Essays in Housing and Public Finance

by

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To Victor, Paul, and Misha

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ABSTRACT

This dissertation contains three essays that use reduced form techniques to examine how taxation shapes residential housing markets. Chapter I studies how homebuyers responded to changes in the US federal tax treatment of housing. Chapter II focuses on the capitalization of property taxes into housing prices. Chapter III investigates the presence of cognitive bias with respect to the size of recurring future payments in residential housing markets.

The US tax code contains provisions that significantly reduce homeownership costs, including by allowing itemizing income tax payers to deduct property tax and mortgage interest payments from their taxable income. The Tax Cuts and Jobs Act of 2017 capped these deductions and raised the standard deduction, which increased the real cost of property taxes and mortgages for a subset of taxpayers. This shift in the tax law was the most significant change in the US federal tax treatment of homeownership since the Tax Reform Act of 1986. Chapter I and Chapter II of this dissertation study the impact of this change in the law on residential housing markets.

In the first chapter, "The Impact of the Tax Cuts and Jobs Act on Residential Housing Choices", I examine how individual homebuyers responded to these changes. The data used in this chapter was constructed by matching of home loan records to deeds and mortgage documents in New Jersey's Middlesex County. Employing a continuous difference in differences estimation technique, this chapter shows that homebuyers responded by purchasing smaller homes with lower property tax burdens, with the level of response indicating that the price elasticity of housing demand is approximately unit elastic. Homebuyers also reduced the size of their home loans (relative to sale price) by the equivalent of the response to a two percentage point increase in interest rates.

The second chapter, "Housing Prices and Deductibility of Property Taxes: Evidence from the Tax Cuts and Jobs Act", focuses on how residential housing prices responded to these changes. Using the universe of residential home sales in New Jersey and employing a repeat

sales model, this paper estimates that home prices in high-property tax areas fell by an amount corresponding to 70 percent of the increase in property tax liabilities.

Chapter III, "Left Digit Bias in Property Taxes", provides evidence of left digit bias in the housing market when it comes to anticipated future property tax payments. Left digit bias is a well documented cognitive bias wherein individuals overemphasize the left-most digit of a number. Left digit bias means that if one considers all possible pairs of numbers which differ by the same amount, the difference between pairs with different leftmost digits will be perceived as larger than the difference in pairs with identical leftmost digits. Using a regression discontinuity technique, this chapter shows that homes with property taxes just over a $1,000 threshold sell for 0.5% less than homes with property taxes just under a $1,000 threshold. This bias amounts to homeowners overpaying for homes by an average of $1,672. This chapter provides evidence that even in high-cost situations, individuals appear to exhibit bounded rationality.

CHAPTER I

The Impact of the Tax Cuts And Jobs Act on Residential Housing Choices

1.1 Introduction

The US federal tax code contains significant tax benefits for homeowners. Homeowners are not taxed on the imputed rental income of their homes and yet are nonetheless able to deduct property taxes and interest on their home mortgage from their taxable income. Furthermore, homeowners are entitled to large exemptions on capital gains when they sell their homes. The often stated reasoning behind these benefits is that they encourage home-ownership and that there are substantial societal benefits from higher home-ownership rates and homeowners who are more invested in their communities. The Tax Cuts and Jobs Act of 2017 provides an opportunity to study the effect of tax incentives on the housing market, as it substantially reduced homeowner tax benefits for a subset of taxpayers.

The Tax Cuts and Jobs Act of 2017 (TCJA) was one of the largest US federal tax reforms in the last hundred years. It reduced the tax benefits of home-ownership in two major ways. First, it approximately doubled the standard deduction, reducing the fraction of itemizing taxpayers from 30% to 13%. Since only itemizers benefit from deducting property taxes and interest on a home mortgage, this raised the after-tax costs of home-ownership for taxpayers who stopped itemizing. Second, TCJA capped total state and local taxes

(known by the acronym SALT) deductions to a maximum of $10,000. This provision was politically contentious because the largest beneficiaries of SALT deductions were taxpayers in states primarily represented by the Democratic Party while the TCJA was passed by the Republican party with no support from Democrats. Since the passage of the TCJA, there have been several attempts by Congressional Democrats to repeal the SALT cap. New York, New Jersey, Connecticut and Maryland (all states with high property taxes and high pre-TCJA itemization rates) unsuccessfully sued the federal government on the grounds that the deduction cap was an "unconstitutional assault on the States' sovereign choices"[1]. A return to a pre-TCJA system would provide an estimated $171 billion in tax benefits (or approximately 6% of individual income tax revenue), 92% of which would accrue to taxpayers earning over $100,000 a year[2]. Understanding the effect of the tax code on the housing market is thus both a salient policy and economic question.

This paper measures the impact of the TCJA on housing markets in New Jersey. New Jersey has the highest real estate property tax levels in the United States, with the average household paying over $5,000 in property taxes per year[3]. New Jersey also has some of the highest state income tax rates, which coupled with the fact that New Jersey has the second highest median income means that New Jersey residents have particularly large state income tax bills. In tax year 2017 (prior to the passage of TCJA) 42% of New Jersey tax filers itemized their deductions (compared to 32% of all US tax filers) and the mean property tax deduction for New Jersey itemized returns was almost $9,000 (compared to $4,750 for all US itemized returns)[4]. This means that if the TCJA did impact housing markets, New Jersey is one of the most likely places where such an impact would be observed.

To measure individual home-buyer response, it is necessary to actually observe the

[1] See Filing and Outcome
[2] According to the Joint Committee on Taxation
[3] According to data from the 2019 American Community Survey
[4] According to the IRS Statistics of Income

house purchasing choices of home-buyers as well as relevant characteristics which determine tax benefits. This paper uses loan level data from the Home Mortgage Disclosure Act matched to deed and mortgage documents in New Jersey's Middlesex County. This provides (among other things) features of a home-buyer's home loan, their income, marital status, sale price, home characteristics, and property taxes. The data-set creates a complete picture of the choices which are relevant for evaluating the impact of the TCJA. In particular, this paper estimates a difference in differences model which compares groups who did not experience changes to the tax treatment of their home expenses post-TCJA with those who did experience changes to the tax treatment of their home expenses post-TCJA.

The difference-in-differences analysis finds that those households which were induced to stop itemizing by TCJA purchased homes that were 8% less expensive, had 5% lower property taxes, and were 7% smaller. These taxpayers also originated home-purchase loans that were 4.3 percentage points lower as a fraction of their home price. This is roughly equivalent to home-buyers' responsiveness to a 2 percentage point increase in mortgage interest rates. Households that still itemized but are unable to fully deduct their state and local taxes due to the $10,000 cap purchased homes that were 7% less expensive, had 3% lower property taxes, and were 6% smaller. This papers finds no evidence that these taxpayers reduced their relative home loan sizes. This is consistent with the fact that these taxpayers were unable to fully deduct their property taxes but were still able to fully deduct the interest on their home loans. This paper finds that homebuyers are responsive to changes to the tax treatment of home-ownership, and that less generous tax benefits resulted in home-buyers opting for smaller homes with lower property tax burdens. They also used less debt to finance their home purchase in response to the increase in the (after-tax) interest rate.

The rest of the paper proceeds as follows. Section Two discusses the effect of taxation on

the housing market. Section Three discusses the specifics of the changes to the US federal tax code after the enactment of the Tax Cuts and Jobs Act. Section Four describes the details of real estate property taxation in New Jersey. Section Six presents the estimation strategy and main empirical results for the difference in differences analysis. Section Seven summarizes and concludes the results of the paper.

1.2 Related Literature

The preferential treatment of homeowners relative to renters by the United States federal tax code and the impact this has on the housing market has been a topic of discussion for decades. Aaron (1970) argued that the favorable tax treatment of homeowners in the United States lead to higher housing prices and that the benefits of the tax subsidies primarily accrued to upper income homeowners. Poterba (1984) contended that the favorable tax treatment of housing raises prices. Gyourko and Sinai (2003) demonstrated that the benefits of the deductibility of mortgage interest payments and property taxes are distributed highly unevenly throughout the United States. In 1990, New Jersey received $5,915 in net tax benefits per owner-occupied housing unit compared to the national average was $2,092 per owner-occupied housing unit. South Dakota had the lowest net tax benefit at $917 per owner-occupied housing unit, and Hawaii had the highest net benefit at $10,718 per owner-occupied housing unit. They argue that given that high-income high-tax-bracket homeowners tend to live in high-value homes with high property taxes, the deduction of property taxes and mortgage interest payments is at odds with an otherwise progressive tax code. Poterba and Sinai (2008) estimated that repealing the property tax deduction would increase the marginal user cost of housing by three percent, although they use the national average property tax rate so the impact may be expected to be much larger for high tax localities. In later work, Poterba and Sinai (2011) argued that a mortgage interest deduction cap would reduce demand for housing among high marginal income tax households but

would largely have no effect for lower and middle income households.

Engelhardt et al (2010) find that tax subsidies do increase homeownership rates among low income households, however this is not a group that sees many benefits from the tax treatment of US housing under consideration in this paper. However, Gruber et al (2021) find no effect on homeownership after an enactment of more favorable mortgage treatment in Denmark, although they do find that it increases housing demand and loan to value ratios. Ling and McGill (1998) and Dunsky and Follain (2000) examine the US Tax Reform Act of 1986 and find strong (up to unit elastic) responses to the increased cost of mortgage debt. Jappelli and Pistaferri (2007) look at a tax reform that reduced a mortgage interest deduction in Italy and find no evidence of change on either the intensive or extensive margin, which they attribute to borrowing constraints and lack of knowledge about the policy change. In the United States, Hilber and Turner (2014) argue that the mortgage interest deduction boosts homeownership rates only for higher income households in areas with elastic housing supply, Hanson (2012) finds no evidence of the mortgage deduction increasing homeownership but does find that it results in the purchase of larger homes. Using a general equilibrium framework Sommer and Sullivan (2018) estimated that eliminating the deductibility of mortgage interest payments for owner-occupied housing would lead to a reduction in home prices, a reduction in housing consumption by the wealthy, and an increase in homeownership overall.

Studies relating to the question of how to isolating the impact of property taxes on housing prices date back to Oates (1969). The central difficulty in identification in this literature relates to the fact that local public goods in the United States (particularly education) are funded through either local property or incomes taxes. As a result, it is very difficult to accurately estimate property tax capitalization using variation across municipalities, since higher property taxes will generally be correlated with a higher provision of local public goods. Palmon and Smith (1998) estimate property tax capitalization using localities which

are in the same school district but have different funding schemes for other public goods, resulting in different property tax rates. They find a property tax capitalization rate of 62 percent. De Bartolome and Rosenthal (1999) include the itemization behavior of homeowners in estimating the capitalization of property taxes into housing prices. In order to correct for the simultaneity of home prices and property tax burdens, they use the structural attributes of the home from four years prior to the observed sale. They find a capitalization rate of approximately 40 percent. A number of papers have found evidence that lower taxation or increased outside funding raises house prices (such as in Ross and Yinger (1999), Sirmans et al (2008), Hilber et al (2011), Cabral and Hoxby (2012). There is also increasing evidence that the degree of capitalization is tied to the supply of housing (for instance in Lutz (2015), Hilber (2015), and Hilber and Vermeulen (2016). Elinder and Persson (2017) look at the impact of a national property tax reduction in Sweden on home prices. They find little effect for all but the top one percent by price of homes, and for the top one percent they find a 50 percent capitalization rate. Giertz et al (2021) find 70 percent capitalization of higher property tax rates into home prices in Dallas County, Texas, and Livy (2018) finds full capitalization in Franklin County, Ohio. It is important to note that these two papers papers consider reforms in areas that have relatively elastic housing supply. Bradley (2017) estimates an intra-jurisdictional model where new homeowners experience temporary property tax savings due to inheriting the previous owners' capped assessed taxable value for the remainder of the calendar year following a sale. Bradley finds an enormous overcapitalization of 2900-3700 percent which he argues is due to a misapprehension by the new homeowners that the tax savings are permanent rather than temporary. This is an important consideration for this paper as well, since it is unclear how aware homebuyers are of the change to the federal tax code treatment of property taxes.

This paper also broadly relates to literature on transaction real estate taxes, which has shown that that real estate transaction taxes reduce the sale price of homes (such as Besley et al (2014), Kopczuk and Monroe (2015), and Best and Kleven (2018)).

1.3 Tax Cuts and Jobs Act

The Tax Cuts and Jobs Act was signed into law on December 22nd of 2017. Features of the law which were relevant for home-owners went into effect starting in tax year 2018. Public awareness of a major bill and its contents started several months earlier[5]. Because the average time between making an offer and closing on a home is 47 days [6], the paper assumes that only homebuyers who closed on their homes starting in January of 2018 were aware of the post-TCJA tax treatment of home-ownership.

The Tax Cuts and Jobs Act slightly lowered marginal tax rates for all income levels (see Table 1.1). It also substantially increased the standard deduction, from $6,500 to $12,000 for single filers and from $13,000 to $24,000 for joint filers. A federal income tax payer can choose between taking the standard deduction and then paying federal income taxes of (1.3.1) and itemizing their deductions and paying federal income taxes of (1.3.2).

(a) Marginal Tax Rates 2017

Rate	Single	Married Filing Separately	Married Filing Jointly	Head of Household
	Taxable Income Over:			
10%	$0	$0	$0	$0
15%	$9,325	$9,325	$18,650	$13,350
25%	$37,950	$37,950	$75,900	$50,800
28%	$91,900	$76,550	$153,100	$131,200
32%	$191,650	$116,675	$233,350	$212,500
35%	$416,700	$208,350	$416,700	$416,700
39.6%	$418,400	$235,350	$470,700	$444,550

(b) Marginal Tax Rates 2018

Rate	Single	Married Filing Separately	Married Filing Jointly	Head of Household
	Taxable Income Over:			
10%	$0	$0	$0	$0
12%	$9,525	$9,525	$19,050	$13,600
22%	$38,700	$38,700	$77,400	$51,800
24%	$82,500	$82,500	$165,000	$82,500
32%	$157,500	$157,500	$315,000	$157,500
35%	$200,000	$200,000	$400,000	$200,000
37%	$500,000	$300,000	$600,000	$500,000

Table 1.1: Marginal Tax Rates Before and After TCJA

$$\sum_{j=1}^{n} \tau_{f_j} \cdot \min\left[Y_{f_j,\max}, Y - \text{Std. Ded.}\right] \cdot \mathbb{1}[Y - \text{Std. Ded.} > Y_{f_{j-1},\max}] \tag{1.3.1}$$

$$\sum_{j=1}^{n} \tau_{f_j} \cdot \min\left[Y_{f_j,\max}, Y - \sum_{l=1}^{L} \text{Itemized Ded.}_l\right] \cdot \mathbb{1}[Y - \sum_{l=1}^{L} \text{Itemized Ded.}_l > Y_{f_{j-1},\max}] \tag{1.3.2}$$

[5]See Appendix Figure A.1 for Google Trends indices in the second half of 2017

[6]According to EllieMae, a mortgage application processor

Where τ_{f_j} is the jth marginal tax rate (ordered by the income tax schedule from lowest to highest relevant income threshold), $Y_{f_j,\max}$ is the last dollar of income that is taxed at the τ_{f_j} level, Y is the tax payer's income, Std. Ded. is the standard deduction, and $\sum_{l=1}^{L}$ Itemized Ded$_l$ is the sum of allowed deductions. By increasing the standard deduction the TCJA reduced the incentives to itemize deductions, as any taxpayer for whom $\sum_{l=1}^{L}$ Itemized Ded.$_l$ > Std. Ded. should optimally choose to take the standard deduction (ignoring the additional time cost of itemizing or the potential concerns about increased audit risk).

There is an additional caveat, which is that if an itemizing taxpayer ends up with a computed taxable income under equation (1.3.2) which is too low conditional on their income, then they will be subject to the Alternative Minimum Tax. Relative to the ordinary income tax schedule, Alternative Minimum Tax (AMT) provides taxpayers with lower marginal tax rates and an exemption but restricts deductions (including not allowing state and local tax deductions). Table 1.2 shows the Alternative Minimum Tax Schedule in 2017 and 2018.

Table 1.2: Alternative Minimum Tax Schedule

	Type of Filer			
	Single	Married Filing Jointly	Head of Household	Married Filing Separately
	Pre Tax Cuts and Jobs Act (2017)			
Exemption	$54,300	$84,000	$54,300	$42,250
26% Bracket Maximum	$187,800	$187,800	$187,800	$93,900
28% Bracket	>$187,800	>$187,800	>$187,800	>$93,900
Exemption Phaseout Threshold	$120,700	$160,900	$120,700	$80,450
	Post Tax Cuts and Jobs Act (2018)			
Exemption	$72,900	$113,400	$72,900	$56,700
26% Bracket Maximum	$197,900	$197,900	$197,900	$98,950
28% Bracket	>$197,900	>$197,900	>$197,900	>$98,950
Exemption Phaseout Threshold	$518,400	$1,036,800	$518,400	$518,400

The Tax Cuts and Jobs Act also reduced the generally tax preferred treatment of home-ownership in the US federal tax code. Prior to the passage of the TCJA, a taxpayer

could deduct all state and local taxes paid from their federal taxable income. This included state and local income taxes, state and local real estate taxes (including for non-primary residence homes) and any personal property taxes. Taxpayers could also choose to deduct all state and local sales taxes that they had paid, but only if they did not also deduct state and local income taxes (almost all itemizing taxpayers chose to deduct state and local income taxes instead of sale taxes). Following the passage of the TCJA, taxpayers could only deduct a total of $10,000 in state and local taxes. Additionally, the TCJA reduced the generosity of the mortgage interest deduction allowance. Previously, home-owners could deduct any interest they had paid on their first $1,000,000 of mortgage interest debt, but after the passage of the TCJA this was limited to the first $750,000 of mortgage interest debt for homes which were purchased in 2018 and later (interest on mortgage debt for non primary residences could also be applied to this total).

After the passage of the TCJA, the fraction of the New Jersey population which itemized their federal income tax returns fell sharply as evidenced in Table 1.3. Prior to the passage of the TCJA, 86% of filers with incomes between $100,000 and $200,000 itemized their deduction, after the passage this was reduced to 31%. Similar declines were observed across all income levels. Additionally, of those tax payers who still chose to itemize, a large fraction

Table 1.3: Tax Filing Status in New Jersey

	Income Range (In Thousands)				
	$50- $75	$75 - $100	$100 - $200	$200 - $500	$500 - $1,000
2016					
Number of Returns	587,690	398,770	700,750	270,290	42,280
Fraction Joint	32%	52%	76%	88%	89%
Itemized Deductions	47%	65%	86%	98%	98%
2018					
Number of Returns	607,790	416,100	754,470	315,040	49,700
Fraction Joint	29%	49%	73%	87%	89%
Itemized Deductions	17%	24%	31%	48%	65%

Source: IRS Statistics of Income

were unable to fully deduct their state and local taxes due to the $10,000 cap. In 2016, the

mean state and local tax deduction for those with incomes between $100,000 and $200,000 was $14,800, and so unsurprisingly in 2018 93% of taxpayers in that same income range who itemized were unable to fully deduct their state and local taxes (see Table 1.4). Average total deductions are higher in 2018 than in 2016, which is consistent with an increase in the threshold at which it becomes optimal to itemize rather than take the standard deduction.

Table 1.4: Tax Deductions in New Jersey

	Income Range (In Thousands)				
Mean Deductions	$50- $75	$75 - $100	$100 - $200	$200 - $500	$500 - $1,000
2016					
Total Deductions	$19,400	$22,200	$28,200	$47,100	$93,300
State Income Tax	$1,900	$3,100	$6,200	$17,200	$52,000
Property Tax	$ 5,800	$6,800	$8,600	$12,500	$19,800
Interest on Mortgage	$ 4,200	$5,200	$7,000	$9,800	$13,300
2018					
Total Deductions	$23,200	$24,700	$29,000	$36,000	$51,700
State Income Tax	$2,000	$3,200	$6,300	$17,000	$48,200
Property Tax	$6,800	$7,600	$9,300	$13,400	$19,000
Interest on Mortgage	$6,100	$7,200	$10,200	$14,900	$18,000
SALT Deducted	$7,400	$8,400	$ 9,200	$9,600	$9,700

Source: IRS Statistics of Income

These less generous deductibility provisions (and more generous standard deductions) would raise the after tax cost of home-ownership for a large fraction of potential home-buyers in New Jersey. If these home buyers are aware and responsive to this change it may be reflected in the fall in home prices of homes which carry relatively high property tax burdens.

Table 1.5 shows a how a number of hypothetical returns would differ between 2017 and 2018. Property taxes and mortgage interest were chosen on the basis observed property taxes and mortgage interest payments in the IRS Statistics of Income data for New Jersey. Federal income taxes and state income taxes were calculated using the NBER TAXSIM program, as was optimal deduction behavior. In the pre-TCJA period, all households find it optimal to itemize their returns. In the post-TCJA period, only the households filing single returns find it optimal to itemize. Even the household which files jointly and makes $250,000 while

Table 1.5: Hypothetical New Jersey Tax Returns Pre and Post TCJA

	Income					
	$100,000	$100,000	$150,000	$150,000	$250,000	$250,000
Return Type	Single	Joint	Single	Joint	Single	Joint
Property Taxes	$8,000	$8,000	$9,000	$9,000	$12,000	$12,000
State Income Taxes	$3,700	$2,200	$6,800	$4,900	$14,000	$11,100
Mortgage Interest	$7,000	$7,000	$10,000	$10,000	$13,000	$13,000
2017						
Optimal Deduction Behavior	Itemize	Itemize	Itemize	Itemize	Itemize	Itemize
Total Taxable Income	$77,000	$75,000	$120,200	$118,000	$208,000	$205,800
Federal Income Tax (Excluding FICA)	$15,000	$10,300	$ 26,600	$21,000	$52,000	$44,500
2018						
Optimal Deduction Behavior	Itemize	Std. Ded.	Itemize	Std. Ded.	Itemize	Std. Ded
Excess SALT	$1,700	NA	$5,800	NA	$16,000	NA
Total Taxable Income	$83,000	$76,000	$130,000	$126,000	$227,000	$226,000
Total Federal Income Tax (Excluding FICA)	$14,200	$8,700	$25,500	$20,000	$55,000	$42,800

Source: NBER TAXSIM

paying $23,100 in SALT and $13,000 in mortgage interest would find it optimal to take the standard deduction, because only the first $10,000 of SALT is deductible. Of course, this is a simple example which does not include other potential deductions, but given that the sum of SALT and mortgage interest payments comprised 75% of all deductions in New Jersey in 2016 (and this fraction was even higher for high income households) it is instructive to consider the difference in outcomes even with only these deductions. Additionally, all households in this hypothetical ultimately pay less in federal income tax in 2018 than they did in 2017, so even though home-ownership is less subsidized in the post-TCJA world, households are overall better off. This means that if housing and local public goods are normal goods, then any reduction in their consumption post-TCJA would be due to the substitution effect, and the observed change would be partially attenuated by the positive income effects of higher net of tax earnings.

