessment during this period.

Next, we examine heterogeneity by comparing our measures of tax equity descriptively by census tract before and after the adoption of the AVI. Specifically, we examine changes in horizontal tax equity (measured by the COD) by census tract in 2013 (before the AVI) and then after each major reassessment in 2014 and 2019, as well as changes in tax equity by tract-level income status, demographic characteristics, 2014 assessment quartiles, and gentrification status before and after the AVI. We further examine how the PRD changed before and after the AVI, and we benchmark these changes relative to our comparison cities.

To ensure that these changes in horizontal and vertical equity measures were, in fact, induced by the AVI, we use a property-level difference-in-differences (DID) model in which we compare sales transactions in Philadelphia with sales in peer cities that did not experience a similar comprehensive reassessment before and after the AVI (i.e., before and after 2014). We specifically use a model of the following form:

$$Y_{ict} = \beta_0 + \beta_1 TREAT_c + \beta_2 POST_t + \beta_3 TREAT_c{*}POST_t + \Theta TRACT_c + \lambda YEAR_t + \varepsilon_{ict} \qquad (4)$$

in which Y_{ijt} represents the outcome measure for property i in city c and in year t. $TREAT_c$ 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. We include the interaction of these two terms (the DID term), and thus β_3 is our coefficient of interest. $TRACT_c$ and $YEAR_t$ are vectors of tract- and year-fixed effects, respectively.

To further examine heterogeneity in the effects of the AVI across neighborhoods that differ by income, racial composition, and gentrification status, we employ the following model using data from Philadelphia only:

$$Y_{ijt} = \beta_0 + \beta_1 NBHD_j + \beta_2 POST_t + \beta_3 NBHD_j{*}POST_t + \Theta TRACT_i + \lambda YEAR_t + \varepsilon_{ijt} \quad (5)$$

in which Y_{ijt} represents the outcome measure for property *i* in tract *j* and in year *t*. $NBHD_j$ represents the different types of neighborhoods. Specifically, we categorize all neighborhoods in Philadelphia by median income (in quartiles), share of White residents (in quartile), majority race (Black, White, and other),[6] and gentrification status (gentrifying, nongentrifying, and nongentrifiable).[7] We also group properties by property assessed value (in quartiles). The coefficient of the interaction term, β_3, captures the change in the outcome measures post-AVI in the corresponding type of neighborhoods or properties relative to the change in the reference group. In other words, β_3

[6] Based on data from the 2009 to 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.

[7] Ding and Hwang (2020) defined 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. Those tracts not defined as gentrifiable tract would be considered as nongentrifiable.

measures how the AVI impacts properties in a particular type of neighborhood differently than other neighborhoods. All other terms are as defined in equation (4) above.

Data

Data used in this study are obtained primarily from two sources, in addition to the data from the U.S. Census Bureau (2009 to 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), 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, which enables us to match units across data sets. We also used real estate transfer data compiled by the Philadelphia DOR,[8] which were merged to respective parcels; thereby, we have information on assessments and taxes for properties that were transacted during the study period. Using ArcGIS, we also conducted a spatial join to link property-level data to Philadelphia's census tracts.

The administrative data from Philadelphia are compared to control group data from CoreLogic Solutions. The latter were used to construct a transaction and assessment data set for our control group of comparable cities for the 2012 to 2015 period.[9] 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

[8] These are available through OpenDataPhilly at www.opendataphilly.org/.

[9] Unfortunately, the CoreLogic Solutions only offered this data set to us through 2015 at the time of the analysis.

the dataset during our sample period; (3) cites 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.[10] First, the analysis focuses 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 residential units, such as multifamily residences and condos. Additionally, single-family homes have a higher within-class uniformity than other property classes. Each year, about 4 percent to 5 percent of existing homes would be sold and the volume of sales may vary slightly over time. This sample of home sales, thus, may not always be representative of all the residential properties in the city.

[10] 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.

Keeping this caveat in mind, however, this approach has been widely used in the literature on tax assessments (e.g., Berry, 2021; McMillen and Singh, 2020).

Second, sales with a missing value for the sales price, extremely low or high prices (those with 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.[11] 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 are far from accurate.[12] Because it is impossible to verify the validity for millions of sales over multiple years, we followed the IAAO-recommended maximum trimming limits[13] 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.[14] The extremely large number of transactions with missing values or extremely low sales prices (below $1,000), and likely invalid transactions (with extremely high or extremely low assessment ratios) reflects the poor quality of data collection and assessments. After trimming, the statistics provide a more

[11] 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 (slightly higher or lower).

[12] According to the 2018 audit report of Philadelphia OPA (J.F. Ryan Associates, Inc, 2018, page 13), "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."

[13] The IAAO (2013) 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.

[14] 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.

logical and meaningful basis to derive informed policy recommendations and tax administration practices.

These data cleaning procedures were followed also for the control group 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 to 2015 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 single-family home transactions for the control group and 54,683 single-family home transactions for Philadelphia during the 2012 to 2015 period.

Impact of the AVI on Equity: Descriptive Analyses

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 columns. We can see that 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 kept improving after that, with transactions and sale prices smoothly trending up. From 2010 through 2013, the mean assessment ratio stayed in the mid-50s, with the COD 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 (1.03).

Adopted as a response to increasing inequity in property taxation, the AVI seemed to have done what it was supposed to do. The *average assessment ratio* (AR) more than doubled, increasing to 1.19 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 one-quarter from 55 percent in 2013 to 41 percent in 2014 — meaning 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 *average assessment ratio* becomes closer to 1 (a decrease from 1.19 in 2014 to 0.91 in 2019. This adjustment could be explained, among other reasons, as institutional learning from repeated reassessments within a short window of time.[15] 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 sales with CODs within the threshold, however, dropped by 4 percentage points, which reflects the need for continued improvement and preexisting gaps in knowledge during this 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 revaluation (in 2014) shifted the distribution to the left, suggesting a significant improvement in

[15] 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.

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 (Column 9, Table 1) 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. The citywide average effective tax rate started to fall between 2013 and 2014, then it steadily declined each year after 2013. This trend is in line with those of COD and PRD in the 2013–2019 period, as achievements of the AVI.

Figure 4 compares trends from 2012 to 2015 between Philadelphia and the control group of 15 cities. The mean values of the assessment ratio (upper left panel), the COD (upper right panel), the percentage of CODs below 15 percent (lower left panel), and the PRD (lower right panel) of the control group are smooth over this four-year period; Philadelphia's metrics generally 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 from the above 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 the CODs. This pattern implies that each comprehensive reassessment results in a level shift — but not necessarily a trend shift — in measures of horizontal equity.

Heterogeneity in Assessment Quality post-AVI

To evaluate how the quality of assessment changed over time for properties in more disadvantaged communities, we group transactions by tract median income, share of White residents, majority race, gentrification status, as well as property value (property-level).

Figure 6 displays the trends of the average COD across neighborhoods. Overall, the four panels show that before the AVI was implemented, tracts that were higher income, higher housing value, non-Black, and gentrifying were more likely to have higher CODs, meaning that tracts with these characteristics were more likely to have less accurate assessments. After the AVI, these trends generally flipped.

The average COD by neighborhood income (upper left panel) flipped completely with the AVI. Until 2013, higher-income neighborhoods had the highest average CODs and lower-income

neighborhoods (those in the bottom two quartiles) had the lowest CODs — income went opposite assessment accuracy. From 2014 to 2019, the order went exactly the other way — assessment accuracy seemed to increase by income. It is especially interesting to notice that the COD of the top income-quartile of neighborhoods improved tremendously, from 60 percent to close to 20 percent, and the third income-quartile of neighborhoods also improved significantly, from around 55 percent to 30 percent. The second quartile of neighborhoods remained at pre-AVI level until 2015 and then improved a little each year. The COD of the first quartile of neighborhoods jumped up (worsened) immediately after the AVI and remained the highest among the four groups, although it improved slightly over time.

The same pattern is apparent by property assessed values (upper right panel): higher value quartile properties had higher CODs and lower value quartile properties had lower CODs before the AVI. After 2014, all went by the opposite order, with similar magnitudes as by income quartile. The same pattern is also observable by the majority race of neighborhoods (lower left panel) and by gentrification status (lower right panel).

The above results suggest two important findings. First, the initial reassessment under the AVI dramatically improved assessment uniformity (COD) for higher-income, White, gentrifying, and nongentrifiable neighborhoods, as well as higher-value properties. The initial reassessment maintained the uniformity for lower-middle income quartile neighborhoods as well as the majority non-White neighborhoods. But the initial reassessment was not able to do the same for the lowest-income, Black, and nongentrifying neighborhoods, as well as properties with the lowest assessed values. The assessment uniformity for the latter groups worsened. The increase in tract average COD in these neighborhoods is more likely due to deteriorated quality of assessments, including becoming systematically farther away from true market values and increases in the extremes or

erroneous valuations. This finding points to major loopholes in the practice of property assessment in the city.[16] Second, fortunately, the second reassessment under AVI was able to improve the COD of all quartiles, which provides assurance that regular reassessments work regardless of issues in assessment implementation.

Although the descriptive analysis does not allow us to establish a causal link from the implementation of the AVI to the correlations discussed above, the distinctive trends across the neighborhood or property value groups suggest that changes surrounding the AVI may have exerted some negative impact on assessment quality immediately following the policy's implementation of the already-vulnerable groups (i.e., homes in majority-Black, nongentrifying, and lower-income neighborhoods or lower-value properties). Nonetheless, it is very encouraging that the gap in the average COD across groups trend toward convergence after the second reassessment (in 2019).

Vertical Equity

The price related differential (PRD) of Philadelphia from 2010 through 2013 was between 1.39 and 1.42 (Table 1, Column 8 and Figure 3, lower right panel), markedly above the threshold of 1.03, indicating that assessed values in the city were highly regressive. In other words, lower-priced homes were systematically assessed at a greater proportion of their market values. The long absence of comprehensive reassessments and the disparities in Great Recession–induced price crashes across submarkets should have contributed to such high levels of regressivity. The differential effects of the Great Recession on the various submarkets could also have exacerbated

[16] The City Government acknowledge in 2019 that "OPA should focus its time and resources on addressing its assessment shortcomings in the neighborhoods where it performs the worst. This includes areas of the city that show the greatest regressivity, like North, Southwest and West Philadelphia. Our analysis shows that these neighborhoods, also among the lowest income in the city, are overburdened as a result of OPA's flawed assessments" (Rhynhart, 2019, paragraph 13). See more details at controller.phila.gov/philadelphia-audits/property-assessment-review/.

the low quality of assessment. The PRD decreased by over a quarter to 1.28 in 2014, indicating a marked improvement under the AVI, but it remained in the regressive zone. The 2019 round of reassessment then slashed assessment inequity by half (decreasing the PRD further to 1.14).