1.4 New Jersey Property Taxes

In New Jersey, taxes on real estate are levied only by municipalities, and represent a significant sources of revenue for municipalities. Municipalities in New Jersey received an average of 52% of their revenue from property taxes, compared to an average of 28% for municipalities in other states [7].

Homes are taxed based on their assessed value as of October of the previous year, with some municipalities requiring quarterly tax payments and others biannual. Unlike in some states, the value on which homes can be taxed is not capped at the value at the time of purchase, so homes are taxed on the full current value of their home. Homes are regularly reassessed, with some municipalities reassessing all homes every year and all municipalities reassessing all homes at least every five years. As a result, the assessed value of a home does not change dramatically immediately after it is purchased. In the property tax data, the median reassessed home increased in assessed value by $6,800 if the home had not been sold in the last year, and $10,000 if it had been sold in the last year at fair market price [8].

[7] According to the New Jersey State League of Municipalities

[8] Fair market price as determined by the assessor

1.5 Data

All of the data used in this paper is publicly available data obtained from the New Jersey Department of the Treasury, the individual counties of New Jersey, and the Home Mortgage Disclosure Act. Yearly property tax records from 2012 to 2020 for all residential homes were obtained from the New Jersey Department of the Treasury. These yearly records include information on the location of the property, the value of the assessed property, the amount of property tax levied, any deductions or exemptions for the property, the total acreage of the property, as well as information on the name and address of the property owner, the most recent sale date, and the most recent sale price. Deed records for all deeds between 2014 and 2019 are also obtained from the New Jersey Department of the Treasury. These deeds include information on the location of the property, the square footage of the building, the deed date, the sale price, whether the sale was between related parties, whether the assessor considered the sale to be at fair market price, whether the property is a condominium, the year in which the home was built, as well as the names and addresses of both the seller and the buyer. All properties are assigned a unique identifier, which were used to link deed records to property tax records.

A publicly available walkability index from the EPA is also used to identify the extent to which a home is in an urban location. The National Walkability Index calculates for each Census group how easily residents can reach public transportation services, the mix of residential and business property in the block (including types of businesses), and the number of street intersections (more street intersections indicating a more walkable area).

For the difference in differences estimation this paper combines several sources of data in order to create a mortgage loan level data set consisting of households which purchased homes in New Jersey's Middlesex County between 2014 and 2019. This paper combines the deed and property tax data described above with mortgage documents and data from

the Home Mortgage Disclosure Act. Mortgage documents are publicly available from the Middlesex County Clerk's office.Optical Character Recognition software was used to extract the mortgaged property location, the name(s) of the mortgagor(s), the marital status of the mortgagor, the name of the lender, the date on which the mortgage was signed, and the size of the loan. Mortgages were matched to deeds using the property location on the mortgage document and the property location in the deed, the name of the buyer and mortgagor (if there are multiple buyers or mortgagors, at least one of the names must appear in both documents), and the date of the home sale and mortgage (the mortgage could be signed no later than two months after the deed date). This mortgage and deed data was then matched to the Home Mortgage Disclosure Act data set. The Home Mortgage Disclosure Act (HMDA) is a publicly available data set published by the Consumer Financial Protection Bureau. The Home Mortgage Disclosure Act requires all sufficiently large lending institutions (estimated to cover approximately 80 percent of the home loan market) to provide the federal government with information on every received home loan application. This includes, among other things, the census tract in which the property is located, the purpose of the loan, the gender and race of the applicant (and any co-applicants), the income of the applicant, the size of the loan, whether the property will be owner-occupied (and whether it will be a principle dwelling), and whether the loan application resulted in an originated loan. The HMDA data is matched to the mortgage and deed data on the name of the lender, the property location (using the census tract in the HMDA), and the size of the loan. This is sufficient to uniquely identify over 90 percent of originated loans in Middlesex County. This method is able to match approximately 50 percent of fair market home purchases to their corresponding HMDA record.

1.6 Difference in Differences Estimation

This paper employs a difference-in-differences strategy to determine the responsiveness of households who move to the changed tax incentives under the TCJA. The assumption is that households make the decision to move independent of changes to the tax treatment of property tax and mortgage interest, but that conditional on moving they will take into account these changes. The NBER TAXSIM software is used to determine optimal deduction behavior for each household under 2017 (pre-TCJA) and 2018 (post-TCJA) tax systems. Mortgage documents which were obtained from the county clerks office included the marital status of borrowers and assumption was made that individuals file jointly if they are married. Additionally, this paper assumes that the only sources of deductions are property taxes and state income taxes. This means that households with other substantial deductions that make them optimally itemize rather may be incorrectly classified as itemizers under the post TCJA tax regime (less than 3% of the sample was estimated to be a non-itemizer under the pre TCJA tax regime). This means that the estimates in this section represent a lower limit to the responsiveness of households to the TCJA since some households will be classified as having been exposed to a larger change than the true change to the tax treatment of their home.

There is both a binary treatment estimation and a continuous treatment estimation. In the binary treatment estimation, households which optimally itemize their deductions in both the pre and post TCJA era and do not exceed the $10,000 limit on state and local taxes (which in New Jersey are comprised of property and income taxes) are the untreated group. There are two separate sets of treated groups. The first group is comprised of households which optimally itemize their deduction pre TCJA but not post TCJA. For these households, the real cost of both their property taxes and mortgage interest payments is higher in the post TCJA world because it is no longer reduced by a factor of $(1 - \tau_f)$ as it was before TCJA was passed. The second group is comprised of households which optimally itemize their deductions both in the pre and post TCJA era, do not

have home loans in excess of \$750,000, would not have had any Alternative Minimum Tax Liability under the pre-TCJA tax regime, but whose state and local taxes exceed the \$10,000 limit. For these households, the marginal cost of an additional dollar of property taxes equal to \$1 in the post TCJA era but only equal to $(1-\tau_f)$ in the pre-TCJA era.

For the binary treatment, the estimated difference in differences equation is:

$$Y_{i,t} = \beta_0 + \beta_1 \text{Treatment}_i + \beta_2 \text{Treatment}_i \cdot \text{Post TCJA} + \beta_3 \text{Post TCJA} + \delta X_{it} + \varepsilon_{it} \quad (1.6.1)$$

The estimated outcomes of interest $Y_{i,t}$ are the home purchasing price, the home loan size, the home loan size as a fraction of sale price, and the yearly property tax. The treatment groups and the control group are as described in the previous paragraph.

In the continuous treatment estimation, this paper exploits variation in marginal tax rates within treated groups and employs a continuous difference in differences approach. The degree of property tax and mortgage subsidization is increasing in marginal tax rates, so a household in a higher tax bracket which is induced to stop itemizing by TCJA experiences a larger real increase in property tax and mortgage costs than a household in a lower tax bracket which also stops itemizing after TCJA. Additionally, households which continue to itemize and do not have state and local taxes in excess of \$10,000 experienced a small (on average 2%) decrease in marginal tax rates, slightly raising the real cost of deductible home expenses. The continuous difference in differences specification is

$$Y_{i,t} = \beta_0 + \beta_1 \Delta\tau_i + \beta_{3,t} \Delta\tau_i \cdot \text{Deed Year} + \beta_{4,t} \text{Deed Year} + \delta X_{it} + \varepsilon_{it} \quad (1.6.2)$$

Where $\Delta\tau_i$ is the change in the real marginal cost of property taxes (or interest on a home loan). A household which itemized before and after TCJA and did not exceed the SALT cap would have $\Delta\tau_i = \tau_{i,2017} - \tau_{i,2018}$. A household which itemized before TCJA but not after would have $\Delta\tau_i = \tau_{i,2017}$ since prior to TCJA they received a reduction in the real cost of their itemized deductions. Similarly, a household that itemized before and after TCJA but

exceeded the SALT cap would when considering property taxes have $\Delta\tau_i = \tau_{i,2017}$ since the marginal dollar of property taxes would not be deductible (even though some portion of their property taxes may have been deductible).

Tables 1.6, 1.7, and 1.8 show summary statistics by treatment group. Compared to both of the treatment groups, the control group is unsurprisingly less wealthy, and purchases smaller, less expensive homes which carry lower yearly property taxes. This group is overwhelmingly single, because married couples who choose to itemize will almost certainly have more than $10,000 in SALT (otherwise, it is unlikely that they will find it optimal to itemize).

Figures 1.3 through 1.8 show pre and post TCJA trends for home-buyers who do not optimally itemize under TCJA (but would have before TCJA), home-buyers who optimally itemize before and after TCJA but who have SALT of less than $10,000, and home-buyers optimally itemize before and after TCJA and who have SALT of more than $10,000. In the first year after the passage of TCJA home-buyers who stop itemizing or exceed the SALT limit purchase less expensive, smaller homes with lower property taxes. Additionally, as can be seen in figure 1.2, homebuyers who do not optimally itemize post TCJA take out smaller loans (as a fraction of their sale price). This is consistent with the fact that the after-tax cost of home loans has risen for this group. Homeowners who continue to itemize appear to have no change in the relative size of their home loans, consistent with the after-tax cost of home loans remaining the same for both homebuyers with SALT less than $10,000 and homebuyers with SALT in excess of $10,000.

These post-TCJA trends appear to somewhat reverse in 2019. Falling home loan interest rates in 2019 and rising stock values may be an explanatory factor. Higher stock values may be more beneficial for both the no longer itemizing group and the group with SALT greater

than $10,000 than the itemizers with less than $10,000 in SALT. This is due to these two groups of homebuyers having significantly higher incomes than the itemizers with SALT less than $10,000 and higher incomes correlate in the general population with larger savings.

For the continuous difference in differences estimations, figures 1.9 to 1.14 show trends for home loans and property taxes decomposed by change in $\Delta\tau_i$ from equation (1.6.2) of home loans (figures 1.9 to 1.12) and property taxes (figures 1.13 and 1.14). For the purposes of graphically representing trends changes in costs, $\Delta\tau_i$ from equation (1.6.2) is rounded to the nearest 10%. In order account for the seasonality of the residential real estate market, figures 1.9 to 1.14 show a twelve month moving average. This has the downside that values for time periods within six months of the start of 2018 (when the Tax Cuts and Jobs Act was enacted) are dependent on transactions before and after the tax regime change. To somewhat remedy this, trends which only include the data from before the passage of the TCJA are also shown.

Table 1.6: Characteristics of Home Buyers

	Mean	Std. Dev.	10th Percentile	90th Percentile
Control Group:				
Itemizing, SALT < $10,000				
Income	$69,767	$17,025	$50,000	$92,000
Percent Married	3.7%			
Number of Observations	2,296			
Treatment Groups:				
No Longer Itemizing				
Income	$107,393	$77,555	$57,000	$164,000
Percent Married	60%			
Number of Observations	8,931			
Itemizing, SALT > $10,000				
Income	$137,420	$60,529	$85,000	$196,000
Percent Married	45%			
Number of Observations	5,963			

Tables 1.9 through 1.16 show the results of the difference in differences estimation. Households which were induced to stop deducting reduced their home loan size by approximately 4.3% as a fraction of home price. This result is roughly the same as the

Table 1.7: Characteristics of Purchased Homes

	Mean	Std. Dev.	10th Percentile	90th Percentile
Control Group:				
Itemizing, SALT < $10,000				
Home Sale Price	$256,745	$58,047	$190,000	$335,000
Home Loan (in Dollars)	$223,981	$57,609	$159,125	$303,036
Yearly Property Tax Post Sale	$6,197	$1,205	$4,591	$7,779
Treatment Groups:				
No Longer Itemizing				
Home Sale Price	$310,925	$86,946	$213,000	$412,000
Home Loan (in Dollars)	$256,290	$64,044	$170,000	$334,650
Yearly Property Tax Post Sale	$7,731	$2,293	$5,193	$10,576
Itemizing, SALT > $10,000				
Home Sale Price	$454,273	$131,122	$300,000	$625,000
Home Loan (in Dollars)	$384,487	$102,707	$250,800	$512,800
Yearly Property Tax Post Sale	$10,966	$3,059	$7,540	$14,897

impact of a 2% increase in the 30 year fixed mortgage rate which suggests that home buyers are highly responsive and aware of changing tax incentives. That the effect is not large in overall magnitude may by due to the fact that even with reduced tax preferential treatment, home loans are relatively less expensive or more accessible than other sources of household financing. This may be in part due to particularly low home loan interest rates and high rates of return on other investments during the time period that is being studied. Households who do not optimally itemize under TCJA also take out loans which are approximately $19,000 lower as a result of TCJA, even when accounting for their home purchase price. Households also purchase homes with slightly smaller property tax bills. For households which have SALT in excess of $10,000, there is no evidence that they change the relative size of their home loans. This is consistent with the fact that their tax benefits for home loans have not changed. Additionally, while they purchase homes which are between $15,000 and $38,000 lower (depending on the specification), there is no change in their property tax bills. This seems to be because essentially all other potential home-buyers for a given property would also be unable to fully deduct their property taxes, and so while home prices fall there is no readjustment in terms of yearly property tax bills.

Table 1.8: Physical Characteristics of Purchased Homes

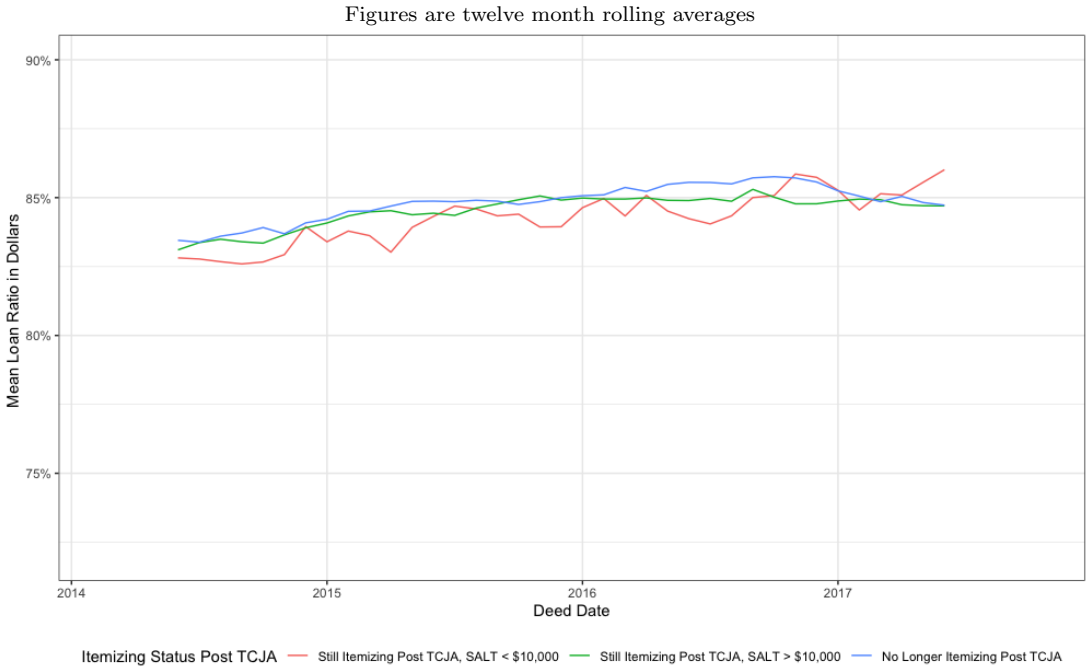
	Mean	Std. Dev.	10th Percentile	90th Percentile
Control Group:				
Itemizing, SALT < $10,000				
Square Feet	1316	328	924	1737
Age of Home (Years)	56	27	25	97
Acreage	0.14	0.44	0	0.23
Treatment Groups:				
No Longer Itemizing				
Square Feet	1574	497	1026	2171
Age of Home (Years)	50	25	20	86
Acreage	0.17	0.52	0	0.34
Itemizing, SALT > $10,000				
Square Feet	2157	658	1382	2998
Age of Home (Years)	41	24	14	68
Acreage	0.26	0.44	0	0.47

Figures 1.15 through 1.18 show the difference in differences coefficient and 95% confidence intervals from estimating equation 1.6.2. In particular, figures 1.15 and 1.16 estimate equation 1.6.3.

$$\begin{aligned}\log(\text{Sale Price}) = \beta_0 + \beta_1 \Delta\tau_i + \beta_{3,t}\Delta\tau_i + \beta_{4,t}\text{Deed Year} * \text{Deed Month} \\ + \log(\text{Income}) + \text{Muni}_j + \varepsilon_{it}\end{aligned} \tag{1.6.3}$$

The estimation shows that after the passage of TCJA, homebuyers who experienced higher marginal costs of previously deductible expenses significantly reduced their home prices. These results are partially explained by homebuyers purchasing smaller homes with lower property tax burdens. Estimates are approximately 58% larger for taxpayers who no longer itemize compared to taxpayers who itemize but have SALT in excess of $10,000. This is consistent with the fact that the latter group is both able to partially deduct their property taxes and are still able to deduct the interest on their home loan. Figures 1.17 and 1.18 estimate equation 1.6.4.

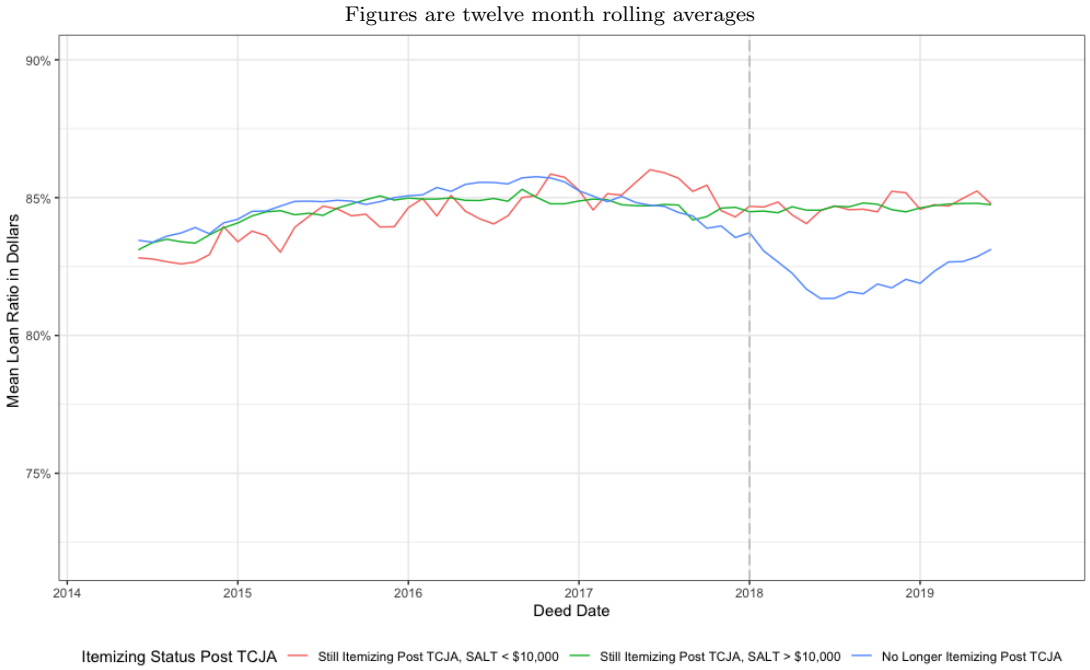
Figure 1.1: Pre TCJA Trends in Loan to Sale Price Ratios



$$\begin{aligned}\text{Loan To Sale Price Ratio} = \beta_0 + \beta_1 \Delta\tau_i + \beta_{3,t}\Delta\tau_i + \beta_{4,t}\text{Deed Year} * \text{Deed Month} \\ + \beta_4 \log(\text{Income}) + \text{Muni}_j + \varepsilon_{it}\end{aligned} \tag{1.6.4}$$

The estimation shows no change in the home loan choices of homebuyers who still itemize, consistent with the fact that they are still able to deduct the interest on their home loan. Homebuyers who stopped itemizing have large responses to the size of their home loan. Given that both groups purchased less expensive homes, it appears that this is not a liquidity response.

Figure 1.2: Pre and Post TCJA Trends in Loan to Sale Price Ratios

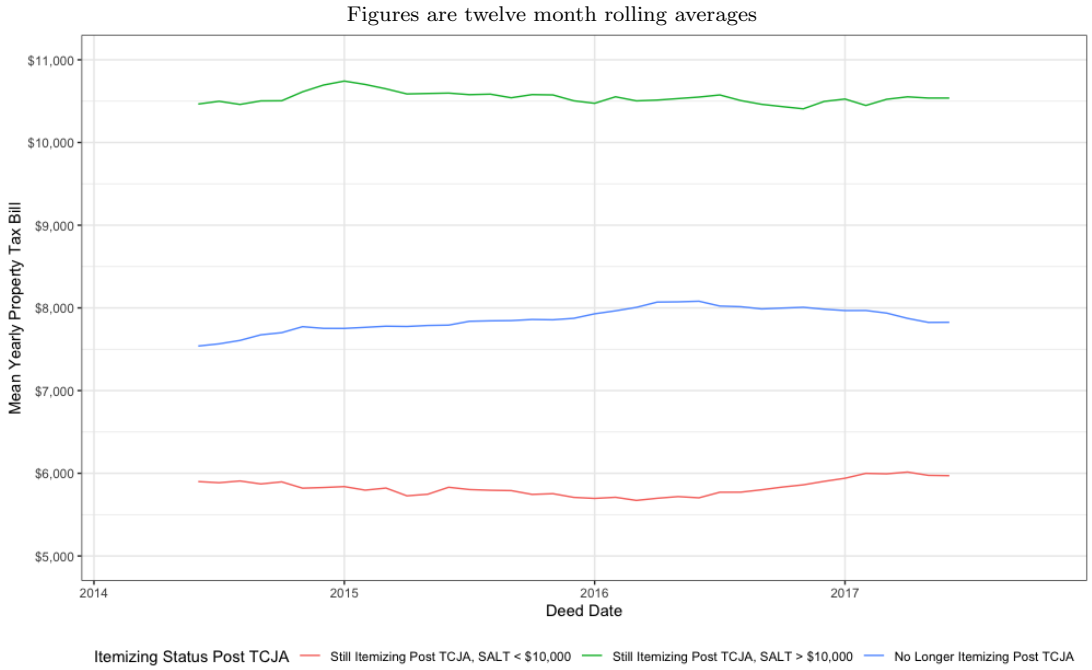


1.7 Conclusion

This paper examines the impact of the TCJA on homes and home buyers. The TCJA reduced tax benefits for homeowners, both by explicitly capping property tax and mortgage interest deductions, and by doubling the standard deduction which discouraged taxpayers from itemizing their deductions. This paper estimates the response from individual home-buyers in terms of the types homes that they purchased and their home financing choices. Understanding how homebuyers and housing markets responded to these changes is relevant for determining the ways in which government policy can shape housing markets.