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 that 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 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 outperformed any city in the control group, most likely because of the adoption of the AVI. Of course, assessment 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 vertical uniformity of the property tax system following each comprehensive reassessment.

Impact of the Avi on Horizontal Equity: Regression Results

This section presents and discusses our results of causal analyses from regressions of the short-term impact of the AVI on horizontal equity that is captured by the interaction variable (*TREAT * POST*); the coefficient of this term represents the change in the corresponding outcome measure post-AVI of an average property in Philadelphia. As defined earlier, the control group consists of residential property sales in the 15 comparison cities, none of which experienced significant changes in their property tax systems during the study period (2012 to 2015). Based on the

observations in Philadelphia, we further evaluate the disparate impact of the AVI on properties in different types of neighborhoods.

Effects of AVI on Horizontal Equity of Assessments

As shown in Table 3, we find that the AVI is associated with a significant improvement in horizontal equity in residential property assessments. Implementing the AVI leads to a decrease of 11.0 percentage points in the COD for an average property. In other words, the COD results confirm that, compared with cities without similar comprehensive changes in their assessment system, conducting regular reassessments generally makes assessments more uniform across properties of similar values.

When the outcome variable is the binary of whether the COD of a transacted property is below the threshold (15 percent), the results are quite consistent: The probability of having a COD below 15 percent increases by 25.8 percentage points after adopting the AVI. These results confirm that the AVI not only helped improve *average* assessment accuracy but also markedly increased the *proportion* of properties with assessment accuracy within the acceptable range. With assessment ratio as the outcome variable, the results are also consistent that the AVI achieved its design objective by raising assessment ratio close to one.

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 show that the assessment ratio of properties in disadvantaged neighborhoods (majority-Black,[17] lower-income, or nongentrifying) or lower-value properties experienced a larger decline after the AVI adoption relative to other properties. All these

[17] 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.

suggest that 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 the other neighborhoods.

The improvement in the uniformity of assessments, however, was smaller in these more disadvantaged neighborhoods: The improvement in COD was much smaller in majority-Black, lower-income, or gentrifying neighborhoods relative to other neighborhoods. For example, there was a larger variation in assessed values from sales prices in majority-Black neighborhoods, and quality of assessments in those neighborhoods even slightly worsened post-AVI: The COD in majority-Black neighborhoods declined 0.282, smaller than the decline in non-Black neighborhoods; the percent of sales with a COD below 15 percent decreased by 24.9 percentage points in majority-Black neighborhoods relative to other neighborhoods.

When we use yearly dummies instead of one POST dummy (Table 5), 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 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 percentage points). Similar patterns can be found for properties using other measures of neighborhood disadvantages, such as lower-income, high-minority, or nongentrifying

neighborhoods, as well as lower-value properties. It is disconcerting if such an assessment system renders low-income and predominantly minority neighborhoods more vulnerable. More research is warranted regarding additional interventions to mitigate the potential disparate impacts of regular reassessments.

Effects of the AVI on Horizontal Equity of Property Owners' Tax Burdens

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

Table 4, however, shows that the AVI impact on tax burdens varies significantly across neighborhoods. Property owners in majority-Black, high-minority, low-income, and nongentrifying neighborhoods saw a larger decrease in their effective tax rate relative to the decrease in other more advantaged neighborhoods. Taken together with the PRD results (Table 2), these results suggest that implementing the AVI has generally made the property tax more equitable in Philadelphia. This is especially evident in the model using yearly dummies (Table 5), which shows the effective tax rate declining each year post-AVI in majority-Black neighborhoods (with increasing magnitudes from -0.334 percentage points in 2014 to -0.753 in 2019) relative to non-Black ones. These results indicate that tax burden for homeowners in these neighborhoods lessened after the AVI adoption, although assessment uniformity for disadvantaged neighborhoods decreased in general.

While the results of the disparate impact on tax burdens (measured by the effective tax rate) are interesting, effective tax rates are driven by both assessments and tax relief programs, not

necessarily the changes in assessment quality alone. For example, the Homestead Exemption program and LOOP, adopted together with the AVI, can also help mitigate the regressivity of the property tax by targeting low-income and longer-term homeowners.[18] In contrast, certain tax programs may increase property tax regressivity. A typical example is Philadelphia's abatement program, 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. It is assuring to see that a reform was introduced in 2019 to scale back such reductions.[19]

CONCLUSION

Despite decades of property tax revolts since the 1970s, local governments in the U.S. have continued to rely heavily on property taxes for revenue. Property assessment, however, is a complex and constantly evolving field; so far, there has been no universal mandate that properties be regularly reassessed to assure equity of the real property tax.

This paper provides the most recent empirical results in support of regular revaluations. The quality of assessments in Philadelphia, as measured by the COD, improves significantly after the revaluation in 2014. Property tax generally became less regressive after the AVI, as the tax burden for properties in less advantaged neighborhoods was reduced after the AVI was introduced. 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 neighborhood gentrification

[18] Ding and Hwang (2020) found that assessment updates did increase the amount of property taxes and the risk of tax delinquency, but not necessarily residential mobility, likely because the tax relief programs adopted together with the AVI helped mitigate the negative impact of tax increases on vulnerable populations.