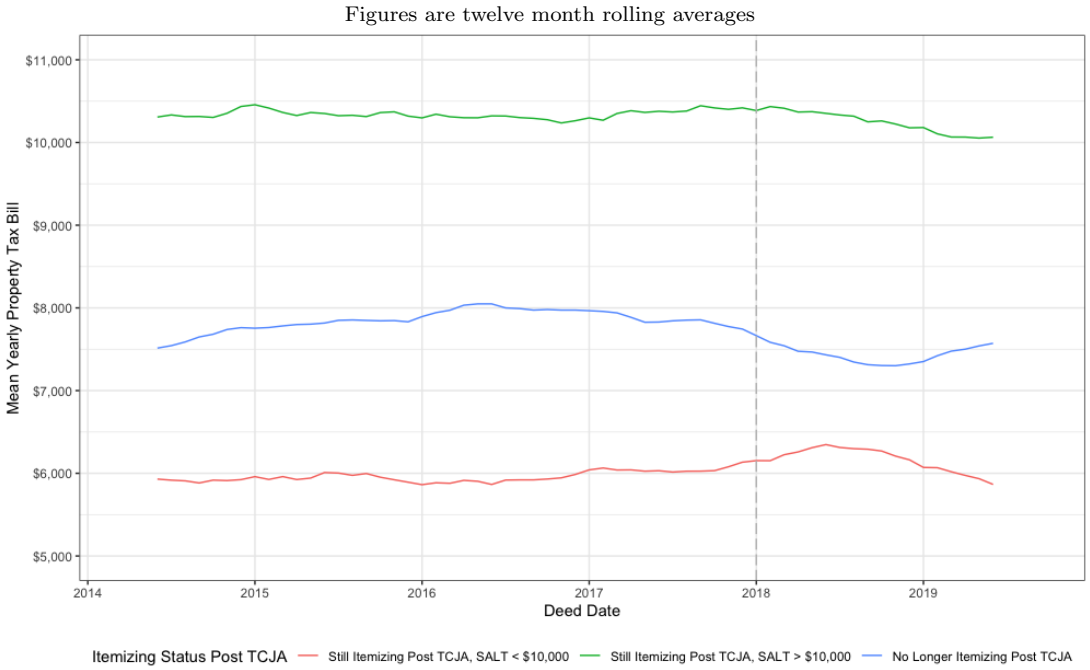
This paper estimates the responsiveness of individual homebuyers by creating a unique data set that matches deed and mortgage records to data from the Home Mortgage Disclosure Act, a publicly available mortgage loan-level data set that covers the overwhelming majority of mortgages in the United States. This paper finds that homebuyers who would have itemized under the pre-TCJA tax system but who take the standard deduction under the

Figure 1.3: Pre TCJA Trends in Yearly Property Tax Bills



post-TCJA tax system responded to the change by purchasing smaller, less expensive homes with lower property taxes and financed less of their purchase using mortgage debt (even after conditioning on home price). Homebuyers that itemized under both the pre and post TCJA tax systems but that had SALT deductions in excess of $10,000 also responded by purchasing smaller, less expensive homes with lower property taxes but did not change the fraction of their purchase which was financed by mortgage debt. This lack of response in the dimension of mortgage debt is consistent with the fact that this second group was still able to fully deduct the interest on their home loan. In the short run, despite these adjustments on the part of homebuyers, there was no change in municipalities' property tax revenues because of the process by which New Jersey property taxes levels are determined. However, in the long run, homeowner preferences for lower post-TCJA property taxes may manifest themselves in lower municipality budgets and a corresponding lower provision of local public goods. This may be welfare reducing given that many public schools are primarily funded by property taxes and that education is generally believed to have positive externalities. How concerning this is will also depend on the degree of

Figure 1.4: Pre and Post TCJA Trends in Yearly Property Tax Bills



economic segregation between municipalities. If a municipality has a high degree of income variance then subsidizing the property tax cost of a high income taxpayer may benefit lower income households in the form of more funding for schools (and other local public goods). However, if municipalities are more homogeneous in terms of income, then such subsidies for high income taxpayers will not have positive benefits for lower income households.

This paper finds that homebuyers had strong responses to changes to the tax treatment of homeownership under the TCJA. The magnitude of these responses indicate that tax policy has a real impact on housing decisions, and suggests that reducing such benefits may in the long run reduce housing consumption. It also suggests that reducing tax benefits for homeownership will also lead to lower property taxes and therefore a lower provision of local public goods.

Figure 1.5: Pre TCJA Trends in Sale Prices

Figures are twelve month rolling averages

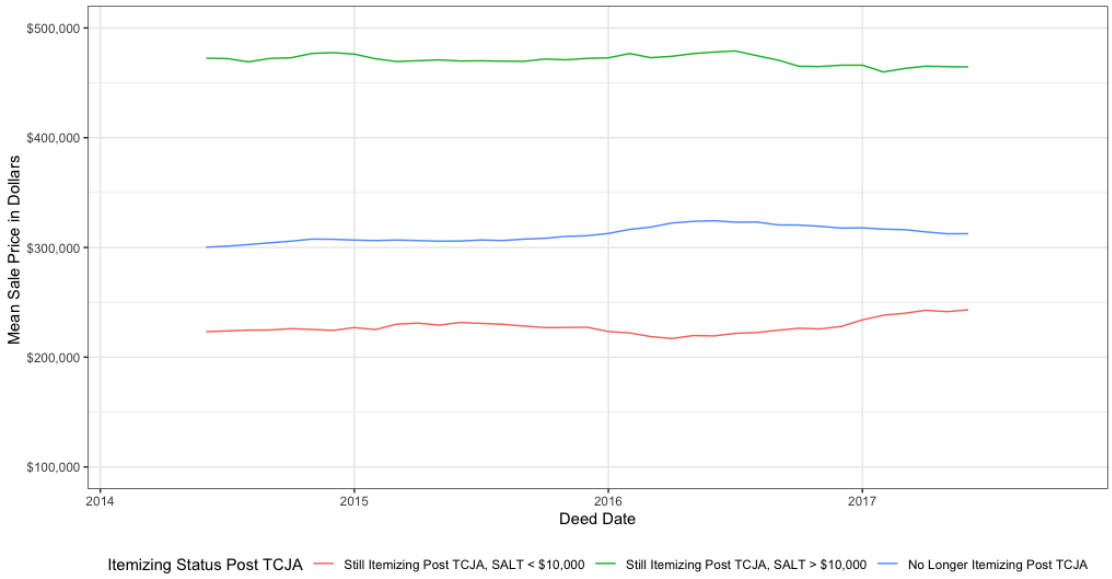


Figure 1.6: Pre and Post TCJA Trends in Sale Prices

Figures are twelve month rolling averages

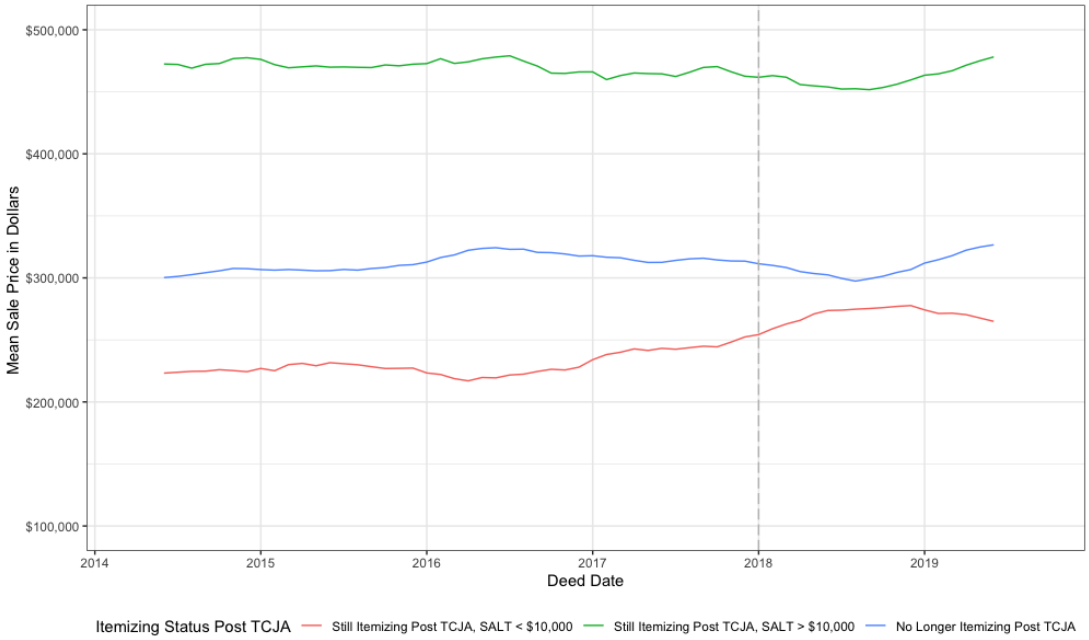


Figure 1.7: Pre TCJA Trends in Square Footage of Homes

Figures are twelve month rolling averages

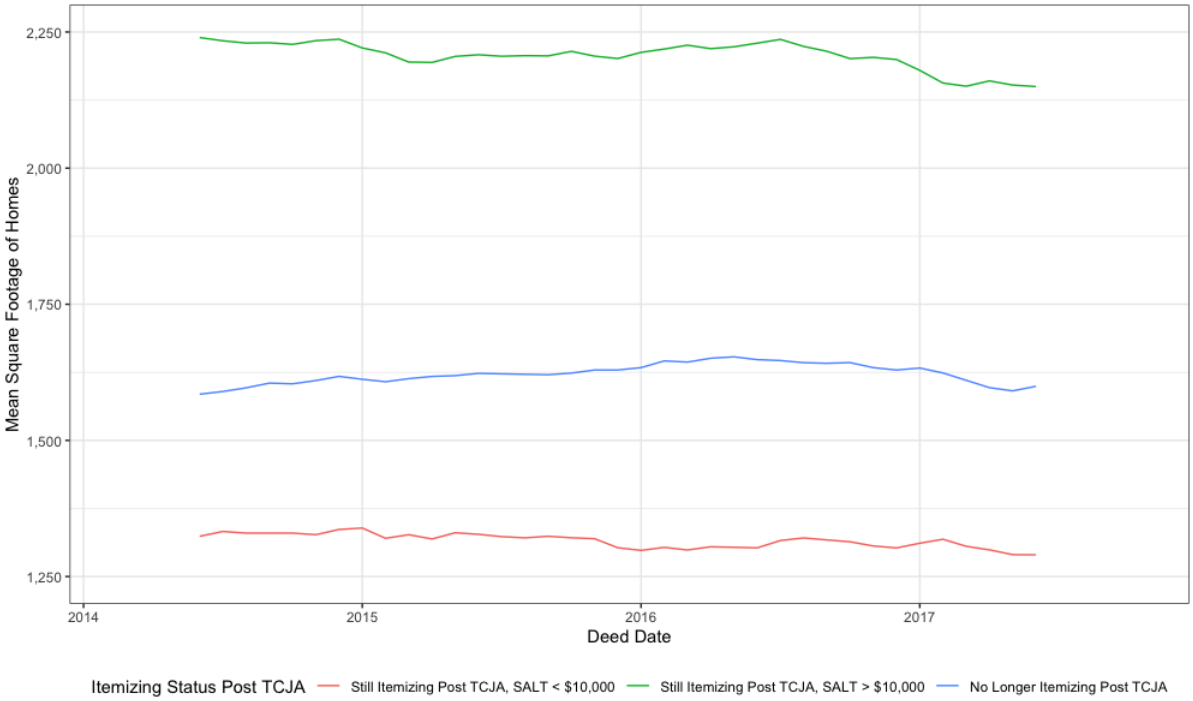


Figure 1.8: Pre and Post TCJA Trends in Square Footage of Homes

Figures are twelve month rolling averages

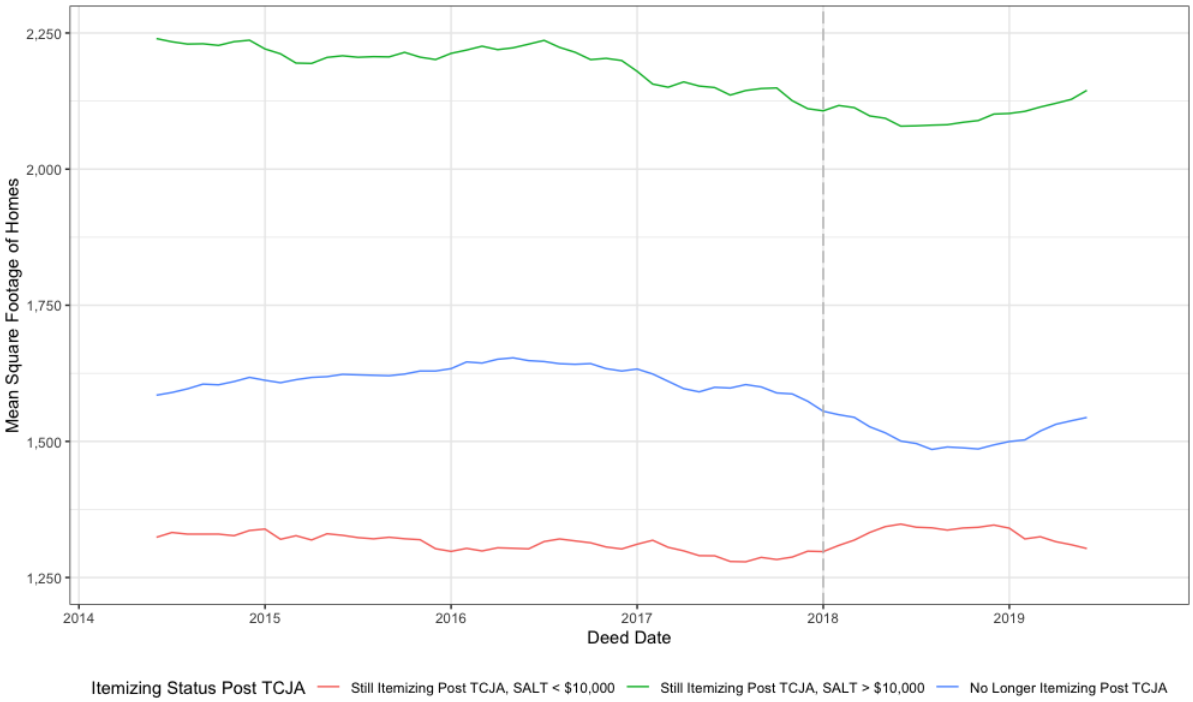


Figure 1.9: Pre TCJA Trends in Ratio of Home Loan to Sale Price

Figures are twelve month rolling averages, change in marginal costs are rounded to nearest 10%

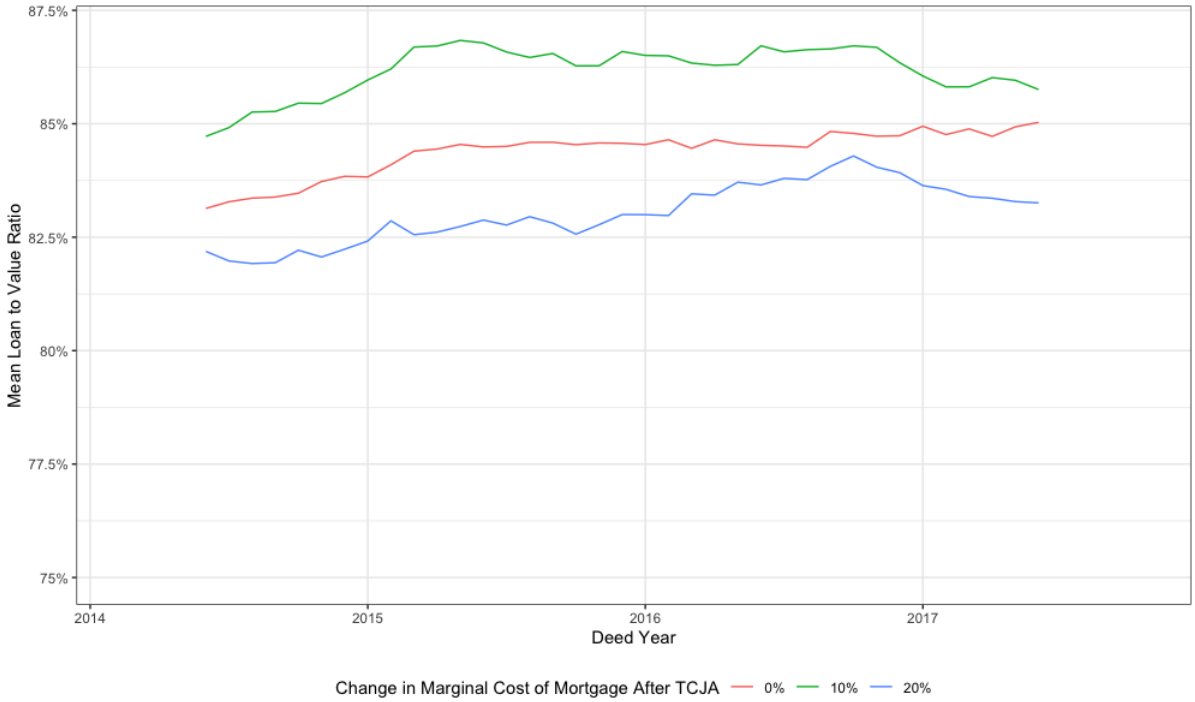


Figure 1.10: Pre and Post TCJA Trends in Ratio of Home Loan to Sale Price

Figures are twelve month rolling averages, change in marginal costs are rounded to nearest 10%

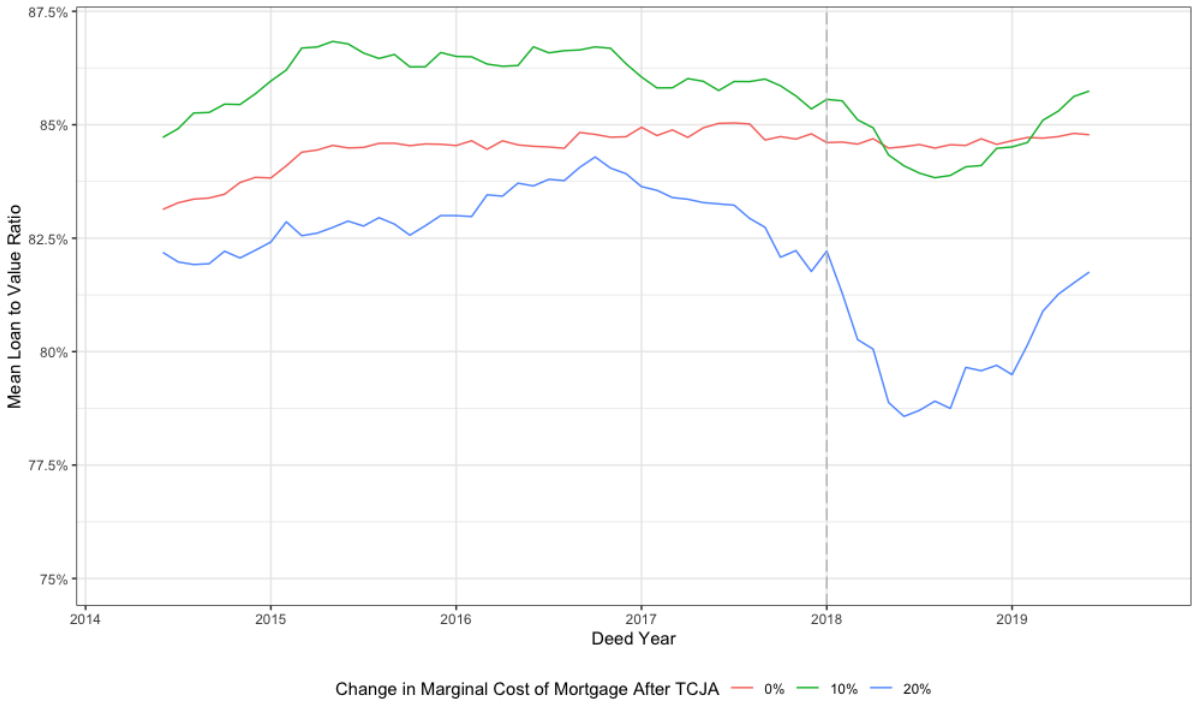


Figure 1.11: Pre TCJA Trends in Home Loan Size

Figures are twelve month rolling averages, change in marginal costs are rounded to nearest 10%