[19] A reform in 2019 has reduced the property tax break by 10 percent each year over the subsidy's decade-long span, which should not have a significant impact on the results of this study.

status. Of course, regular reassessment itself is not enough; other factors such as programmatic improvements in reassessments also matter and may be more important.

While our findings suggest that more regular reassessments, together with improved assessment practices over time, do improve vertical and horizontal equity, such a program does not address all the challenges in property assessment or property tax administration in general. The assessment quality of Philadelphia properties, although significantly improved post-AVI, is still far outside 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 reassessments at an interval of four years (Weber et al., 2010). Such changes would not only improve assessment quality and equity across all counties in Pennsylvania but also lower the administrative costs of reassessment, simplify assessment 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 Office of Property Assessment 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 the OPA target 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 at protecting 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 to 2023 because of the COVID-19 crisis. Approaches such as these city- and state-level policy proposals may help fill the equity gaps in Philadelphia's property tax system that the AVI has not been able to mitigate.

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 here supports the idea that equity and efficiency can improve in unison, such that each reinforces the other through more frequent, regular property reassessments. This paper has not conducted empirical tests on efficiency, leaving it for further research. As a case study, this empirical research contributes to debates on the design of property tax systems. The results can help researchers and policymakers understand the complicated relationship between property sales, assessments, and property taxes.

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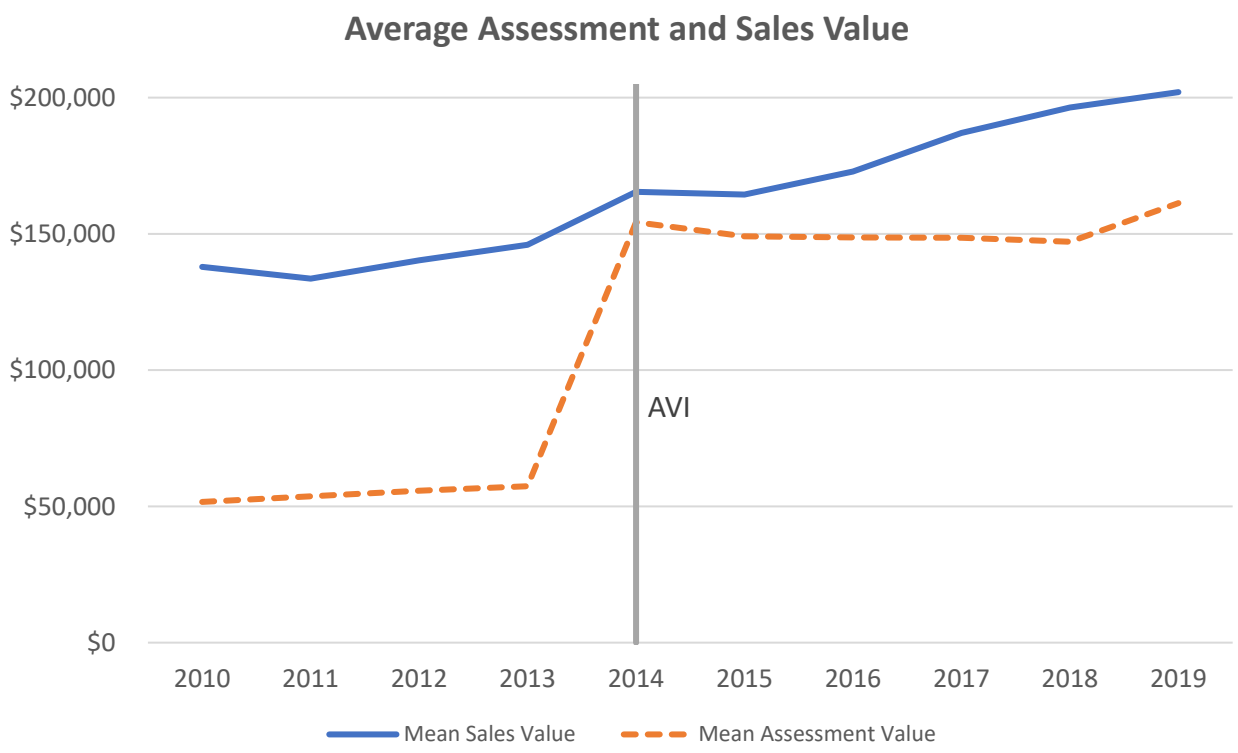

Figure 1. Mean Sales Prices and Mean Assessments of Single-Family Residential Properties in Philadelphia, 2010 to 2019

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.