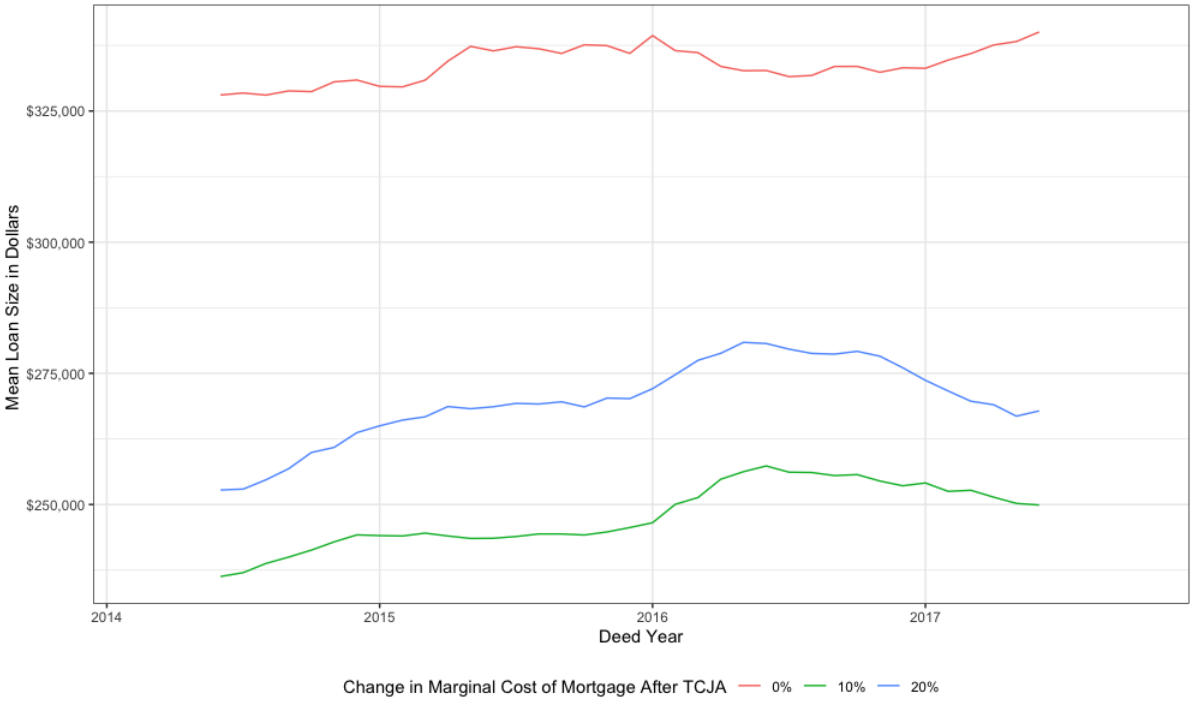


Figure 1.12: Pre and Post TCJA Trends in Home Loan Size

Figures are twelve month rolling averages, change in marginal costs are rounded to nearest 10%

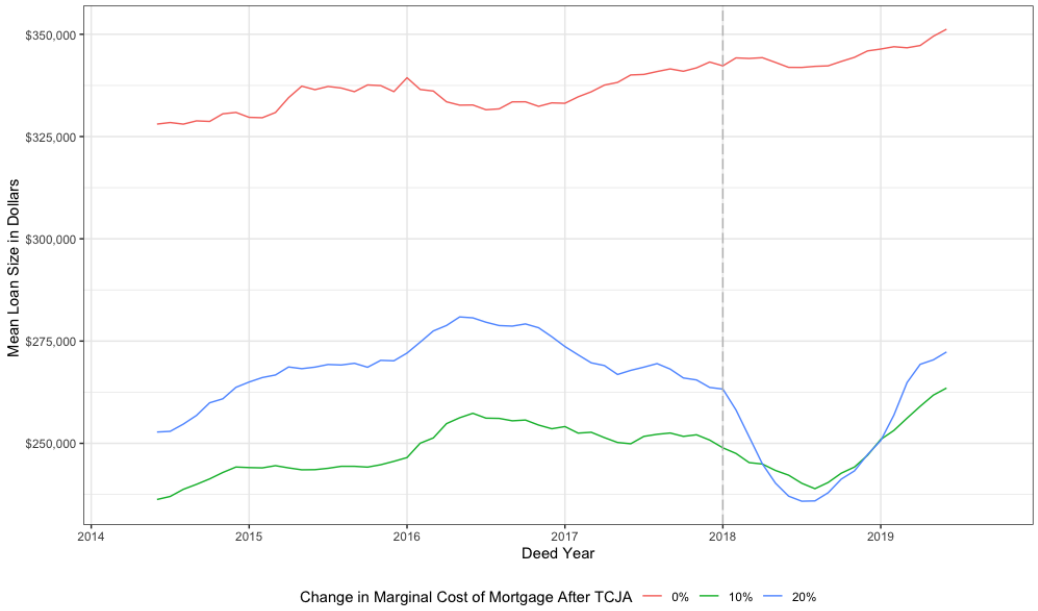


Figure 1.13: Pre TCJA Trends in Property Tax Size

Figures are twelve month rolling averages, change in marginal costs are rounded to nearest 10%

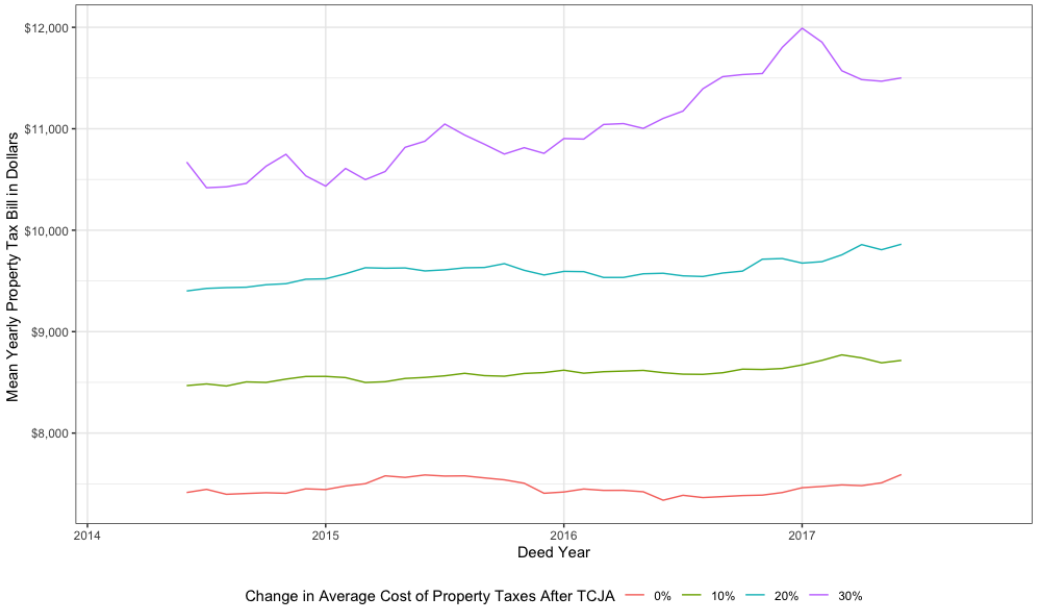


Figure 1.14: Pre and Post TCJA Trends in Property Tax Size

Figures are twelve month rolling averages, change in marginal costs are rounded to nearest 10%

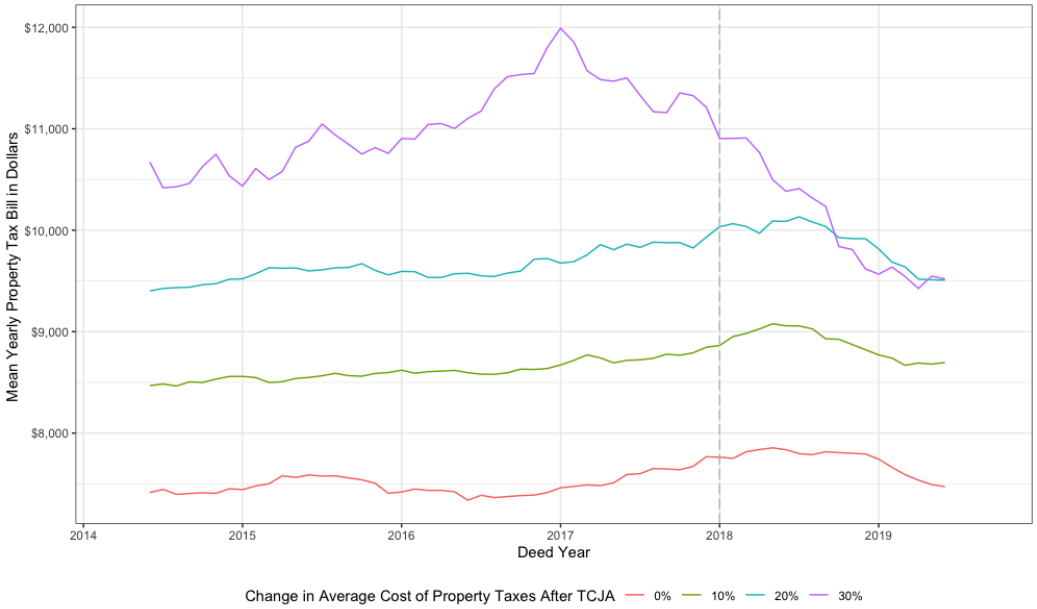


Table 1.9: Difference in Differences Estimation Of Home Loan Size For Homebuyers Who No Longer Optimally Itemize

	Dependent Variable: Loan Amount (Dollars)			
	(1)	(2)	(3)	(4)
Post 2018, Opt. Not Item. Post TCJA	-$32,575***	-$19,755***	-$19,747***	-$19,723***
	($3,989)	($3,046)	($3,047)	($2,974)
Post 2018	$37,958***	$17,904***	$17,905***	$17,902***
	($3,706)	($2839)	($2,839)	($2,775)
Opt. Not Item. Post TCJA	$43,978***	$13,282***	$13,304***	$13,299***
	($2,574)	($2,008)	($2,016)	($1,975)
30 Year Fixed Mortgage Rate	-$34,466***	-$18,029***	-$18,030***	-$18,848***
	($2,325)	($1,787)	($1,787)	($1742)
Home Sale Price		Yes	Yes	Yes
Income			Yes	Yes
Municipality F.E.				Yes
Constant	$349,560***	$165,237***	$165,254***	$173,058***
	($9,432)	($7,634)	($7,636)	($8,040)
R2	0.07176	0.4608	0.4608	0.4910
Number Of Observations	7155			

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 1.10: Difference in Differences Estimation Of Home Loan Size For Home-buyers Who Still Optimally Itemize But With SALT>$10,000

	Dependent Variable: Loan Amount (Dollars)			
	(1)	(2)	(3)	(4)
Post 2018, SALT>$10,000	-$31,355***	-$4,902	-$4,691	-$4,315
	(6109)	(3005)	(2998)	(3007)
Post 2018	$33,445***	$8,622**	$8,622**	$8,160**
	(5522)	(2716)	(2710)	(2719)
SALT>$10,000	$184,820***	$29,865***	$27,456***	$27,083***
	(4054)	(2357)	(2405)	(2443)
30 Year Fixed Mortgage Rate	-$22,070***	-$8,751***	-$8,945***	-$9,217***
	(4204)	(2065)	(2061)	(2058)
Home Sale Price		Yes	Yes	Yes
Income			Yes	Yes
Municipality F.E.				Yes
Constant	300918.7887***	78539.1269***	77537.3710***	93537.5675***
	(16868.6930)	(8472.9703)	(8455.8793)	(10218.5718)
R2	0.4038	0.8565	0.8572	0.8593
Number of Observations	4756			

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 1.11: Difference in Differences Estimation Of Ratio of Home Loan to Sale price For Homebuyers Who No Longer Optimally Itemize

	Dependent Variable: $\frac{\text{Home Loan Size}}{\text{Sale Price of Home}}$			
	(1)	(2)	(3)	(4)
Post 2018 and Opt. Not Item. Post TCJA	-0.0241**	-0.0435***	-0.0432***	-0.0455***
	(0.0092)	(0.0083)	(0.0083)	(0.0081)
Post 2018	0.0051	0.0355***	0.0355***	0.0376***
	(0.0085)	(0.0077)	(0.0077)	(0.0076)
Opt. Not Item. Post TCJA	-0.0234***	0.0230***	0.0238***	0.0250***
	(0.0059)	(0.0055)	(0.0055)	(0.0054)
30 Year Fixed Mortgage Rate	-0.0185***	-0.0434***	-0.0434***	-0.0457***
	(0.0053)	(0.0049)	(0.0049)	(0.0048)
Home Sale Price		Yes	Yes	Yes
Income			Yes	Yes
Municipality F.E.				Yes
Constant	0.9427***	1.2217***	1.2223***	1.2528***
	(0.0217)	(0.0208)	(0.0208)	(0.0219)
R2	0.0134	0.1932	0.1935	0.2362
N	7155			

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 1.12: Difference in Differences Estimation Of Ratio of Home Loan to Sale price For Homebuyers Who Still Optimally Itemize But With SALT>$10,000

	Dependent Variable: $\frac{\text{Home Loan Size}}{\text{Sale Price of Home}}$			
	(1)	(2)	(3)	(4)
Post 2018, SALT>$10,000	0.0056	-0.0053	-0.0049	-0.0062
	(0.0074)	(0.0071)	(0.0071)	(0.0071)
Post 2018	0.0035	0.0138*	0.0138*	0.0146*
	(0.0067)	(0.0064)	(0.0064)	(0.0064)
SALT>$10,000	-0.0172***	0.0467***	0.0415***	0.0412***
	(0.0049)	(0.0055)	(0.0057)	(0.0057)
30 Year Fixed Mortgage Rate	-0.0140**	-0.0195***	-0.0199***	-0.0209***
	(0.0051)	(0.0049)	(0.0049)	(0.0048)
Home Sale Price		Yes	Yes	Yes
Income			Yes	Yes
Municipality F.E.				Yes
Constant	0.9252***	1.0170***	1.0148***	1.0685***
	(0.0204)	(0.0199)	(0.0199)	(0.0240)
R2	0.0054	0.0934	0.0970	0.1131
Number of Observations	4756			

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 1.13: Difference in Differences Estimation Of Yearly Property Tax Bill For Homebuyers Who No Longer Optimally Itemize

	Dependent Variable: Yearly Property Tax Bill			
	(1)	(2)	(3)	(4)
Post 2018, Opt. Not Item. Post TCJA	-$358*	-$373**	-$342**	$105
	(140.82)	(138.97)	(130.52)	(72.430)
Post 2018	$235	$195	$225	-$484***
	(130.84)	(129.14)	(121.50)	(67.574)
Opt. Not Item. Post TCJA	$1,679***	$1,511***	$1,334***	$273***
	(90.857)	(90.465)	(85.446)	(48.094)
30 Year Fixed Mortgage Rate	-$571***	-$537***	-$523***	$111**
	(82.082)	(81.038)	(75.990)	(42.416)
Income		0.004503***	0.004319***	0.00006628
		(0.0003241)	(0.0003058)	(0.0001728)
Home Sale Price				0.02173***
				(0.0001714)
Municipality F.E.			Yes	Yes
Constant	$8,412***	$7,973***	$7,110***	$63
	(332.92)	(330.05)	(338.66)	(195.77)
R2	0.07785	0.1021	0.2166	0.7594
Number Of Observations	7155			

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 1.14: Difference in Differences Estimation Of Yearly Property Tax Bill For Homebuyers Who Still Optimally Itemize But With SALT>$10,000

	Dependent Variable: Yearly Property Tax Bill			
	(1)	(2)	(3)	(4)
Post 2018, SALT>$10,000	-$272	-$274	-$123	$259**
	(184)	(184)	(176)	(91)
Post 2018	$26	$107	$12	-$512***
	(160)	(166)	(159)	(82)
SALT>$10,000	$5174***	$5180***	$4016***	$497***
	(122)	(122)	(129)	(74)
30 Year Fixed Mortgage Rate		-$222	-$216	$173**
		(126)	(121)	(62)
Income			$0.0158***	-$0.0009*
			(0.0008)	(0.0004)
Home Sale Price				$0.0221***
				(0.0002)
Municipality F.E.			Yes	Yes
Constant	$6,168***	$7,041***	$5,948***	-$276
	(105)	(508)	(489)	(311)
R2	0.3915	0.3919	0.4426	0.8531
Number of Observations	4756			

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 1.15: Difference in Differences Estimation Of Home Sale Price For Home-buyers Who No Longer Optimally Itemize

	Dependent Variable: Home Sale Price		
	(1)	(2)	(3)
Post 2018, Opt. Not Item. Post TCJA	-$26,506***	-$27,234***	-$20,597***
	(5340)	(5215)	(4999)
Post 2018	$41,461***	$39,498***	$32,689***
	(4961)	(4847)	(4652)
Opt. Not Item. Post TCJA	$63,465***	$55,070***	$48,832***
	(3445.5)	(3395.4)	(3272.6)
30 Year Fixed Mortgage Rate	-$33,983***	-$32,282***	-$29,229***
	(3112.7)	(3041.6)	(2910.5)
Income		0.2262***	0.1957***
		(0.01217)	(0.01171)
Constant	$381,101***	$359,071***	$324,253***
	(12625.0)	(12388.0)	(12971.0)
Municipality F.E.			Yes
R2	0.07437	0.1171	0.1979
Number Of Observations	7155		

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure 1.15: Continuous Difference in Differences Estimation of Home Sale Price For Home-buyers Who No Longer Optimally Itemize

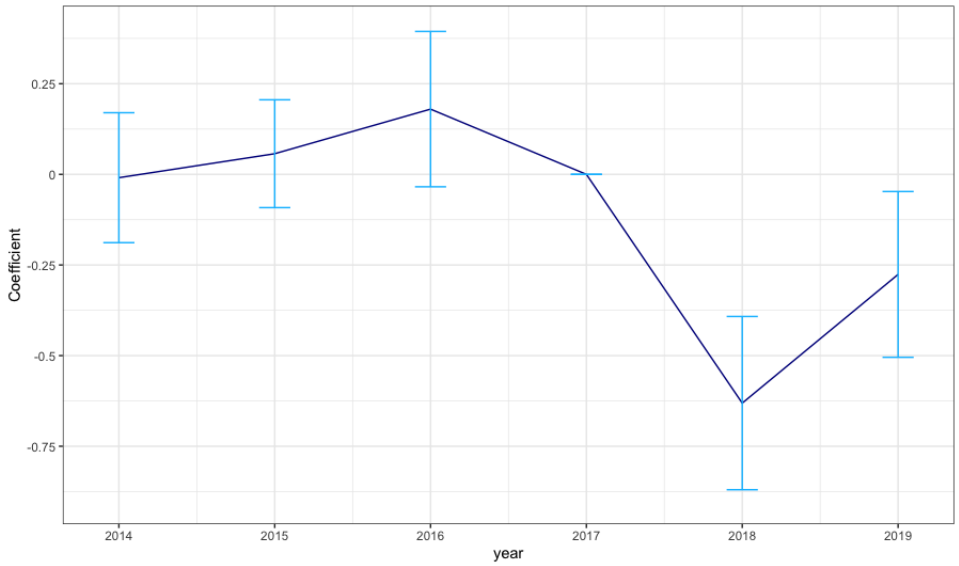


Table 1.16: Difference in Differences Estimation Of Home Sale Price For Home-buyers Who Still Optimally Itemize But With SALT>$10,000

	Dependent Variable: Home Sale Price		
	(1)	(2)	(3)
Post 2018, SALT>$10,000	-$38,525***	-$30,006***	-$15,233*
	($7,753)	($7,160)	($6,523)
Post 2018	$36,151***	$30,768***	$21,238***
	($7,008)	($6,469)	($5,893)
SALT>$10,000	$225,672***	$160,232***	$142,240***
	($5,145)	($5,263)	($4,883)
30 Year Fixed Mortgage Rate	-$19,397***	-19081***	-$15,043***
	($5,336)	($4,923)	($4,461)
Income		0.8868***	0.6885***
		(0.0308)	(0.0286)
Municipality F.E.		Yes	
Constant	$323,866***	$262,423***	$243,919***
	(21407.9082)	(19867.8375)	(21893.1169)
R2	0.3844	0.4760	0.5750
Number of Observations	4756		

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure 1.16: Continuous Difference in Differences Estimation of Home Sale Price Home-buyers Who Still Optimally Itemize But With SALT>$10,000

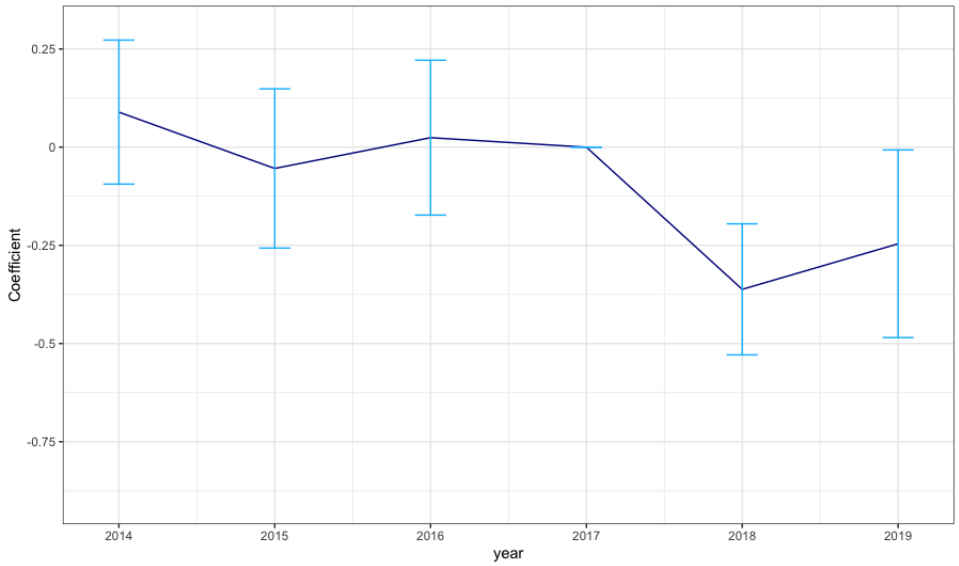


Figure 1.17: Continuous Difference in Differences Estimation of Home Loan Ratio For Home-buyers Who No Longer Optimally Itemize