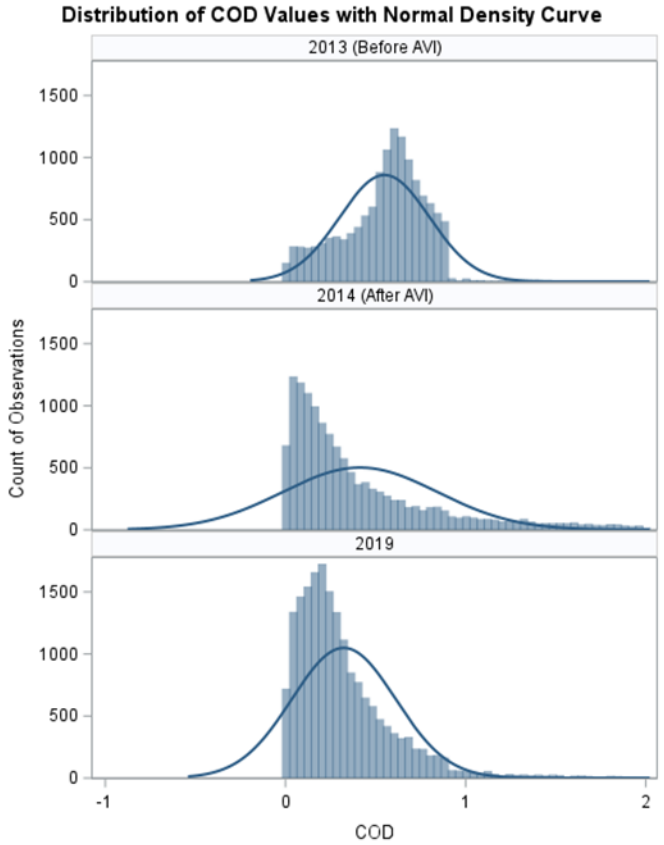

Figure 2. Philadelphia Coefficient of Dispersion (COD) Distribution in 2013, 2014, and 2019

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.

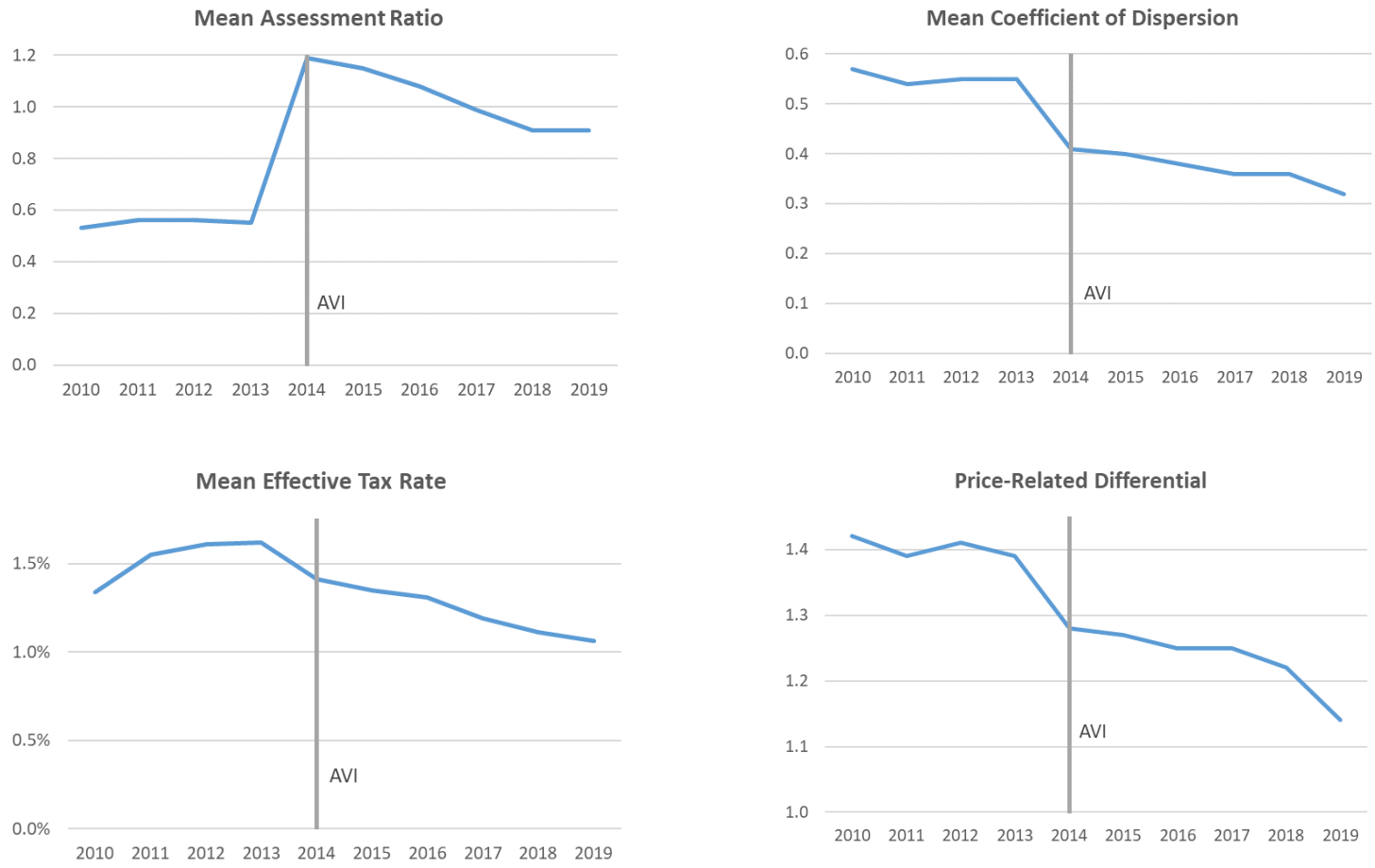

Figure 3. Mean Assessment Ratio, Coefficient of Dispersion, Effective Tax Rate, and Price-Related Differential, Philadelphia, 2010 to 2019

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.