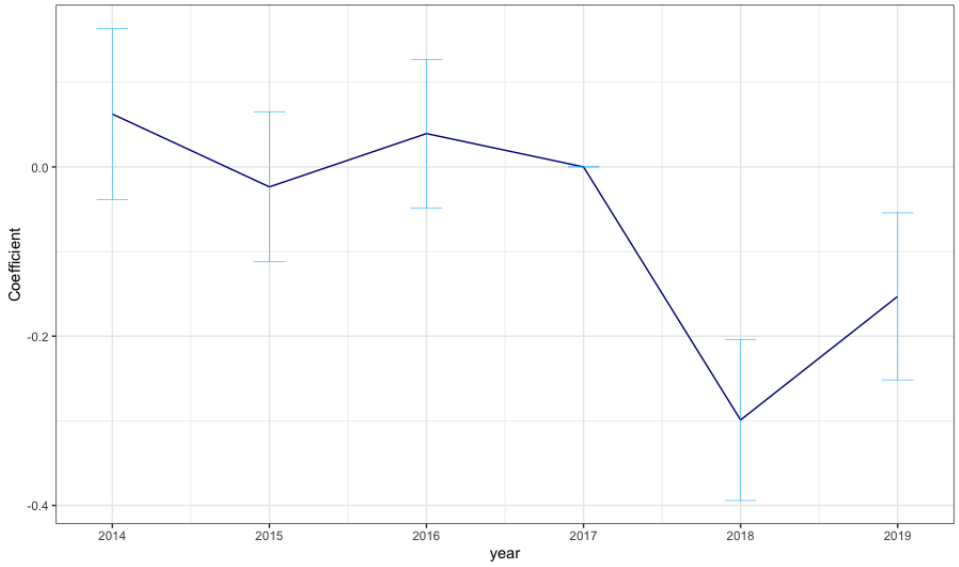
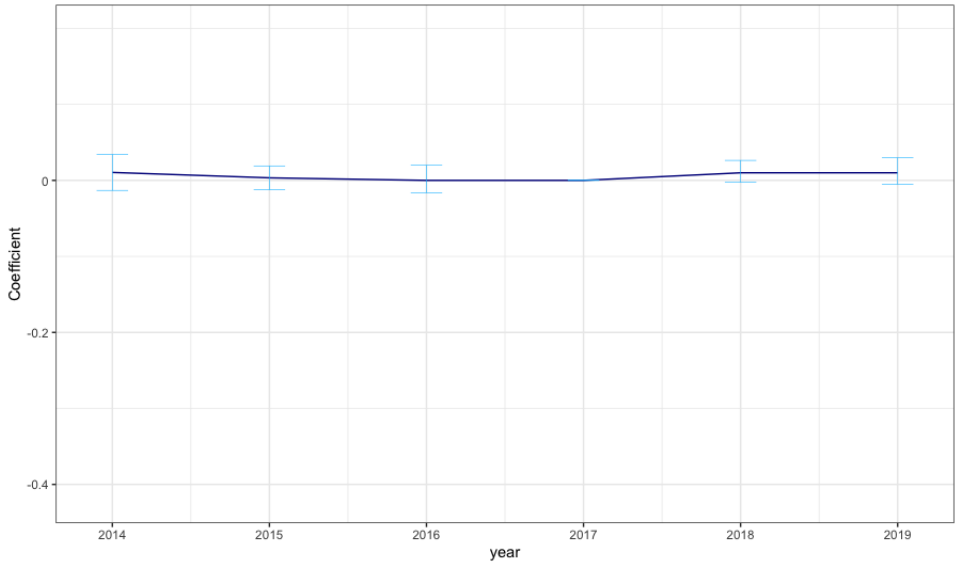


Figure 1.18: Continuous Difference in Differences Estimation of Home Loan Ratio For Home-buyers Who Still Optimally Itemize But With SALT>$10,000



CHAPTER II

Housing Prices and the Deductibility of Property Taxes: Evidence from the Tax Cuts and Jobs Act

2.1 Introduction

The US federal tax code contains significant tax benefits for homeowners. Homeowners are not taxed on the imputed rental income of their homes and are entitled to large exemptions on capital gains when they sell their homes. Despite this, they are able to deduct real estate property taxes and interest on their home mortgage. In effect, this means that the federal government treats homes like taxable capital goods when it comes to the costs associated with homeownership (property taxes and home loan interest payments) but does not treat homes like taxable capital goods comes when it comes to the benefits of homeownership (capital gains and imputed rental income). These benefits are regressive on both the extensive and intensive margin since higher income individuals are more likely to be homeowners and the average value (and therefore both costs and benefits) of an individual's home rises with income. The often stated motivation for these benefits is that they encourage homeownership and that homeownership generates substantial societal benefits in the form of homeowners who are more invested in their communities. This paper studies how responsive housing prices are to these tax benefits in order to try to provide evidence for how these federal tax benefits shape housing markets. The Tax Cuts and Jobs Act of 2017 provides an opportunity to study the effect of tax incentives on the housing market, as it substantially

reduced homeowner tax benefits for a subset of taxpayers.

The Tax Cuts and Jobs Act of 2017 (TCJA) was one of the largest US federal tax reforms in the last hundred years. It reduced the tax benefits of homeownership in two major ways. First, it approximately doubled the standard deduction, reducing the fraction of itemizing taxpayers nationwide from 30% to 13%. Since only itemizers benefit from deducting property taxes and interest on a home mortgage, this raised the after-tax costs of homeownership for taxpayers who stopped itemizing. Second, TCJA capped total state and local taxes (known by the acronym SALT) deductions to a maximum of $10,000. This provision was considered politically contentious because the TCJA was passed by members of the Republican party along party lines and the largest beneficiaries of SALT deductions were taxpayers in states primarily represented in Congress by members of the Democratic party. Since the passage of the TCJA, there have been several attempts by Congressional Democrats to repeal the SALT cap. New York, New Jersey, Connecticut and Maryland (all states with high property taxes and high pre-TCJA itemization rates) unsuccessfully sued the federal government on the grounds that the deduction cap was an "unconstitutional assault on the States' sovereign choices"[1]. A return to a pre-TCJA system would provide an estimated $171 billion in tax benefits (or approximately 6% of individual income tax revenue), 92% of which would accrue to taxpayers earning over $100,000 a year [2]. Understanding the effect of the tax code on the housing market is thus both a salient policy and economic question.

This paper measures the impact of the TCJA on housing prices in New Jersey. New Jersey has the highest real estate property tax levels in the United States, with the average household paying over $5,000 in property taxes per year[3]. New Jersey also has some of the highest state income tax rates, which, coupled with the fact that New Jersey has the second

[1] See Filing and Outcome
[2] According to the Joint Committee on Taxation
[3] According to data from the 2019 American Community Survey

highest median income, means that New Jersey residents have particularly large state income tax bills. Tables B.1 and B.2 show itemization behavior and average deductions in New Jersey relative to other US states. In tax year 2017 (prior to the passage of TCJA) 42% of New Jersey tax filers itemized their deductions (compared to 32% of all US tax filers), only Maryland had a higher fraction of tax filers itemize their deductions. The mean property tax deduction for New Jersey itemized returns was almost $9,000 (compared to $4,750 for all US itemized returns). Conversely, in tax year 2018 (the first post-TCJA tax year) only 17% of of New Jersey tax filers itemized their deductions (compared to 11% of tax filers in the overall United States). New Jersey also had the highest mean real estate tax deduction in both 2017 and 2018 (in 2017, the mean real estate tax deduction for itemizers in New Jersey was $9,000, Connecticut had the second highest mean real estate tax deduction at $7,600). This means that if the TCJA did impact housing markets, New Jersey is one of the most likely places where such an impact would be observed.

If the TCJA affected housing markets, one of the measurable impacts would on be housing prices. If the higher (after tax) cost of property taxes and home loans reduced demand for housing, this should be reflected in changing home prices. This paper estimates the impact of the tax reform using a repeat sales model which looks at how a residential property's price changes between two sales. Theory and empirical evidence suggests that anticipated (but not unanticipated) future costs, such as property taxes, should be priced into a property at the time of a sale. If an unanticipated change is announced, this should be reflected in the price of the property for all sales after the announcement but not prior to the announcement. This paper uses homes that are sold repeatedly during the sample period in order to account potential changes in the unobserved characteristics of sold homes around the time of the passage of the TCJA (either as a direct result of the Tax Cuts and Jobs Act or due to a continuation of a preexisting trend). The real estate properties considered in this study are the universe of all residential home sales in New Jersey between 1991 and 2019. To

the extent that TCJA was an unexpected shock, there should be differential price growth rates between homes purchased by home-buyers more or less impacted by the TCJA.

This paper finds an elasticity of home prices with respect to property taxes of -0.1 post TCJA, with no relationship between property taxes and home prices prior to TCJA. The lack of relationship between property taxes and home price growth prior to the passage of TCJA is consistent with the theory that anticipated future property taxes are capitalized into current property prices. For the median home in the sample, the estimates imply that a $1,000 increase in yearly property taxes would reduce a home's price by $3,800. Given itemization behavior in New Jersey prior to the passage of the TCJA (and scaling by the change in the after-tax cost of property taxes) these results imply a roughly 70% capitalization rate of increased property tax costs into home prices. The results imply that home-buyers are responsive to changes in the after-tax cost of property taxes.

The rest of the paper proceeds as follows. Section Two discusses the effect of taxation on the housing market. Section Three discusses the specifics of the changes to the US federal tax code after the enactment of the Tax Cuts and Jobs Act. Section Four describes the details of real estate property taxation in New Jersey. Section Five describes the data. Section Six covers estimation strategy and the main empirical results. Section Seven summarizes and concludes the results of the paper.

2.2 Related Literature

The preferential treatment of homeowners relative to renters by the United States federal tax code and the impact this has on the housing market has been a topic of discussion for decades. Aaron (1970) argued that the favorable tax treatment of homeowners in the United States lead to higher housing prices and that the benefits of the tax subsidies primarily

accrued to upper income homeowners. Poterba (1984) contended that the favorable tax treatment of housing raises prices. Gyourko and Sinai (2003) demonstrated that the benefits of the deductibility of mortgage interest payments and property taxes are distributed highly unevenly throughout the United States. In 1990, New Jersey received $5,915 in net tax benefits per owner-occupied housing unit compared to the national average was $2,092 per owner-occupied housing unit. South Dakota had the lowest net tax benefit at $917 per owner-occupied housing unit, and Hawaii had the highest net benefit at $10,718 per owner-occupied housing unit. They argue that given that high-income high-tax-bracket homeowners tend to live in high-value homes with high property taxes, the deduction of property taxes and mortgage interest payments is at odds with an otherwise progressive tax code. Poterba and Sinai (2008) estimated that repealing the property tax deduction would increase the marginal user cost of housing by three percent, although they use the national average property tax rate so the impact may be expected to be much larger for high tax localities. In later work, Poterba and Sinai (2011) argued that a mortgage interest deduction cap would reduce demand for housing among high marginal income tax households but would largely have no effect for lower and middle income households.

Engelhardt et al (2010) find that tax subsidies do increase homeownership rates among low income households, however this is not a group that sees many benefits from the tax treatment of US housing under consideration in this paper. However, Gruber et al (2021) find no effect on homeownership after an enactment of more favorable mortgage treatment in Denmark, although they do find that it increases housing demand and loan to value ratios. Ling and McGill (1998) and Dunsky and Follain (2000) examine the US Tax Reform Act of 1986 and find strong (up to unit elastic) responses to the increased cost of mortgage debt. Jappelli and Pistaferri (2007) look at a tax reform that reduced a mortgage interest deduction in Italy and find no evidence of change on either the intensive or extensive margin, which they attribute to borrowing constraints and lack of knowledge about the policy change. In the United States,

Hilber and Turner (2014) argue that the mortgage interest deduction boosts homeownership rates only for higher income households in areas with elastic housing supply, Hanson (2012) finds no evidence of the mortgage deduction increasing homeownership but does find that it results in the purchase of larger homes. Using a general equilibrium framework Sommer and Sullivan (2018) estimated that eliminating the deductibility of mortgage interest payments for owner-occupied housing would lead to a reduction in home prices, a reduction in housing consumption by the wealthy, and an increase in homeownership overall.

Studies relating to the question of how to isolating the impact of property taxes on housing prices date back to Oates (1969). The central difficulty in identification in this literature relates to the fact that local public goods in the United States (particularly education) are funded through either local property or incomes taxes. As a result, it is very difficult to accurately estimate property tax capitalization using variation across municipalities, since higher property taxes will generally be correlated with a higher provision of local public goods. Palmon and Smith (1998) estimate property tax capitalization using localities which are in the same school district but have different funding schemes for other public goods, resulting in different property tax rates. They find a property tax capitalization rate of 62 percent. De Bartolome and Rosenthal (1999) include the itemization behavior of homeowners in estimating the capitalization of property taxes into housing prices. In order to correct for the simultaneity of home prices and property tax burdens, they use the structural attributes of the home from four years prior to the observed sale. They find a capitalization rate of approximately 40 percent. A number of papers have found evidence that lower taxation or increased outside funding raises house prices (such as in Ross and Yinger (1999), Sirmans et al (2008), Hilber et al (2011), Cabral and Hoxby (2012). There is also increasing evidence that the degree of capitalization is tied to the supply of housing (for instance in Lutz (2015), Hilber (2015), and Hilber and Vermeulen (2016). Elinder and Persson (2017) look at the impact of a national property tax reduction in Sweden on home

prices. They find little effect for all but the top one percent by price of homes, and for the top one percent they find a 50 percent capitalization rate. Giertz et al (2021) find 70 percent capitalization of higher property tax rates into home prices in Dallas County, Texas, and Livy (2018) finds full capitalization in Franklin County, Ohio. It is important to note that these two papers papers consider reforms in areas that have relatively elastic housing supply. Bradley (2017) estimates an intra-jurisdictional model where new homeowners experience temporary property tax savings due to inheriting the previous owners' capped assessed taxable value for the remainder of the calendar year following a sale. Bradley finds an enormous overcapitalization of 2900-3700 percent which he argues is due to a misapprehension by the new homeowners that the tax savings are permanent rather than temporary. This is an important consideration for this paper as well, since it is unclear how aware homebuyers are of the change to the federal tax code treatment of property taxes.
This paper also broadly relates to literature on transaction real estate taxes, which has shown that that real estate transaction taxes reduce the sale price of homes (such as Besley et al (2014), Kopczuk and Monroe (2015), and Best and Kleven (2018)).

The estimation method that I employ in this paper includes confining my estimates to homes which have been sold multiple times and using the growth in home price rather than the home price itself as the outcome variable. The use of repeat sales to measure the change in real estate prices started with Bailey, Muth, and Nourse (1963) with current methods attributable to Case and Shiller's seminal 1989 paper. Case and Shiller outline a method for decomposing property prices into municipality wide changes, individual changes in housing price, and noise in the price due to imperfections in the housing market. This method has been used broadly in the literature, including by Flavin and Yamashita (2002) Shapiro (2006), Glaeser et al (2008), Campbell et al (2011), Favara and Imbs (2015), and Bogin et al (2019). Harding, Rosenthal, and Sirmans (2007) provide a framework to deal with potentially endogenous explanatory variables. They estimate the impact that maintenance

expenditures have on the the growth in home prices using a repeat sales model. In order to address concerns that maintenance expenditures may be endogenous to the growth in home prices, they instrument for maintenance expenditures using time invariant characteristics of the home. Although structural attributes are an important explanatory variable for home prices, if they do not change between sales they should not be relevant in explaining how the price of the home changed.

Because homes with different property tax magnitude may be heterogeneously impacted by the TCJA and it is not obvious at which level of property taxes the difference should occur, a threshold estimation strategy is employed. In threshold estimation, an independent variable is believed to have a different impact on the dependent variable above and below some unknown level of the independent variable. In order to assess this possibility, an indicator variable for whether the independent variable is above or below a certain threshold interacted with the independent variable itself and the regression is estimated multiple times, varying only the threshold level. Generally, the threshold which minimizes the sum of squared errors is considered to be the "true" threshold, because it provides the greatest explanatory power to the data. Hansen (2017) describes estimation strategies, inference in a regression kink model with an unknown threshold, and testing for the presence of a threshold. Kourtellos, Stengos, and Tan (2014) describe estimation strategies in the presence of both an endogenous threshold variable and endogenous regressors. Their strategy, which is the primary one employed in this paper, involves a two stage least squares estimation repeated at various threshold levels and includes a Heckman correction term to account for the endogeneity of the threshold variable.

2.3 Tax Cuts and Jobs Act

The Tax Cuts and Jobs Act was signed into law on December 22nd of 2017. Features of the law which were relevant for homeowners went into effect starting in tax year 2018.

Public awareness of a major bill and its contents started several months earlier[4]. Because the average time between making an offer and closing on a home is 47 days [5], the paper assumes that only homebuyers who closed on their homes starting in January of 2018 were aware of the post-TCJA tax treatment of homeownership.

The Tax Cuts and Jobs Act slightly lowered marginal tax rates for all income levels (see Table 2.1). It also substantially increased the standard deduction, from $6,500 to $12,000 for single filers and from $13,000 to $24,000 for joint filers. A federal income tax payer can choose between taking the standard deduction and then paying federal income taxes of (2.3.1) and itemizing their deductions and paying federal income taxes of (2.3.2).

(a) Marginal Tax Rates 2017

Rate	Single	Married Filing Separately	Married Filing Jointly	Head of Household
	Taxable Income Over:			
10%	$0	$0	$0	$0
15%	$9,325	$9,325	$18,650	$13,350
25%	$37,950	$37,950	$75,900	$50,800
28%	$91,900	$76,550	$153,100	$131,200
32%	$191,650	$116,675	$233,350	$212,500
35%	$416,700	$208,350	$416,700	$416,700
39.6%	$418,400	$235,350	$470,700	$444,550

(b) Marginal Tax Rates 2018

Rate	Single	Married Filing Separately	Married Filing Jointly	Head of Household
	Taxable Income Over:			
10%	$0	$0	$0	$0
12%	$9,525	$9,525	$19,050	$13,600
22%	$38,700	$38,700	$77,400	$51,800
24%	$82,500	$82,500	$165,000	$82,500
32%	$157,500	$157,500	$315,000	$157,500
35%	$200,000	$200,000	$400,000	$200,000
37%	$500,000	$300,000	$600,000	$500,000

Table 2.1: Marginal Tax Rates Before and After TCJA

$$\sum_{j=1}^{n} \tau_{f_j} \cdot \min\left[Y_{f_j,\max}, Y - \text{Std. Ded.}\right] \cdot \mathbb{1}[Y - \text{Std. Ded.} > Y_{f_{j-1},\max}] \tag{2.3.1}$$

$$\sum_{j=1}^{n} \tau_{f_j} \cdot \min\left[Y_{f_j,\max}, Y - \sum_{l=1}^{L} \text{Itemized Ded.}_l\right] \cdot \mathbb{1}[Y - \sum_{l=1}^{L} \text{Itemized Ded.}_l > Y_{f_{j-1},\max}] \tag{2.3.2}$$

Where τ_{f_j} is the jth marginal tax rate (ordered by the income tax schedule from lowest to highest relevant income threshold), $Y_{f_j,\max}$ is the last dollar of income that is taxed at the τ_{f_j} level, Y is the tax payer's income, Std. Ded. is the standard deduction, and

[4]See Appendix Figure A.1 for Google Trends indices in the second half of 2017

[5]According to EllieMae, a mortgage application processor

$\sum_{l=1}^{L}$ Itemized Ded$_l$ is the sum of allowed deductions. By increasing the standard deduction the TCJA reduced the incentives to itemize deductions, as any taxpayer for whom $\sum_{l=1}^{L}$ Itemized Ded.$_l$ > Std. Ded. should optimally choose to take the standard deduction (ignoring the additional time cost of itemizing or the potential concerns about increased audit risk).

There is an additional caveat, which is that if an itemizing taxpayer ends up with a computed taxable income under equation (2.3.2) which is too low conditional on their income, then they will be subject to the Alternative Minimum Tax. Relative to the ordinary income tax schedule, Alternative Minimum Tax (AMT) provides taxpayers with lower marginal tax rates and an exemption but restricts deductions (including not allowing state and local tax deductions). Table B.4 shows the Alternative Minimum Tax Schedule in 2017 and 2018.

The Tax Cuts and Jobs Act also reduced the generally tax preferred treatment of homeownership in the US federal tax code. Prior to the passage of the TCJA, a taxpayer could deduct all state and local taxes paid from their federal taxable income. This included state and local income taxes, state and local real estate taxes (including for non-primary residence homes) and any personal property taxes. Taxpayers could also choose to deduct all state and local sales taxes that they had paid, but only if they did not also deduct state and local income taxes (almost all itemizing taxpayers chose to deduct state and local income taxes instead of sale taxes). Following the passage of the TCJA, taxpayers could only deduct a total of $10,000 in state and local taxes. Additionally, the TCJA reduced the generosity of the mortgage interest deduction allowance. Previously, homeowners could deduct any interest they had paid on their first $1,000,000 of mortgage interest debt, but after the passage of the TCJA this was limited to the first $750,000 of mortgage interest debt for homes which were purchased in 2018 and later (interest on mortgage debt for non primary residences could also be applied to this total).

After the passage of the TCJA, the fraction of the New Jersey population which itemized their federal income tax returns fell sharply as evidenced in Table 2.2. Prior to the passage of the TCJA, 86% of filers with incomes between $100,000 and $200,000 itemized their deduction, after the passage this was reduced to 31%. Similar declines were observed across all income levels.

Table 2.2: Tax Filing Status in New Jersey

	Income Range (In Thousands)				
	$50- $75	$75 - $100	$100 - $200	$200 - $500	$500 - $1,000
2016					
Number of Returns	587,690	398,770	700,750	270,290	42,280
Fraction Joint	32%	52%	76%	88%	89%
Itemized Deductions	47%	65%	86%	98%	98%
2018					
Number of Returns	607,790	416,100	754,470	315,040	49,700
Fraction Joint	29%	49%	73%	87%	89%
Itemized Deductions	17%	24%	31%	48%	65%

Source: IRS Statistics of Income

Additionally, of those tax payers who still chose to itemize, a large fraction were unable to fully deduct their state and local taxes due to the $10,000 cap. In 2016, the mean state and local tax deduction for those with incomes between $100,000 and $200,000 was $14,800, and so unsurprisingly in 2018 93% of taxpayers in that same income range who itemized were unable to fully deduct their state and local taxes (see Table 2.3). Average total deductions are higher in 2018 than in 2016, which is consistent with an increase in the threshold at which it becomes optimal to itemize rather than take the standard deduction.

These less generous deductibility provisions (and more generous standard deductions) would raise the after tax cost of homeownership for a large fraction of potential home-buyers in New Jersey. If these home buyers are aware and responsive to this change it may be reflected in the fall in home prices of homes which carry relatively high property tax burdens.