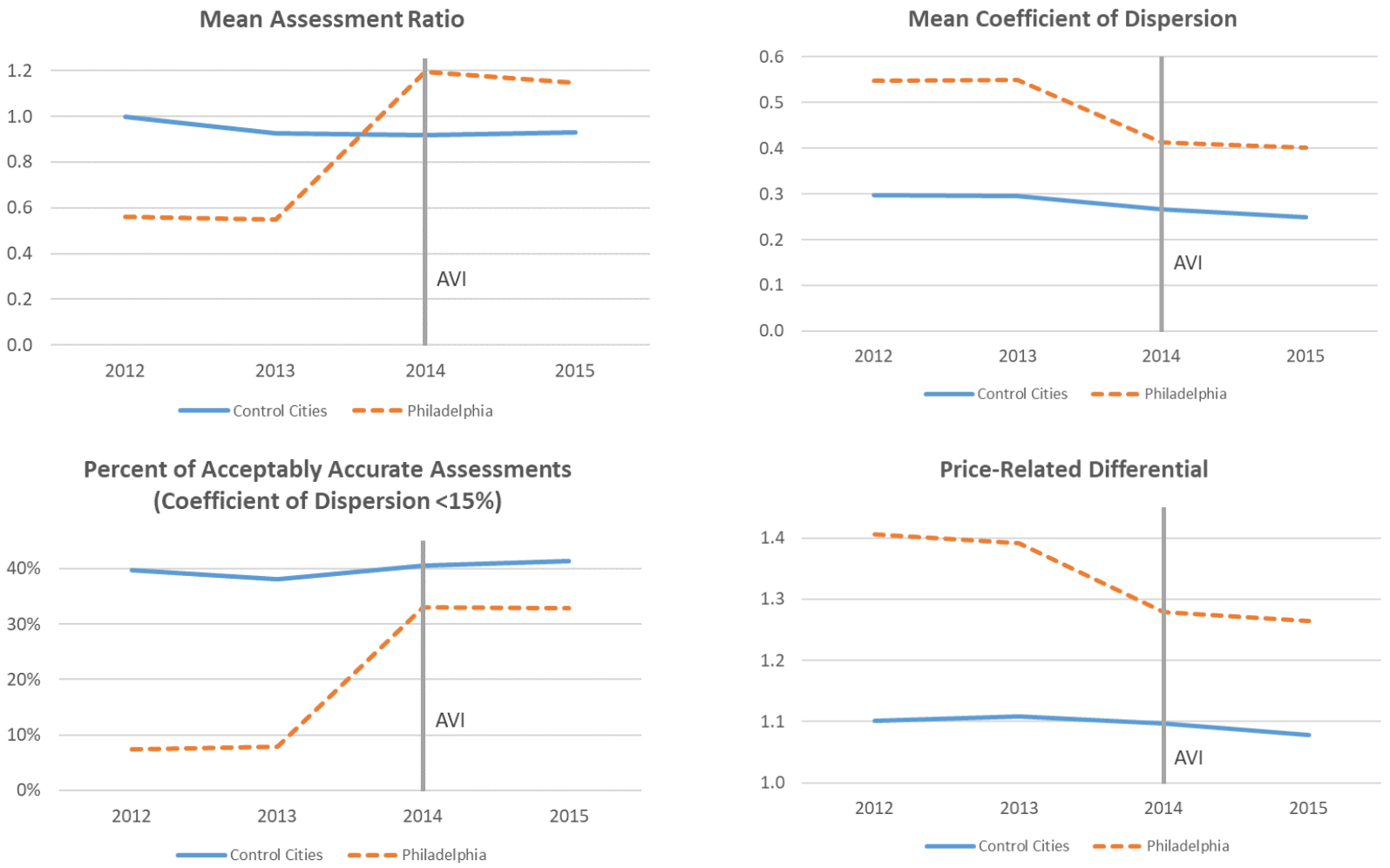

Figure 4. Measures of Horizontal Equity and Vertical Equity, Philadelphia vs. Control Group of Cities, 2012 to 2015

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.