Table 2.3: Tax Deductions in New Jersey

	Income Range (In Thousands)				
Mean Deductions	$50- $75	$75 - $100	$100 - $200	$200 - $500	$500 - $1,000
2016					
Total Deductions	$19,400	$22,200	$28,200	$47,100	$93,300
State Income Tax	$1,900	$3,100	$6,200	$17,200	$52,000
Property Tax	$ 5,800	$6,800	$8,600	$12,500	$19,800
Interest on Mortgage	$ 4,200	$5,200	$7,000	$9,800	$13,300
2018					
Total Deductions	$23,200	$24,700	$29,000	$36,000	$51,700
State Income Tax	$2,000	$3,200	$6,300	$17,000	$48,200
Property Tax	$6,800	$7,600	$9,300	$13,400	$19,000
Interest on Mortgage	$6,100	$7,200	$10,200	$14,900	$18,000
SALT Deducted	$7,400	$8,400	$ 9,200	$9,600	$9,700

Source: IRS Statistics of Income
Rounded to nearest hundred dollars

Table 2.4 shows a how a number of hypothetical returns would differ between 2017 and 2018. Property taxes and mortgage interest were chosen on the basis observed property taxes and mortgage interest payments in the IRS Statistics of Income data for New Jersey. Federal income taxes and state income taxes were calculated using the NBER TAXSIM program, as was optimal deduction behavior. In the pre-TCJA period, all households find it optimal to itemize their returns. In the post-TCJA period, only the households filing single returns find it optimal to itemize. Even the household which files jointly and makes $250,000 while paying $23,100 in SALT and $13,000 in mortgage interest would find it optimal to take the standard deduction, because only the first $10,000 of SALT is deductible. Of course, this is a simple example which does not include other potential deductions, but given that the sum of SALT and mortgage interest payments comprised 75% of all deductions in New Jersey in 2016 (and this fraction was even higher for high income households) it is instructive to consider the difference in outcomes even with only these deductions. Additionally, all households in this hypothetical ultimately pay less in federal income tax in 2018 than they did in 2017, so even though homeownership is less subsidized in the post-TCJA world, households are overall better off. This means that if housing and local public goods are normal goods, then any reduction in their consumption post-TCJA would be due to the substitution effect, and the

Table 2.4: Hypothetical New Jersey Tax Returns Pre and Post TCJA

	Income					
	$100,000	$100,000	$150,000	$150,000	$250,000	$250,000
Return Type	Single	Joint	Single	Joint	Single	Joint
Property Taxes	$8,000	$8,000	$9,000	$9,000	$12,000	$12,000
State Income Taxes	$3,700	$2,200	$6,800	$4,900	$14,000	$11,100
Mortgage Interest	$7,000	$7,000	$10,000	$10,000	$13,000	$13,000
2017						
Optimal Deduction Behavior	Itemize	Itemize	Itemize	Itemize	Itemize	Itemize
Total Taxable Income	$77,000	$75,000	$120,200	$118,000	$208,000	$205,800
Federal Income Tax (Excluding FICA)	$15,000	$10,300	$ 26,600	$21,000	$52,000	$44,500
2018						
Optimal Deduction Behavior	Itemize	Std. Ded.	Itemize	Std. Ded.	Itemize	Std. Ded
Excess SALT	$1,700	NA	$5,800	NA	$16,000	NA
Total Taxable Income	$83,000	$76,000	$130,000	$126,000	$227,000	$226,000
Total Federal Income Tax (Excluding FICA)	$14,200	$8,700	$25,500	$20,000	$55,000	$42,800

Source: NBER TAXSIM

observed change would be partially attenuated by the positive income effects of higher net of tax earnings.

2.4 New Jersey Property Taxes

In New Jersey, taxes on real estate are levied only by municipalities, and represent a significant sources of revenue for municipalities. Municipalities in New Jersey received an average of 52% of their revenue from property taxes, compared to an average of 28% for municipalities in other states [6].

Homes are taxed based on their assessed value as of October of the previous year, with some municipalities requiring quarterly tax payments and others biannual. Unlike in some states, the value on which homes can be taxed is not capped at the value at the time of purchase, so homes are taxed on the full current value of their home. Homes are regularly

[6] According to the New Jersey State League of Municipalities

reassessed, with some municipalities reassessing all homes every year and all municipalities reassessing all homes at least every five years. As a result, the assessed value of a home does not change dramatically immediately after it is purchased. In the property tax data, the median reassessed home increased in assessed value by $6,800 if the home had not been sold in the last year, and $10,000 if it had been sold in the last year at fair market price [7].

2.5 Data

All of the data used in this paper is publicly available data obtained from the New Jersey Department of the Treasury, the individual counties of New Jersey, and the Home Mortgage Disclosure Act. Yearly property tax records from 2012 to 2020 for all residential homes were obtained from the New Jersey Department of the Treasury. These yearly records include information on the location of the property, the value of the assessed property, the amount of property tax levied, any deductions or exemptions for the property, the total acreage of the property, as well as information on the name and address of the property owner, the most recent sale date, and the most recent sale price. Deed records for all deeds between 2009 and 2019 are also obtained from the New Jersey Department of the Treasury. These are supplemented with additional deeds from the individual counties to expand the deed data to all deeds between 1991 and 2019. These deeds include information on the location of the property, the square footage of the building, the deed date, the sale price, whether the sale was between related parties, whether the assessor considered the sale to be at fair market price, whether the property is a condominium, the year in which the home was built, as well as the names and addresses of both the seller and the buyer. Because all properties are assigned a unique location identifier it is possible to link a deed with all other deeds associated with the same property in the sample period. This same identifier is used in the property tax data, so deeds are also linked to their property tax record.

[7] Fair market price as determined by the assessor

Properties that were purchased between 2014 and 2019 and also were previous purchased a previous time since 1991 are included in the repeat sale model study. Previous sales must have both been at fair market prices and not between related parties, which leaves approximately 35% of deeds. Additionally, because of concerns about significant renovations between sales, only those properties which have the same square footage listed on both deeds are included. This does not account for renovations which do not involve home additions, but at least prevents properties which experienced substantial changes between sales from being included in the sample. Homes which were previously sold three or fewer years ago are not included in order to avoid homes which were "flipped" (that is, purchased and then quickly resold, either after significant renovation or because the home was previously purchased at below market rates).

A publicly available walkability index from the EPA is also used to identify the extent to which a home is in an urban location. The National Walkability Index calculates for each Census group how easily residents can reach public transportation services, the mix of residential and business property in the block (including types of businesses), and the number of street intersections (more street intersections indicating a more walkable area).

2.6 Empirical Strategy and Estimation of Repeat Sales Model

Following the repeat sales price index literature, suppose that the price of house i in municipality m sold at time t is

$$P_{i,t} = e^{\gamma_{m,t}} \cdot f(X_{i,t}, \beta_t) \cdot age_{i,t}^{\alpha} \cdot \left(\sum_{s=t}^{T} \delta^{s-t} \cdot g_t(\tau_{m,s} \cdot ATV_{i,s}) \right)^{\mu} \cdot e^{\varepsilon_{i,t}} \tag{2.6.1}$$

Where $e_{m,t}^{\gamma}$ is the component of price due to market conditions in municipality m at time t, $f(X_{i,t}, \beta_t)$ is the component of price due to structural characteristics of the home, $X_{i,t}$,

and their shadow prices, β_t, $age_{i,t}$ is the age of home i at time t, $\tau_{m,s}$ is the property tax rate in municipality m at time s, $ATV_{i,s}$ is the assessed taxable value of home i at time s, $\sum_{s=t}^{T} \delta^{s-t} g_t(\tau_{m,s} \cdot ATV_{i,m,s})$ is the present value of the after-tax stream of property tax bills, T is the time horizon over which the home will continue to be habitable, μ is the capitalization of property tax bills into housing prices, δ is the discount rate, and $e^{\varepsilon_{i,t}}$ is the error term.

The function $g_t(\cdot)$ is allowed to vary by time of purchase to account for the fact that different tax regimes or beliefs about the future at the time of purchase will lead to different expectations of the future after-tax property tax burden. Because housing is a durable good, a potential home-buyer will take into consideration the home's resale value when determining the appropriate price for a home. That resale value will depend on the future benefits and costs of homeownership. An unanticipated change in the tax treatment of housing will change $g_t(\cdot)$ which will in turn affect the price of a home.

Following the literature (and supported by the observed property characteristics), this paper assumes that homes' structural characteristics and home buyers' marginal willingness to pay for them are time invariant:

$$f(X_{i,t}, \beta_t) = f(X_i, \beta) \tag{2.6.2}$$

This assumption would be violated (in the case of a particular home) if a home were to undergo unobserved major renovations or (in the case of the housing market generally) if home buyers' preferences were to change over time. Figures 2.1 and 2.2 provides some evidence to address the concerns that homebuyer tastes in home size are changing over time, which would the price of differently sized homes to grow at different rates. Figure 2.1 gives the distinct price indices for single family homes between one to five bedrooms in New Jersey

from 1996 and 2021. It appears to be the case that the price of homes with different numbers of bedrooms grew at roughly the same rate. To further demonstrate this, using the same underlying data, figure 2.2 shows the monthly percent change (using a 12 month rolling average) in the price indices. It is clear from the figure that the price indices changed in tandem with one another. While number of bedrooms is distinct from square footage, there is a strong positive correlation between the two, so it reasonable to extrapolate that homebuyer taste for square footage do not appear to be changing over the observed time period. These figures suggest that the underlying assumption of equation 2.6.2 is reasonable, at least when it comes to home size, which is necessary for this paper as square footage is used as an instrumental variable.

Figure 2.1: Zillow Monthly Home Value Index In New Jersey

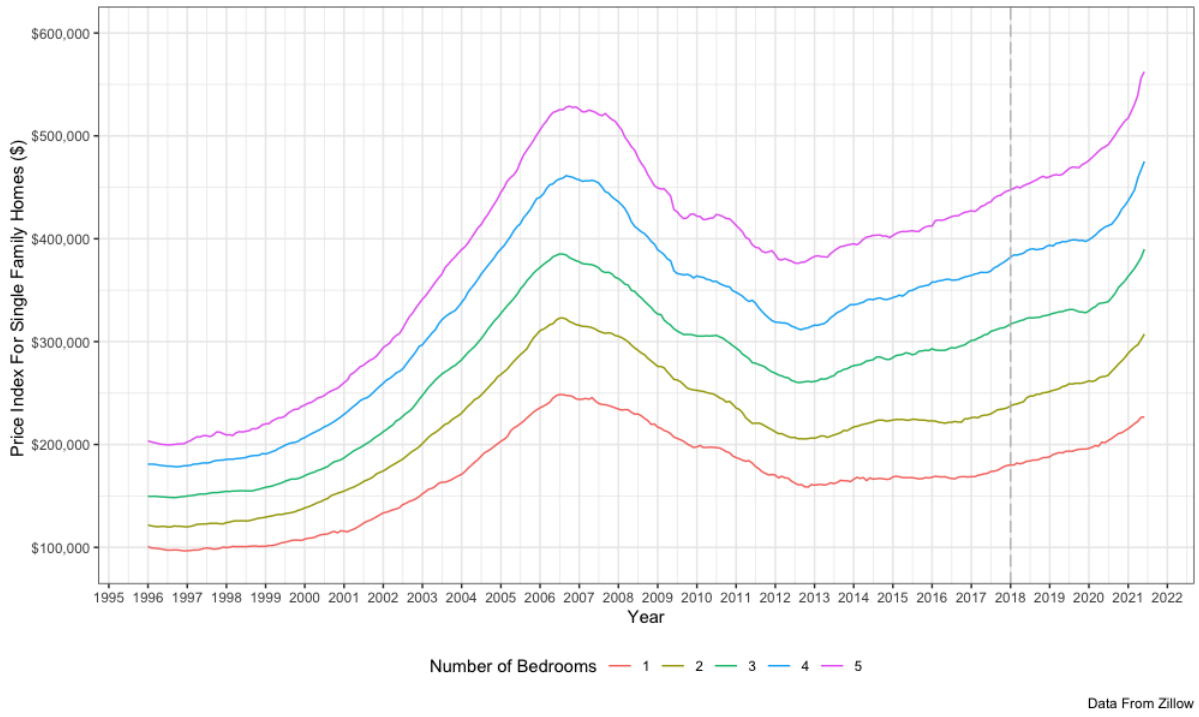
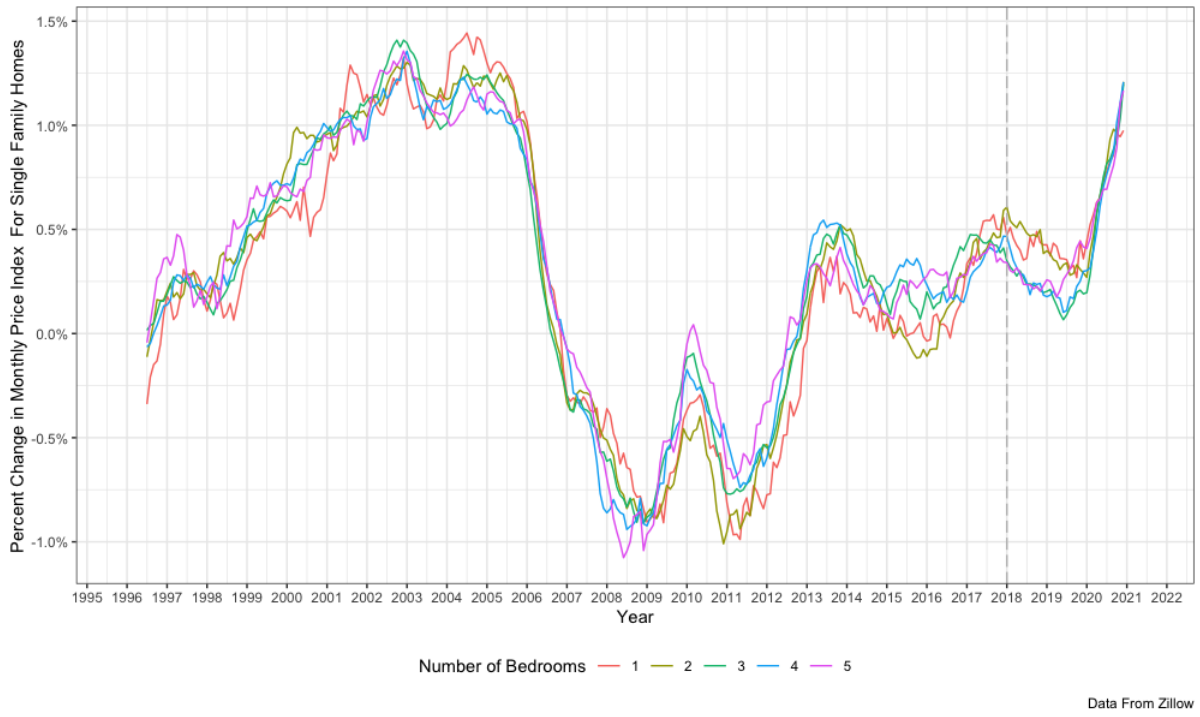


Figure 2.2: Zillow Change in Monthly Home Value Index In New Jersey



Data points are twelve month rolling averages

Suppose a home is sold in two distinct time periods, t and $t+u$. Then the price functions would be:

$$P_{i,t} = e^{\gamma_{m,t}} \cdot f(X_i, \beta) \cdot age_{i,t}^{\alpha} \cdot \left(\sum_{s=t}^{T} \delta^{s-t} \cdot g_t(\tau_{m,s} \cdot ATV_{i,s}) \right)^{\mu} \cdot e^{\varepsilon_{i,t}} \tag{2.6.3}$$

$$P_{i,t+u} = e^{\gamma_{m,tu}} \cdot f(X_i, \beta) \cdot age_{i,t+u}^{\alpha} \cdot \left(\sum_{s=t+u}^{T} \delta^{s-t} g_{t+u}(\tau_{m,s} \cdot ATV_{i,s}) \right)^{\mu} \cdot e^{\varepsilon_{i,t+u}} \tag{2.6.4}$$

Dividing equation (2.6.3) by equation (2.6.4) and rearranging:

$$\frac{P_{i,t+u}}{P_{it}} = e^{\gamma_{m,t+u} - \gamma_{m,t}} \cdot \left(\frac{age_{i,t+u}}{age_{i,t}} \right)^{\alpha} \cdot \left(\frac{\sum_{s=t+u}^{T} \delta^{s-t-u} g_{t+u}(\tau_{m,s} \cdot ATV_{i,s})}{\sum_{s=t}^{T} \delta^{s-t} g_t(\tau_{m,s} \cdot ATV_{i,s})} \right)^{\mu} \cdot e^{\varepsilon_{i,t+u} - \varepsilon_{i,t}} \tag{2.6.5}$$

Taking logs:

$$\begin{aligned} &\log(P_{i,t+u}) - \log(P_{i,t}) = (\gamma_{m,t+u} - \gamma_{m,t}) + \alpha(\log(age_{i,t+u}) - \log(age_{i,t})) \\ &+ \mu \left(\log(\sum_{s=t+u}^{T} \delta^{s-t-u} g_{t+u}(\tau_{m,s} \cdot ATV_{i,s})) - log(\sum_{s=t}^{T} \delta^{s-t} g_t(\tau_{m,s} \cdot ATV_{i,s})) \right) + (\varepsilon_{i,t+u} - \varepsilon_{i,t}) \end{aligned} \tag{2.6.6}$$

The impact of the property tax on the change in home prices between sales is made up of two components. The first is the difference between the current discounted value of future property taxes and the discounted value of future property taxes at the time of the previous home sale. The second is the property taxes that were incurred by the previous homeowner and were therefore relevant for their valuation of the home when they purchased it but which are not relevant for the new homeowner. If $g_t(\cdot) = g_{t+u}(\cdot)$ then the impact of the property tax on on the change in home prices would reflect the fact that because the previous homeowner purchased the home in an earlier time period the previous homeowner

discounted any overlapping property tax bills at higher rate than the current homeowner. Because of inherent difficulties in estimating either the discount rate or beliefs about future property tax bill sizes, the property tax terms are substituted for the property tax bill in the year after sale.

$$\begin{aligned}\log(P_{i,t+u}) - \log(P_{i,t}) =&(\gamma_{m,t+u} - \gamma_{m,t}) + \alpha(\log(age_{i,t+u}) - \log(age_{i,t}))+ \\ &\mu \cdot \log(\tau_{m,t+u} \cdot ATV_{i,t+u}) + (\varepsilon_{i,t+u} - \varepsilon_{i,t})\end{aligned} \tag{2.6.7}$$

Additionally, because homes with lower property tax bills may not be impacted by the TCJA in the same way as homes with higher property tax bills, μ is allowed to take on different values below and above some unspecified threshold.

$$\begin{aligned}\log(P_{i,t+u}) - \log(P_{i,t}) =&(\gamma_{m,t+u} - \gamma_{m,t}) + \alpha(\log(age_{i,t+u}) - \log(age_{i,t}))+ \\ &\mu_1 \cdot \log(\tau_{m,t+u} \cdot ATV_{i,t+u}))\mathbb{1}[\log(\tau_{m,t+u} \cdot ATV_{i,t+u})) <= \gamma]+ \\ &\mu_2 \cdot \log(\tau_{m,t+u} \cdot ATV_{i,t+u}))\mathbb{1}[\log(\tau_{m,t+u} \cdot ATV_{i,t+u})) > \gamma]+ \\ &(\varepsilon_{i,t+u} - \varepsilon_{i,t})\end{aligned} \tag{2.6.8}$$

Where γ is the property tax threshold.

Equation (2.6.8) is estimated using a two stage least square estimators, with the logarithm of property tax variables instrumented by a the logarithm of square footage, an inverse hyperbolic sine transformation of the acreage, and a walk-ability score. All of these instruments do not change between sales so should have no impact on the growth in home price. The inverse hyperbolic sine transformation is used instead of a log transformation because it has similar features to a logarithmic transformation but with the advantage that it transforms observations with a value of 0 to 0. Most condominiums have no private acreage (because in many cases, all outdoor space is owned jointly by the condominium owners). The μ variables are allowed to vary by year, on the assumption that the impact of property taxes

on home prices should be different before and after the TCJA. In addition to the variables indicated above, indicators for the condo status of the property, whether or not the property was subject to a realty transfer tax (a 1% New Jersey tax on all property sales where the property price exceeds $1,000,000), the deed month of the most recent sale fixed effects, the deed month of the prior sale fixed effects, locality (either county or municipality, depending on the specification) by deed year fixed effects, and fixed effects for the previous deed year by county.

Because the property tax bill size in an endogenous variable, the indicator variable for whether or not the property tax bill is above or below a threshold will also be endogenous. Following Kourtellos, Stengos, and Tan (2014), the following correction term is included in (2.6.8):

$$\Lambda(\gamma, \widehat{\text{Prop. Tax}}, \text{Prop. Tax}) = \\ -\frac{\phi(\gamma - \widehat{\text{Prop. Tax}})}{\Phi(\gamma - \widehat{\text{Prop. Tax}})} \cdot \mathbb{1}(\text{Prop. Tax} < \gamma) + \frac{\phi(\gamma - \widehat{\text{Prop. Tax}})}{1 - \Phi(\gamma - \widehat{\text{Prop. Tax}})} \cdot \mathbb{1}(\text{Prop. Tax} \geq \gamma) \tag{2.6.9}$$

Where $\phi()$ and $\Phi()$ are the normal distribution's probability distribution function and cumulative distribution function, respectively.

The the estimated equation is

$$\log(P_{i,t+u}) - \log(P_{i,t}) = \alpha_1 + \mu_{1t} \cdot (\tau_{m,t+u} \cdot ATV_{i,t+u}) \cdot \mathbb{1}[\tau_{m,t+u} \cdot ATV_{i,t+u} <= \gamma] + \\ \mu_{2t} \cdot (\tau_{m,t+u} \cdot ATV_{i,t+u}) \cdot \mathbb{1}[\tau_{m,t+u} \cdot ATV_{i,t+u} > \gamma] + \Lambda(\gamma, \widehat{\text{Prop. Tax}}_{t+u}, \text{Prop. Tax}) + \\ \delta_{1,t}\mathbb{1}\left[\text{Condo Status}_{t+u}\right] + \delta_{2,t}\mathbb{1}\left[(\text{Realty Transfer Tax} \cdot \text{Prev Realty Transfer Tax})_{t+u}\right] + \\ \text{Deed Year}_{l,t+u} + \text{Yrs Since Sold}_{c,k} + \text{Prev Deed Year}_{c,t} + \text{Year Built}_{t+u} + \text{Deed Month}_{p,t+u} + \\ \text{Prev Deed Month}_{p,t} + \text{Locality}_{l} \tag{2.6.10}$$

Subscripts $t+u$ and t indicate effects which are allowed to vary by the current deed year and the previous deed year, respectively. Subscripts c indicate effects which are allowed to vary by county. Subscripts l indicate effects which are allowed to vary by either county or municipality, depending the specification.

Equation (2.6.10) is estimated for all property tax threshold levels γ between \$1,000 and \$20,000 which are multiples of \$500.

There may be concern that houses which are sold repeatedly over the sample period are different from houses which are sold once. Below are tables of summary statistics by year for houses which are sold once between 2016 and 2019 and also one other time since 1991 and houses which are sold once between 2016 and 2019 and at no other time since 1991.

Homes which are sold repeatedly do appear to be approximately 10% smaller than homes which are not sold repeatedly. The are also slightly more expensive and approximately the same age. Despite being slightly more expensive, they also appear to generate less property taxes than homes which are only sold once. This may indicate that homes in high tax communities sell less frequently, perhaps indicating that high tax localities attract longer term residents. To the extent that repeat sale homes are different than non repeat sale homes, it is encouraging that the ways in which they differ is consistent across years.

Table 2.5: Summary Statistics 2016 Home Sales

	Sale Price	Square Footage	Year Built	Acreage	Prop. Taxes Year After Sale
Repeat					
Mean	$418,500	1743	1963	9.7	$8,875
Median	$354,000	1583	1966	0.16	$7,997
Standard Deviation	$297,000	802	32	364	$4,655
N	6,309				
Non-Repeat					
Mean	$400,536	1937	1963	12.5	$9,456
Median	$335,000	1768	1965	0.19	$8,498
Standard Deviation	$306,362	870	32	620	$5,247
N	19,449				

Table 2.6: Summary Statistics 2017 Home Sales

	Sale Price	Square Footage	Year Built	Acreage	Prop. Taxes Year After Sale
Repeat					
Mean	$414,000	1720	1963	12.3	$8,843
Median	$355,000	1566	1967	.15	$7,987
Standard Deviation	$266,500	787	32	591	$4,518
N	7,495				
Non-Repeat					
Mean	$380,000	1901	1963	14.5	$9,232
Median	$320,000	1729	1965	.19	$8,321
Standard Deviation	$284,300	896	31	874	$5,028
N	21,821				

Table 2.7: Summary Statistics 2018 Home Sales

	Sale Price	Square Footage	Year Built	Acreage	Prop. Taxes Year After Sale
Repeat					
Mean	$415,000	1707	1964	25.4	$8,758
Median	$350,000	1544	1969	0.15	$7,859
Standard Deviation	$287,000	805	31	1038	$4,834
N	9,872				
Non-Repeat					
Mean	$399,000	1920	1963	17.6	$9,393
Median	$335,000	1731	1965	.19	$8,384
Standard Deviation	$308,000	913	32	1023	$5,331
N	26,093				

Table 2.8: Summary Statistics 2019 Home Sales

	Sale Price	Square Footage	Year Built	Acreage	Prop. Taxes Year After Sale
Repeat					
Mean	$403,000	1729	1965	10.5	$8,708
Median	$340,000	1556	1971	0.16	$7,826
Standard Deviation	$286,000	837	31	651	$4,894
N	11,150				
Non-Repeat					
Mean	$392,500	1905	1964	18.9	$9,270
Median	$330,000	1723	1966	0.18	$8,273
Standard Deviation	291,600	910	33	1107	$5,344
N	29,029				

Results for the threshold estimations are included below. Figure B.1 shows results using county level fixed effects and Figure 2.3 shows results using municipality level fixed effects, both with 95% confidence intervals for the 2019 estimates. Figures B.2 and 2.4 show the threshold estimations with 2018 95% confidence intervals. Figures B.5 and 2.5 show the threshold estimations with 2017 95% confidence intervals. Figure 2.6 shows the sum of square errors at various thresholds for both county and fixed effects.

It is clear in Figure B.1 and Figure 2.3 that estimates for the impact of property taxes on housing price growth are more negative in 2018 and 2019 (after the passage of the TCJA) than in 2016 and 2017. Additionally, the estimates for 2018 and 2019 tend to move in tandem, as do the estimates for 2016 and 2017, which provides supportive evidence for a structural change starting in 2018. Coefficients for 2018 and 2019 appear to be more negative when using municipality fixed effects than when using county fixed effects, suggesting that there are larger intra-municipality effects than inter-municipality effects. That is, more of the change is occurring due to home-buyers purchasing properties which carry lower property tax burdens within a municipality rather than opting for municipalities which have lower property tax rates.

As would be expected, the municipality fixed effects generally has lower sum of squared errors than the county fixed effects model, since a municipality comprises a local market for homes and thus average conditions in the municipality provide a substantial amount of explanatory power in home price growth.

The sum of squared errors is minimized at $\gamma = \$3,500$ for the county fixed effects model, and at $\gamma = \$5,500$ for the municipality fixed effects model. However, because this sum of squared errors is not separately estimated the pre- and post- TCJA era, it is difficult to draw conclusive evidence based on this result.

Table 2.9 show the point estimates at various γ levels for all years. Results for 2018 and 2019 are most negative (and most significant) at $\gamma = \$5,000$ and $\gamma = \$20,000$. This suggests that the most impacted properties may be where the average purchasers are likely to no longer be itemizers and properties where the average purchaser vastly exceeds the $10,000 SALT cap. Additionally, although results are statistically significant for some of the 2018 and 2019 results, they are never statistically significant for the 2017 and 2016 results (as can also be observed for 2017 in 2.5). This is driven by point estimates for 2016 ad 2017 which are closer to 0 (rather than by larger standard errors), suggesting that property taxes depressed property values more after the implementation of the TCJA than they did before. Additionally, estimates do not appear to be systematically decreasing over time, so this does not appear to be a continuation of a pre-existing trend. The fact that estimates are more negative for homes purchased in 2019 than those purchased in 2018 may be evidence that home-buyers became more aware of the change in the tax law over time.

Table 2.9: Repeat Homes Sales 2016-2019 : Property Taxes Above Threshold

$\gamma = \$5,000$ or $\gamma = \$10,000$

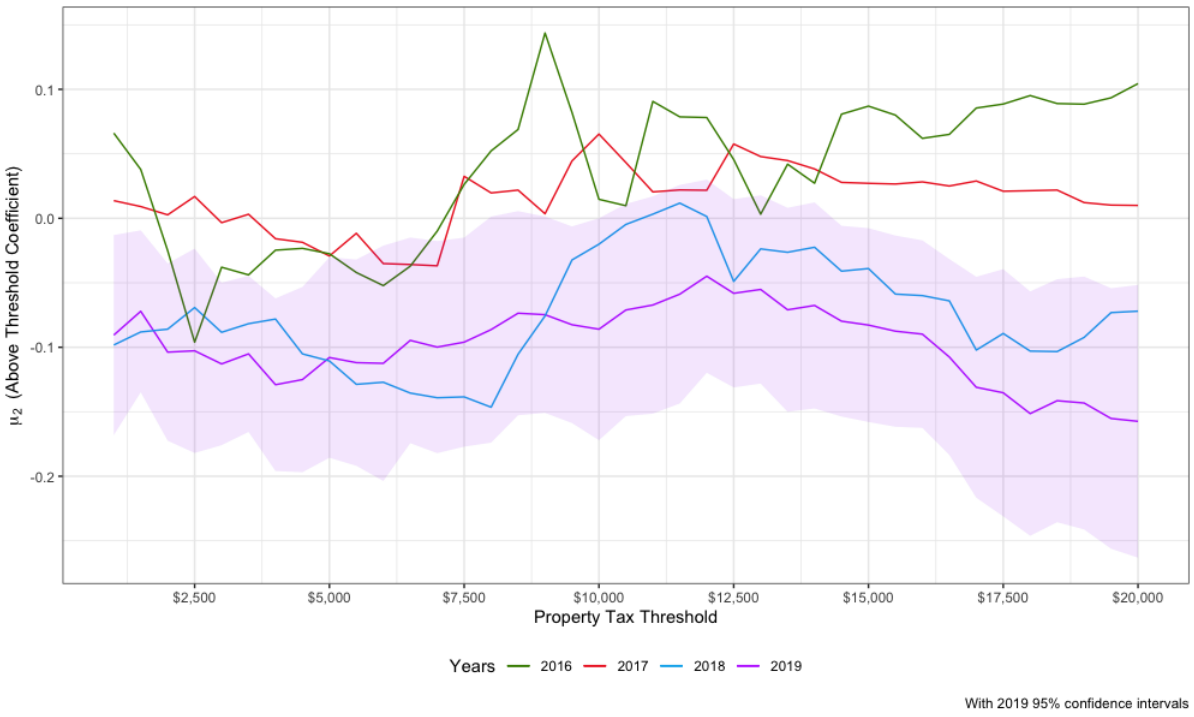
	Δ log(price) Municipality F.E.	Δ log(price) County F.E.	Δ log(price) Municipality F.E.	Δ log(price) County F.E.
	$\gamma = \$5,000$		$\gamma = \$10,000$	
2019	-0.108**	-0.158***	-0.086*	-0.044
	(0.040)	(0.039)	(0.044)	(0.043)
2018	-0.111**	-0.147 **	-0.020	0.003
	(0.042)	(0.042)	(0.066)	(0.062)
2017	-0.029	-0.023	0.065	0.010
	(0.044)	(0.050)	(0.054)	(0.070)
2016	-0.027	0.002	0.0147	0.0004
	(0.049)	(0.054)	(0.116)	(0.088)
Observations: 34,609				
	Δ log(price) Municipality F.E.	Δ log(price) County F.E.	Δ log(price) Municipality F.E.	Δ log(price) County F.E.
	$\gamma = \$15,000$		$\gamma = \$20,000$	
2019	-0.083*	-0.043	-0.157**	-0.093**
	(0.038)	(0.028)	(0.054)	(0.0347)
2018	-0.039	-0.014	-0.072	-0.073
	(0.055)	(0.043)	(0.075)	(0.048)
2017	0.027	0.003	0.010	0.004
	(0.036)	0.032)	(0.047)	(0.036)
2016	0.087	0.031	0.104	0.038
	(0.070)	(0.050)	(0.079)	(0.051)
Observations: 34,609				

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Standard errors clustered at the municipal level

Figure 2.3: Threshold Estimation μ_{2t} Coefficients With Municipality Fixed Effects

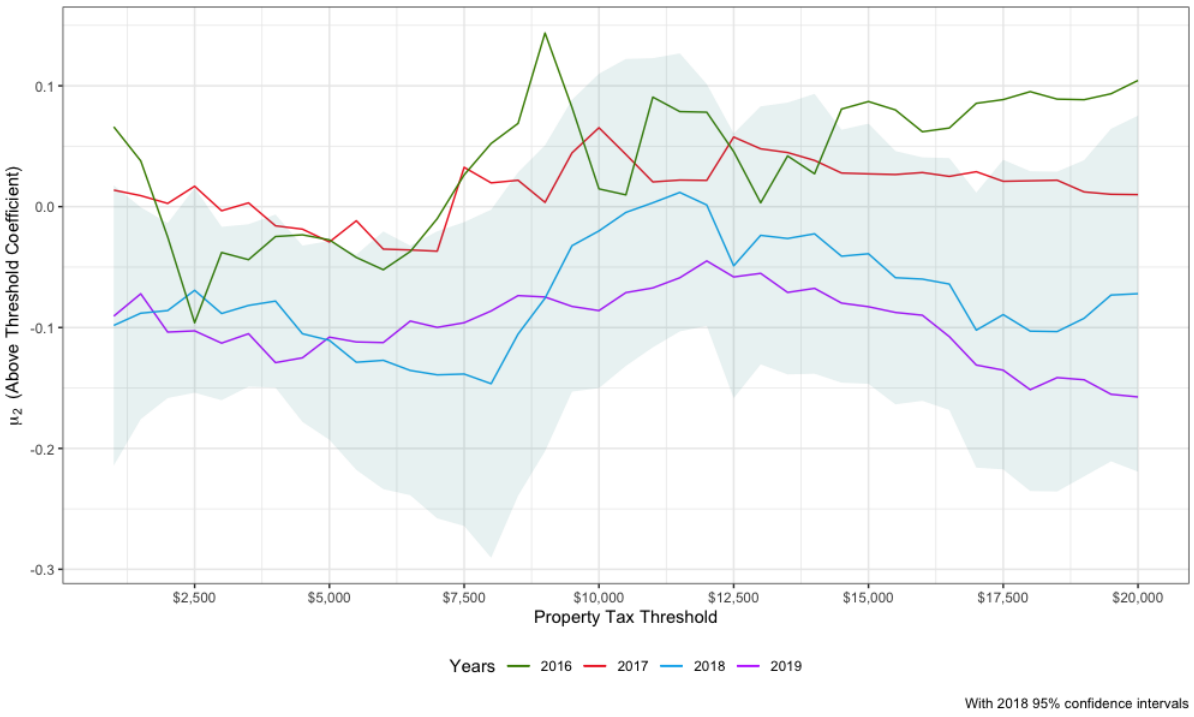


2.7 Capitalization Estimate

The American Community Survey estimates that in 2017 New Jersey had a total of 3,199,111 occupied housing units (with a margin of error of 7,594), of which 2,052,073 were owner-occupied (with a margin of error of 7,594)[8]. For tax year 2017, the IRS Statistics of Income reports that there were 1,596,170 New Jersey tax filers that claimed a deduction on real estate taxes. These deduction claims would not be coming from individuals who own housing units that generate rental income and in which they do not reside, since landlords report all income and expenses (including real estate taxes) using the IRS Schedule E Form (Supplemental Income and Loss) and then add the remainder to their reported income. Taking the ratio of the number of filers claiming a real estate deduction to the number of owner-occupied houses, this suggests that in 2017, 78% of New Jersey homeowners itemized their real estate expenses. This estimate may be a lower bound, since an owner-occupied

[8]These includes only homes that are currently occupied and will be for at least two months, therefore these estimates should not include non-primary residences

Figure 2.4: Threshold Estimation μ_{2t} Coefficients With Municipality Fixed Effects



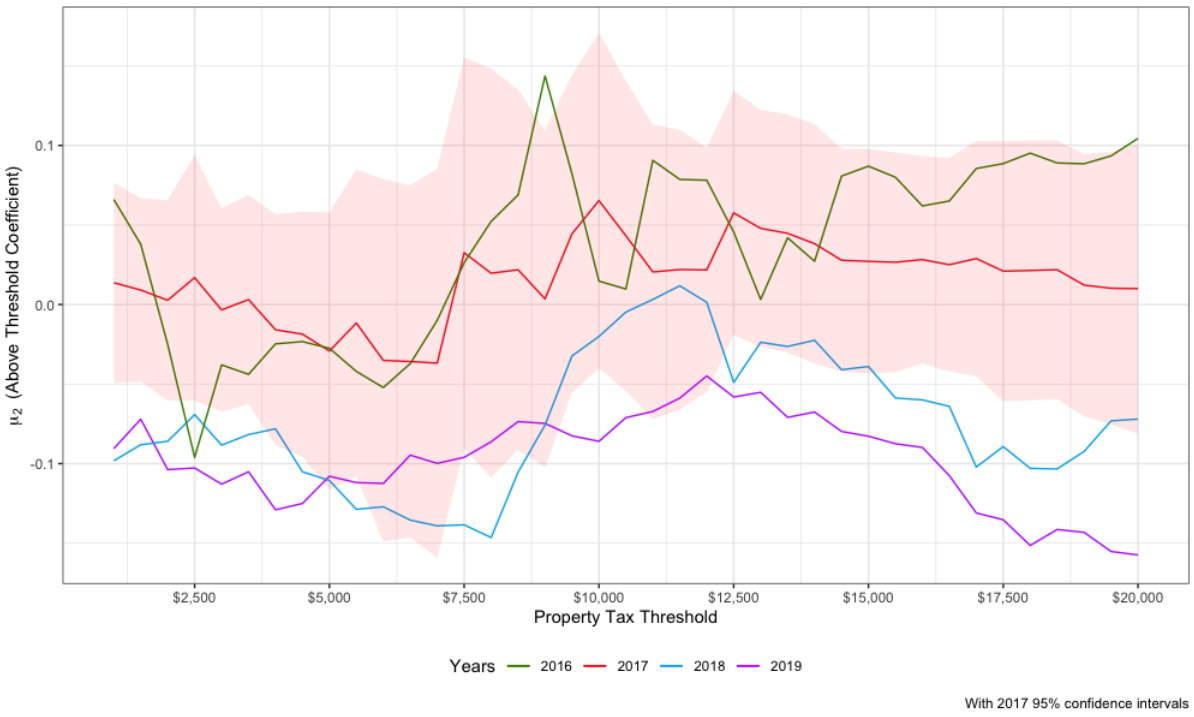
household with multiple filers may have only one filer claim the real estate tax deduction.

The overall percent increase in the after-tax cost of property taxes in New Jersey after the passage of the TCJA can be written as:

$$\text{Pct. } \Delta \text{ After Tax Cost of Prop. Tax} = \frac{\sum_{i=1}^{n} \tau_i \times \text{Total Prop. Tax}_i}{\text{Total Property Tax Paid}} - \frac{\sum_{j=1}^{m} \tau_j \times \text{Total Prop. Tax}_j}{\text{Total Property Tax Paid}} \quad (2.7.1)$$

Where the first summation gives the total property tax deductions under the pre-TCJA tax system and the second summation gives the total property tax deductions under the post-TCJA tax system. n and m represent the total number of distinct income tax rates under the pre and post TCJA tax system, respectively, i represents subscripts for the pre-TCJA tax regime, j represents subscripts for the post-TCJA tax regime. τ is the

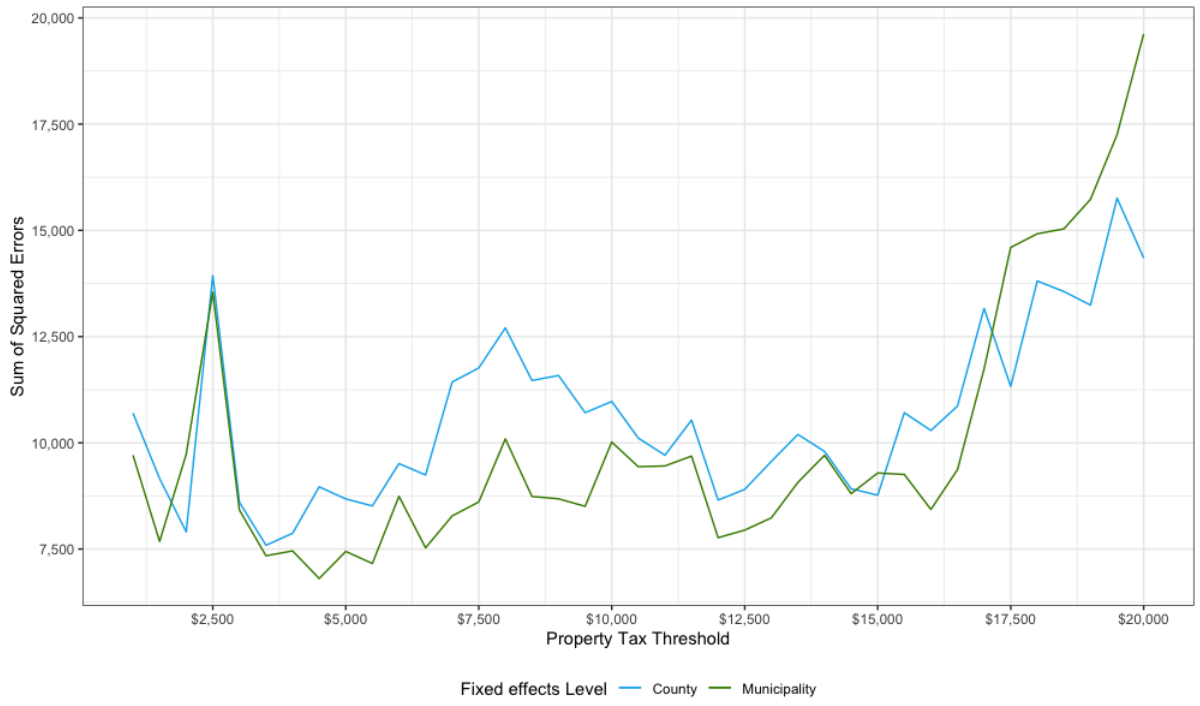
Figure 2.5: Threshold Estimation μ_{2t} Coefficients With Municipality Fixed Effects



marginal income rate, Total Prop. Tax_i is the total amount of property tax deducted by homeowners in a particular tax bracket. Each fraction gives how much homeowners in total deduct from property tax expenses as a fraction of overall property tax expenses, and so the difference between the two gives a percent increase in the average increase in real estate taxes.

Unfortunately, the exact distribution of homeowners by itemization status and marginal income tax rate is not available publicly, so I propose a modified version of equation 2.7.1 which allows me to put upper and lower bounds on the average increase in property tax costs using publicly available data from the IRS's Statistics of Income (SOI). The IRS provides data at the state level on the characteristics of filers which are classified into 10 distinct income ranges. For income ranges in the SOI that are a subset of a particular marginal tax range, the marginal tax rate of all tax filers in the group is known. However, for income ranges in the SOI which cover two distinct marginal tax rates, it is not possible to determine

Figure 2.6: Threshold Estimation Sum of Squared Residuals



the exact distribution of marginal tax rates with the income range. As an alternative, it is possible to estimate two versions of equation 2.7.1, one using the maximum marginal tax rate in an income range and the other using the minimum marginal tax rate.