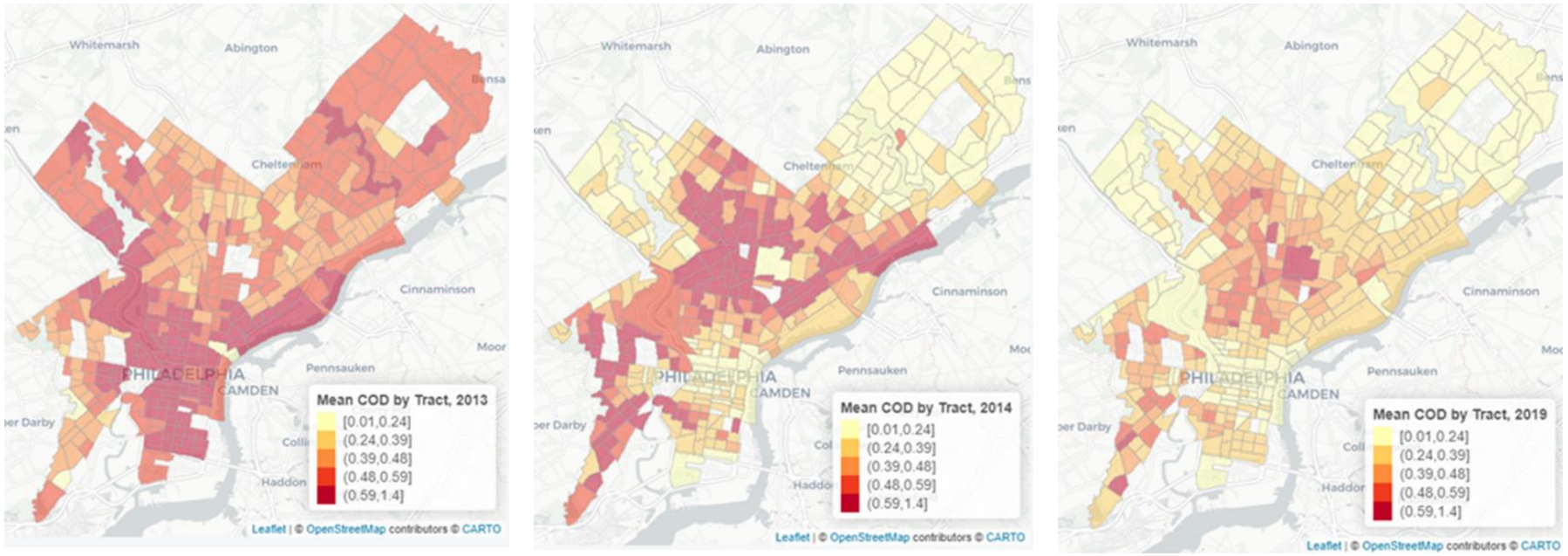

Figure 5. Average Coefficient of Dispersion (COD) in Philadelphia by Neighborhood in 2013, 2014, and 2019

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.

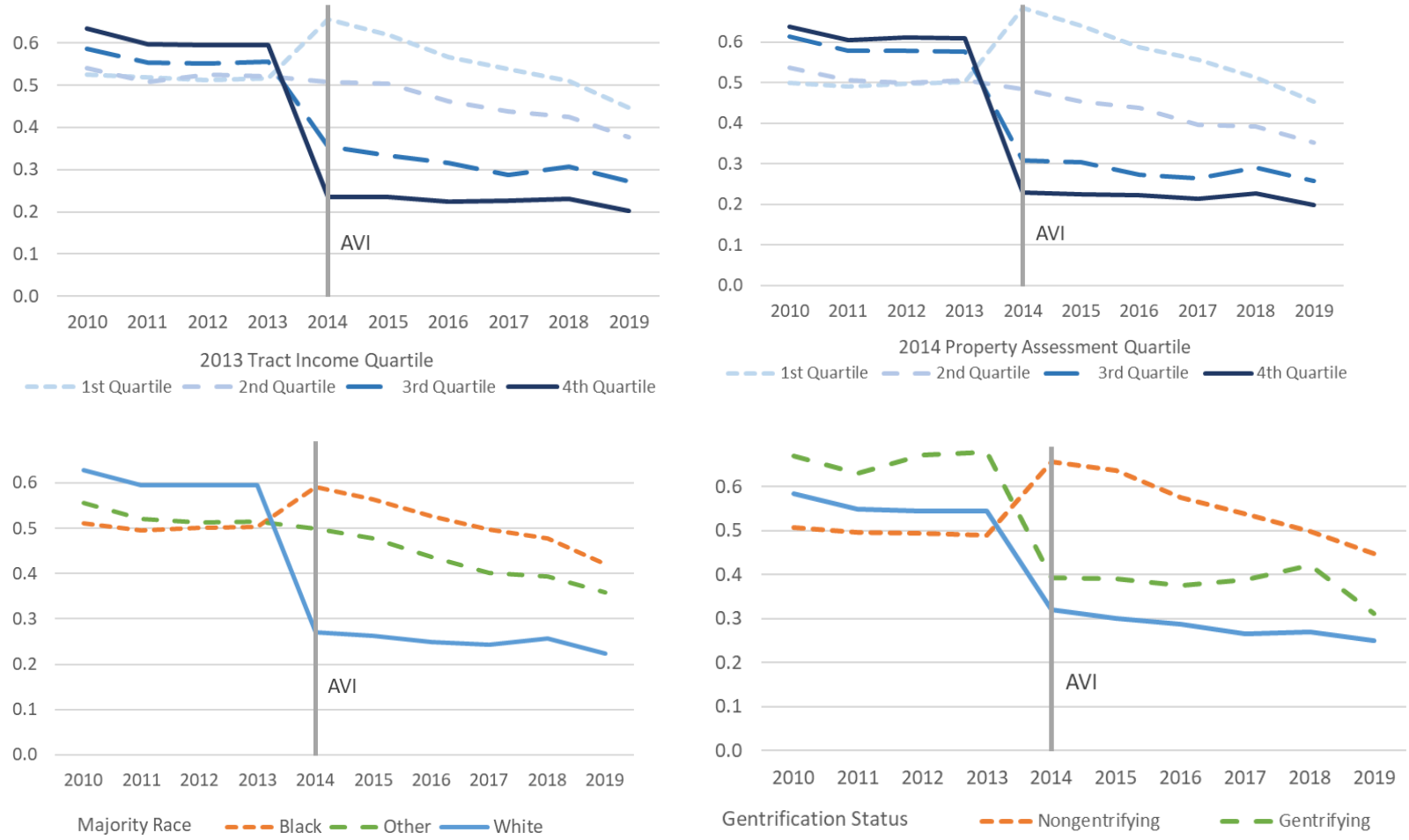

Figure 6. Coefficient of Dispersion (COD) Trends by Neighborhood Characteristics

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 to 2013 American Community Survey data.

Table 1. Descriptive Statistics for Sales in Philadelphia

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Year	**# of Sales**	**Mean sale price**	**Mean assessed value**	**Mean tax amount**	**Mean AR**	**Mean COD**	**Percent COD < 0.15**	**PRD**	**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 value		Mean assessed value		Mean AR		Mean COD		Percent COD < 0.15		PRD		Mean effective tax rate	
	2013	2014	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)

	Assessment ratio		**COD**		**COD < 0.15**		**Effective tax rate**	
	Coef.	**Std. Err.**	**Coef.**	**Std. Err.**	**Coef.**	**Std. Err.**	**Coef.**	**Std. Err.**
Treat	-0.338***	0.013	0.045***	0.006	-0.343***	0.007	-0.028	0.024
Post	-0.062*	0.024	-0.032**	0.011	0.000	0.014	-0.165**	0.048
Treat*Post	0.706***	0.024	-0.110***	0.011	0.258***	0.014	-0.014	0.048

Note: ***, **, and * represent significance at the 0.001, 0.01, and 0.05 levels, respectively; N = 759,582 property years for regressions on different outcomes. Control variables include treatment (Philadelphia), tract dummies, yearly dummies, and the post-AVI dummy.

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 4. Summary of the Coefficients of the Interaction Terms (Philadelphia Properties Only)

	Assessment ratio		COD		COD < 0.15		Effective tax rate	
	Coef.	**Std. Err.**	**Coef.**	**Std. Err.**	**Coef.**	**Std. Err.**	**Coef.**	**Std. Err.**
Majority-Black NBHD (vs. non-Black)	-0.063***	0.018	0.282***	0.019	-0.249***	0.015	-0.475***	0.043
Tract Share of White								
1st quartile (vs upper quartile)	-0.031	0.023	0.443***	0.015	-0.341***	0.02	-0.694***	0.050
2nd quartile (vs upper quartile)	-0.047*	0.021	0.322***	0.021	-0.253***	0.023	-0.487***	0.053
3rd quartile (vs upper quartile)	-0.006	0.018	0.122***	0.021	-0.079**	0.025	-0.137***	0.041
Tract income								
1st quartile (vs upper quartile)	-0.065**	0.024	0.415***	0.024	-0.345***	0.019	-0.745***	0.061
2nd quartile (vs upper quartile)	-0.008	0.02	0.300***	0.023	-0.252***	0.023	-0.449***	0.048
3rd quartile (vs upper quartile)	0.021	0.017	0.128***	0.019	-0.098***	0.023	-0.191***	0.039
Tract gentrification status								
Nongentrifying (vs nongentrifiable)	-0.089***	0.017	0.328***	0.02	-0.299***	0.015	-0.621***	0.046
Gentrifying (vs nongentrifiable)	-0.142***	0.024	-0.021	0.025	-0.152***	0.022	0.028	0.056
Nongentrifying (vs gentrifying)	0.058*	0.028	0.351***	0.027	-0.151***	0.021	-0.642***	0.068
Property value								
1st quartile (vs upper quartile)	-0.149***	0.018	0.461***	0.014	-0.378***	0.015	-0.988***	0.040
2nd quartile (vs upper quartile)	0.044***	0.014	0.292***	0.016	-0.229***	0.017	-0.340***	0.026
3rd quartile (vs upper quartile)	0.043***	0.009	0.091***	0.01	-0.062***	0.016	-0.142***	0.022

Note: ***, **, and * represent significance at the 0.001, 0.01, and 0.05 level respectively; N = 156,171 property years over the 2010-20219 period. Standard error clustered at the tract level. Control variables include neighborhood or property type, tract dummies, yearly dummies, and the post-AVI dummy.

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)

	Assessment ratio		COD		COD < 0.15		Effective tax rate	
	Coef.	**Std. Err.**	**Coef.**	**Std. Err.**	**Coef.**	**Std. Err.**	**Coef.**	**Std. Err.**
Black NBHD*2010	-0.009	0.018	-0.019	0.011	0.002	0.011	-0.142*	0.059
Black NBHD*2011	-0.004	0.015	-0.005	0.009	-0.007	0.009	-0.068	0.049
Black NBHD*2012	-0.004	0.012	0.001	0.008	-0.017	0.009	-0.030	0.041
Black NBHD*2014	0.059*	0.025	0.334***	0.029	-0.273***	0.021	-0.334***	0.067
Black NBHD*2015	0.022	0.023	0.314***	0.028	-0.276***	0.021	-0.401***	0.059
Black NBHD*2016	-0.031	0.022	0.297***	0.025	-0.284***	0.022	-0.478***	0.058
Black NBHD*2017	-0.071	0.022	0.277***	0.021	-0.263***	0.019	-0.547***	0.059
Black NBHD*2018	-0.106	0.021	0.244***	0.016	-0.204***	0.015	-0.588***	0.063
Black NBHD*2019	-0.207	0.022	0.220***	0.018	-0.237***	0.017	-0.753***	0.077

Note: ***, **, and * represent significance at the 0.001, 0.01, and 0.05 level respectively; N = 156,171 property years over the 2010-20219 period. Standard error clustered at the tract level. Control variables include neighborhood type (majority-Black), tract dummies, and yearly dummies.

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.