Table 2.10: Real Estate Tax Behavior in New Jersey By Year

	2016	2017	2018	2019
Occupied Housing Units	3,195,014	3,199,111	3,213,362	3,231,874
Owner-Occupied Housing Units	2,047,794	2,052,073	2,054,413	2,064,240
Tax Filers Claiming Real Estate Deduction	1,573,550	1,596,170	688,140	664,900
Percent of Homeowners Deducting Real Estate Taxes	76.8%	77.8%	33.5%	32.2%

Sources: IRS Statistics of Income and the American Community Survey

In particular, suppose that the income distribution is divided with K distinct ranges $[Y_k, Y_{k+1})$ such that

$$[0, \infty) = [0, Y_1) \cup [Y_1, Y_2) \ldots \cup [Y_k, Y_{k+1}) \ldots \cup [Y_K, \infty) \tag{2.7.2}$$

Then,

$$\frac{\sum_{k=1}^{K} \min(\tau_i | Y_k \leq Y_i \leq Y_{k+1}) \times \text{Total Prop. Tax Ded.}_i}{\text{Total Property Tax Paid}} \leq \frac{\sum_{i=1}^{n} \tau_i \times \text{Total Prop. Tax Ded.}_i}{\text{Total Property Tax Paid}} \tag{2.7.3}$$

and

$$\frac{\sum_{i=1}^{n} \tau_i \times \text{Total Prop. Tax Ded.}_i}{\text{Total Property Tax Paid}} \leq \frac{\sum_{k=1}^{K} \max(\tau_i | Y_k \leq Y_i \leq Y_{k+1}) \times \text{Total Prop. Tax Ded.}_i}{\text{Total Property Tax Paid}} \tag{2.7.4}$$

Where Y_k is the first dollar income taxed at a particular marginal tax rate and Y_{k+1} is the last dollar taxed at that particular marginal tax rate.

This must be done separately for joint, single, and head of household filers since these groups have separate marginal income tax schedules. Total real estate deductions are given by income range but not by filing status, so it is assumed that within an income range each filer group's total real estate deductions are proportional to their size relative to the income range group overall. So if joint filers represented half of the total filers in a particular income range, they would be allotted half of the real estate deductions. These two estimates can then provide an upper and lower bound to the true value of equation 2.7.1. Tables 2.11a and 2.12a show the results of estimating equation 2.7.3 assuming the minimum marginal tax rate. Tables 2.11a and 2.12a show the results of estimating equation 2.7.4 assuming the maximum marginal tax rate. Using the two minimum costs, in 2017 property tax deductions reduced

the after-tax cost of all New Jersey residential property taxes by 19.5%, in 2018 this was reduced to 6.8%. Using two maximum costs, in 2017 property tax deductions reduced the after-tax cost of all New Jersey residential property taxes by 22.5%, while in 2018 this figure was 9.7%.

Estimating the equation using minimum and maximum yields remarkably similar results. Using the minimum of marginal tax rates suggests that the real cost of property taxes increased by 12.7 percentage points (relative to the overall tax bill). Using the maximum suggests that the real cost of property taxes increased in 12.8 percentage points. This is for the housing market overall, and so includes non-owner occupied housing, which did not experience as large of an change in the tax treatment of housing.

Table 2.11: Marginal Tax Rates in New Jersey By Income Range in 2017

(a) Minimum in 2017

	Percent Of Filers That Are			Minimum Income Tax Rate			
Income Range	Single	Joint	Head of Household	Single	Joint	Head of Household	Total Real Estate Deductions
$10,000 to $25,000	63%	13%	23%	15%	15%	15%	$513,219,000
$25,000 to $50,000	57%	20%	22%	15%	15%	15%	$1,158,572,000
$50,000 to $75,000	52%	32%	17%	25%	15%	25%	$1,658,380,000
$75,000 to $100,000	37%	51%	12%	25%	15%	25%	$1,836,965,000
$100,000 to $200,000	18%	76%	6%	28%	25%	25%	$5,717,700,000
$200,000 to $500,000	9%	88%	3%	33%	28%	28%	$3,843,506,000
$500,000 to $1,000,000	8%	90%	2%	39.6%	39.6%	39.6%	$1,008,964,000
Over $1,000,000	8%	90%	2%	39.6%	39.6%	39.6%	$849,619,000
Total Value of Deductions as a Fraction of Total New Jersey Residential Property Taxes: 19.5%							

(b) Maximum in 2017

	Percent Of Filers That Are			Maximum Income Tax Rate			
Income Range	Single	Joint	Head of Household	Single	Joint	Head of Household	Total Real Estate Deductions
$10,000 to $25,000	65%	13%	22%	22%	12%	12%	$199,556,000
$10,000 to $25,000	63%	13%	23%	15%	15%	15%	$513,219,000
$25,000 to $50,000	57%	20%	22%	25%	15%	15%	$1,158,572,000
$50,000 to $75,000	52%	32%	17%	25%	15%	25%	$1,658,380,000
$75,000 to $100,000	37%	51%	12%	28%	25%	25%	$1,836,965,000
$100,000 to $200,000	18%	76%	6%	33%	28%	28%	$5,717,700,000
$200,000 to $500,000	9%	88%	3%	39.6%	35%	35%	$3,843,506,000
$500,000 to $1,000,000	8%	90%	2%	39.6%	39.6%	39.6%	$1,008,964,000
Over $1,000,000	8%	90%	2%	39.6%	39.6%	39.6%	$849,619,000
Total Value of Deductions as a Fraction of Total New Jersey Residential Property Taxes: 22.5%							

Source: IRS Statistics of Income

Table 2.12: Marginal Tax Rates in New Jersey By Income Range in 2018

(a) Minimum in 2018

	Percent Of Filers That Are			Minimum Income Tax Rate			
Income Range	Single	Joint	Head of Household	Single	Joint	Head of Household	Total Real Estate Deductions
$10,000 to $25,000	65%	13%	22%	12%	10%	10%	$199,556,000
$25,000 to $50,000	58%	20%	22%	12%	12%	12%	$459,033,000
$50,000 to $75,000	53%	30%	17%	22%	12%	12%	$714,202,000
$75,000 to $100,000	38%	49%	13%	22%	12%	22%	$774,799,000
$100,000 to $200,000	20%	74%	6%	24%	22%	24%	$2,171,572,000
$200,000 to $500,000	10%	87%	3%	35%	24%	35%	$2,023,643,000
$500,000 to $1,000,000	8%	90%	2%	37%	32%	37%	$608,903,000
Over $1,000,000	8%	90%	2%	37%	37%	37%	$459,253,000
Total Value of Deductions as a Fraction of Total New Jersey Residential Property Taxes: 6.8%							

(b) Maximum in 2018

	Percent Of Filers That Are			Maximum Income Tax Rate			
Income Range	Single	Joint	Head of Household	Single	Joint	Head of Household	Total Real Estate Deductions
$10,000 to $25,000	65%	13%	22%	22%	12%	12%	$199,556,000
$25,000 to $50,000	58%	20%	22%	22%	12%	12%	$459,033,000
$50,000 to $75,000	53%	30%	17%	22%	12%	22%	$714,202,000
$75,000 to $100,000	38%	49%	13%	24%	22%	24%	$774,799,000
$100,000 to $200,000	20%	74%	6%	32%	24%	35%	$2,171,572,000
$200,000 to $500,000	10%	87%	3%	37%	37%	37%	$2,023,643,000
$500,000 to $1,000,000	8%	90%	2%	37%	37%	37%	$608,903,000
Over $1,000,000	8%	90%	2%	37%	37%	37%	$459,253,000
Total Value of Deductions as a Fraction of Total New Jersey Residential Property Taxes: 9.7%							

Source: IRS Statistics of Income

Following the literature on property tax capitalization (Oates (1969), Yinger et al (1988)), the price of a home at time t can be described as the difference between the present value flow of benefits and costs associated with the house (in this case, the costs are limited to property taxes)

$$P_{it} = \sum_{t=1}^{T}(1-r)^t \text{Benefits}_{it} - \sum_{t=1}^{T}(1-r)^t \text{Property Taxes}_{it} \tag{2.7.5}$$

Where (1-r) is the discount rate.

After a tax regime change (and assuming no change in benefits) and with full capitalization the difference in price of a home can be written as

$$\Delta P_{it} = \sum_{t=1}^{T} \frac{\Delta \text{Property Taxes}_{it}}{1-r} \tag{2.7.6}$$

Or with partial capitalization

$$\Delta P_{it} = \beta \sum_{t=1}^{T} \frac{\Delta \text{Property Taxes}_{it}}{1-r} \tag{2.7.7}$$

Where β represents the capitalization rate. Assuming the real value of property taxes does not change over time and the new tax regime continues for T years we can rewrite equation 2.7.7 as

$$\Delta P_{it} = \beta \sum_{t=1}^{T} \cdot \frac{1-(1-r)^{T+1}}{r} \Delta \text{Property Taxes}_{it} \tag{2.7.8}$$

The estimated parameter μ from equation 2.6.6 is the elasticity of the sale price relative to the property tax following a regime change, which means that in the context of the capitalization equation above it represents the product of β and the discounted value of the property taxes. However, calculating the capitalization rate β from the estimated coefficient μ depends on making a decision about both the discount rate and the length of time the

policy will remain in place. To address this, Table 2.13 shows the estimated capitalization rate for discount rates between 2% and 6% and tax policy lengths that range from one year to permanent. The estimates rule out the possibility (assuming that over capitalization is not possible) that homebuyers expect the TCJA regime to revert back after either one or three years. Both the higher standard deduction and the cap on state and local tax deductions is set to expire in 2025, and the results suggest that it is reasonable to suppose that this is what homebuyers expect. If homebuyers anticipate the change to be permanent, then there is severe under-capitalization of the higher cost of property taxes into home prices. Assuming a 3% discount rate and that homebuyers anticipate that the tax regime will revert in 2025, the results suggest that there is a 72% capitalization rate.

Table 2.13: Capitalization Percent By Discount Rate and Time Horizon

		Number of Years TCJA in Effect					
		1 (until 2019)	3 (until 2021)	7 (until 2025)	10 (until 2028)	25 (until 2035)	Permanent
Discount Rate	2%	263%	134%	70%	52%	26%	10%
	3%	265%	136%	72%	55%	29%	16%
	4%	266%	138%	75%	58%	32%	21%
	5%	267%	141%	77%	60%	35%	26%
	6%	269%	143%	80%	63%	39%	31%

2.8 Conclusion

This paper examines the impact of the Tax Cuts and Jobs Act of 2017 on home prices. The TCJA reduced tax benefits for homeowners, both by explicitly capping property tax and mortgage interest deductions, and by doubling the standard deduction which discouraged taxpayers from itemizing their deductions . This paper attempts to isolate the impact of property taxes on residential housing markets by exploring how property prices changed after the enactment of the Tax Cuts and Jobs Act.

Using a repeat sales model, this paper finds evidence that a 1% increase in property taxes was associated with a 0.11% decrease in property values after the passage of the TCJA. For the median home in the sample, this is equivalent to a $870 increase in yearly property taxes reducing property values by $3,370. Assuming a 3% discount rate, this finding implies that approximately 70% of the increased (after federal tax) property tax burden was capitalized into housing prices. The magnitude of these results also implies that homebuyers in 2018 and 2019 believed that the SALT cap would expire in 2025. Given that it was a stated legislative priority for Republicans in 2018 to make the SALT cap permanent (although they ultimately did not succeed in doing so) it would have been understandable for homebuyers to believe that the SALT cap would be permanent. However, a permanent higher standard deduction and SALT cap would mean that there was only about 16% capitalization of the higher property tax costs into housing prices.

This paper finds that property prices had strong responses to changes to the tax treatment of homeownership under the TCJA. The magnitude of these responses indicate that tax policy has a real impact on housing decisions, and suggests that reducing such benefits may in the long run reduce housing consumption. It also suggests that reducing tax benefits for homeownership will also lead to lower property taxes and therefore a lower provision of local public goods.

CHAPTER III

Left Digit Bias in Property Taxes

3.1 Introduction

Potential home buyers face a number of recurring costs, including property taxes. Existing literature suggests that potential home-buyers factor in future property tax payments to their home buying decisions. This paper investigates whether home-buyers display a particular type of cognitive bias when it comes to future property tax payments. In particular, it examines whether homebuyers incorrectly assess the size of future property tax payments due to left digit bias. Left digit bias is a well documented cognitive bias wherein individuals overemphasize the left-most digit of a number. Left digit bias means that if one considers all possible pairs of numbers which differ by the same amount, the difference between pairs with different leftmost digits will be perceived as larger than the difference in pairs with identical leftmost digits. This left digit bias is the source of listed prices whose rightmost digits end in a litany of nines, under the well supported understanding that consumers interpret such a price as significantly lower than the rounded up price.

Property taxes constitute a large and recurring payment for many homeowners. Previous research has shown that despite this, home-buyers are still liable to make mistakes when gauging their future property tax bills. A natural question is then whether one of the ways

home-buyers are making mistakes when it comes to property tax bills is through left digit bias. Property taxes are a reflection of the local public goods in the area and the value of a property, and as a result it is usually not particularly informative to estimate the relationship between home sale prices and property tax bills. However, if home-buyers were perfectly rational (and there were no other relevant real factors) then the relationship between home sale prices and property taxes should not be discontinuous near a leftmost digit threshold.

I evaluate whether home-buyers exhibit left-digit bias using residential home sales in New Jersey between 2013 and 2019. Using a regression discontinuity method and after flexibly controlling for the relationship between property taxes and home prices, homes with property tax obligations that are just over a thousand-dollar threshold sell for 0.5% less than homes with property tax obligations that are just under a thousand-dollar threshold. For the median home in the sample, this type of cognitive error results in an over-payment of $1,672. Property taxes tend to increase over time in New Jersey, so any perceived benefit to the new homeowner of property taxes that fall just under a thousand dollar threshold will necessarily be temporary. The estimated left digit bias is larger in areas with low rental rates, suggesting that owner-occupiers are more susceptible to this cognitive error than professional landlords. Additionally, the size of the cognitive error grows over the sample time period, which coincides with the rise in popularity of online real estate websites such as Zillow that provide access to property tax data for prospective home buyers. These findings suggest that even in the presence of large costs individuals are not able to perfectly assess relative values. This has implications for economic modeling of housing markets. It also has potential public policy implications, as there may be ways of presenting property tax information to housing market participants which may reduce this type of bias.

3.2 Related Literature

This paper relates to existing literature on behavioral economics and property taxation. Literature in behavioral economics has shown that consumers can be inattentive to non salient costs (such as in Chetty et al. (2009) or Finkelstein (2009)). Left digit bias describes a cognitive mistake in which an individual overemphasizes the leading digit of a number when evaluating its size. This has been well documented in the psychology literature (such as in Poltrock and Schwartz (1984), Dehaene et al (1990), and Korvorst and Damien (2008)). Left digit bias in consumer behavior (and the resulting price setting behavior by firms) has been noted since at least the 1930s (Ginzberg 1936). In order to estimate left digit bias, this paper follows a model of inattention developed by DellaVigna (2009) and implemented by Lacetera et al (2012), and makes use of regression discontinuity designs (Lee 2010). Lacetera, Pope, and Sydnor (2012) show evidence of left digit bias in the American used car market in the form of discontinuities in average prices of $150 to $200 at 10,000 mile markers. There have been many papers documenting the presence of consumer left digit bias in a variety of markets, such as Basu (1997), Anderson and Simester(2003), Thomas and Morwitz (2005), and Bray and Harris (2006). This left digit bias can manifest in somewhat surprising surprising ways, such as in Reiley and Samek (2019) where find that changing suggested donations from $100 to $95 reduces donations over $90 by 30%, suggesting that individuals feel differently about rounded numbers. Interestingly, Strulov-Shlain (2021) finds evidence that despite the magnitude of left digit bias among consumers, firms significantly under-utilize this bias when it comes to price setting.

This paper also relates to housing market pricing. In order to isolate the impact of the left digit bias in property taxes on home pricing, this paper controls for a variety of other aspects that may drive a home's value using a method called hedonic pricing. Hedonic pricing was introduced by Rosen (1974) who first demonstrated the method of decomposing housing prices into observed characteristics (such as physical features of a

home and local amenities), a technique which was then expanded upon by the literature, including notably by Palmquist (1984), Can (1992), Zabel (2004), and Hill and Daniel (2008).Hedonic pricing has been used extensively in the housing literature to estimate a number of different qualities on housing prices. These include environmental quality, such as in Kim et al (2003), Chay and Greenstone (2005), Brasington and Hite (2005), Gibbons et al (2005). It has also been used to estimate the impact of physical home characteristics, for instance in Lee et al (2005), Turnbull et al (2006), and Leguizamon and Ross (2012). Hedonic pricing has also been used to estimate the value of transportation accessibility, such as in Voith (1991), Baum-Snow and Kahn (2000), and Debrezion et al (2007).

In the housing literature there have been a number of papers demonstrating behavioral biases. Repetto and Solis (2019) find that homes in Sweden with listing prices just under one million Swedish Krona ultimately sell for 3 to 5 percent more, due to larger bidding activity compared to homes listed at just over one million Swedish Krona. There is also a broader literature which shows that round numbers are prominent in markets and play a role in forming expectations. Cardella and Seiler (2016) show that when initial listing prices are just below a round number, buyers will make lower offers (in terms of percentage discount on listing price) than when listing prices are at a round number. Pope, Pope, and Sydnor (2015) find evidence for focal points in housing prices, with bunching of house price at round numbers divisible by $50,000. Allen et al (2016) find evidence for reference dependence in marathon runners where marathon runners exert effort to complete races in round number times. In the property taxation literature, Bradley (2017) provides evidence of homebuyers misperceiving a temporary tax cut as a permanent one, resulting in overcapitalization by 2700 percent.

Finally, this paper adds to the existing literature on property taxation and housing prices. There is substantial evidence that real estate transaction taxes reduce the sale price of homes

(such as Besley et al (2014), Kopczuk and Monroe (2015), and Best and Kleven (2018)). There is also an extensive literature regarding how responsive homebuyers are to property taxes (including Oates (1969) , Ferreira (2010), Cabral and Hoxby (2012), and Yinger et al (2016)).

3.3 Data

To evaluate the existence of left digit bias in home sales, this study uses the universe of residential home sales in the state of New Jersey between 2013 and 2019. These deeds were obtained from the New Jersey Department of the Treasury and include information on the location of the property, square footage, deed date, sale price, whether the sale was between related parties, whether the assessor considered the sale to be at fair market price, whether the property is a condominium, the year in which the home was built, as well as the names and addresses of both the seller and the buyer. Deed records were matched to yearly property tax records for the years of 2012 to 2019 which were also obtained from the New Jersey Department of the Treasury. These yearly records include information on the location of the property, the value of the assessed property, the amount of property tax levied, any deductions or exemptions for the property, the total acreage of the property, as well as information on the name and address of the property owner, the most recent sale date, and the most recent sale price.

In New Jersey, homes are always taxed at their full value and assessors determine this value on a regular schedule (at least once every five years). A home purchase does not trigger a reassessment and assessments are not based on the sale price but on overall local residential real estate markets conditions. Home-buyers can therefore reasonably expect a home's previous year's property tax bill to be a strong predictor of future property tax bills. In New Jersey, property tax payments are broken up into four roughly equal payments, which are due on February 1, May 1, August 1, and November 1. The assessed value of a property for a given year is determined in October of the preceding year and a tax bill is sent to the property owner in July. The property tax bill in a given year t in municipality m for property

i is determined by the equation

$$\text{Property Tax}_{i,t,m} = \text{Assessed Value}_{i,t,m} \times \frac{\text{Budget}_{m,t}}{\sum_{j=1}^{n} \text{Assessed Value}_{j,t,m}} \tag{3.3.1}$$

Where $\text{Assessed Value}_{i,t,m}$ it the assessed value of property i in year t, $\text{Budget}_{m,t}$ is the municipal budget in year t, and $\sum_{j=1}^{n} \text{Assessed Value}_{j,t,m}$ is the sum of the assessed values of all taxable properties.

This tax bill will be comprised of the bills due in August and November of the same year as well as the bills due in February and May of the following year. Prior years' total yearly (though not quarterly) property tax bills are readily available for any New Jersey property on county websites as well as on real-estate marketplace websites such as Zillow or Redfin (who source their data from public records).

Property tax bills for the current year generally only become readily available late in a calendar year. A potential homebuyer viewing a listing would therefore likely only have immediate access to the property tax bills from the preceding years, but not necessarily the current year (additionally, not even the homeowner would know their exact property tax bill for the remainder of the year until July). Therefore, if homebuyers do exhibit left digit bias, it is likely that the observed response to the left digit of the property tax bill from the year prior to the home sale would be stronger than the observed response to the property tax bill of the year of the home sale.

The sample in this study is restricted to residential homes which the assessor considers to be sold at fair market value and built after 1850. The sample is additionally restricted to homes in municipalities with at least 100 other fair market home sales in the same calendar year, which excludes approximately 9% of home sales. Finally, only homes whose yearly

property taxes in the year before sale were between $2500 and $15,500 are included, which excludes the bottom 5% and top 8% of homes by property tax level. Table 3.1 provides summary statistics for the residential homes retained in the sample.

Table 3.1: Summary Statistics

	Mean	SD	10th Pctile	90th Pctile
Sample Residential Homes:				
Home Sale Price	$366,000	$204,000	$168,000	$600,000
Yearly Property Year Before Sale	$8,000	$3,000	$4,200	$12,400
Yearly Property Year Of Sale	$8,200	$3,100	$4,300	$12,600
Year Built	1965	30	1920	2002
Square Footage	1700	740	900	2700

3.4 Model

This study uses a simple model of home prices where the price of a home is determined by neighborhood and physical characteristics of the home, and property tax levels. Because it will not be relevant for assessing the existence of left digit bias with respect to the property tax level, this study will remain agnostic about the exact mechanism by which homebuyers and sellers come together to complete the sale of a home. It will also remain agnostic about whether it is solely homebuyers or both homebuyers and homeowners who are susceptible to left digit bias. It is possible that the left digit bias is due to how the homebuyer perceives the property tax obligations which impacts their willingness to pay. It is also possible that the bias is due to how the current homeowner perceives the property tax obligations (and thus the price that they are willing to accept).

A homebuyer (or current homeowner) can observe the physical characteristics of the home, but they cannot perfectly predict future property tax levels as they will depend on future municipal budgets and the value of the property relative to other properties in the municipality or taxing district. As a result, a homebuyer will form beliefs about future property tax obligations from current property tax obligations.

Assume that the sale price of the house can be expressed as:

$$P_{i,t} = f(\gamma_{m,t}, X_{i,t}, \sum_{s=t}^{T} \delta^{s-t} \cdot g_t(\text{Prop Tax}_{i,t})) \tag{3.4.1}$$

Where $\gamma_{m,t}$ is the component of price due to market conditions in municipality m at time t, $X_{i,t}$ is a vector of structural characteristics of the home, $\text{Prop Tax}_{i,s}$ is the yearly property tax bill of home i at time s, $\sum_{s=t}^{T} \delta^{s-t} g_t(\text{Prop Tax}_{i,s})$ is the present value of the after-tax stream of property tax bills, T is the time horizon over which the home will continue to be habitable, and δ is the discount rate.

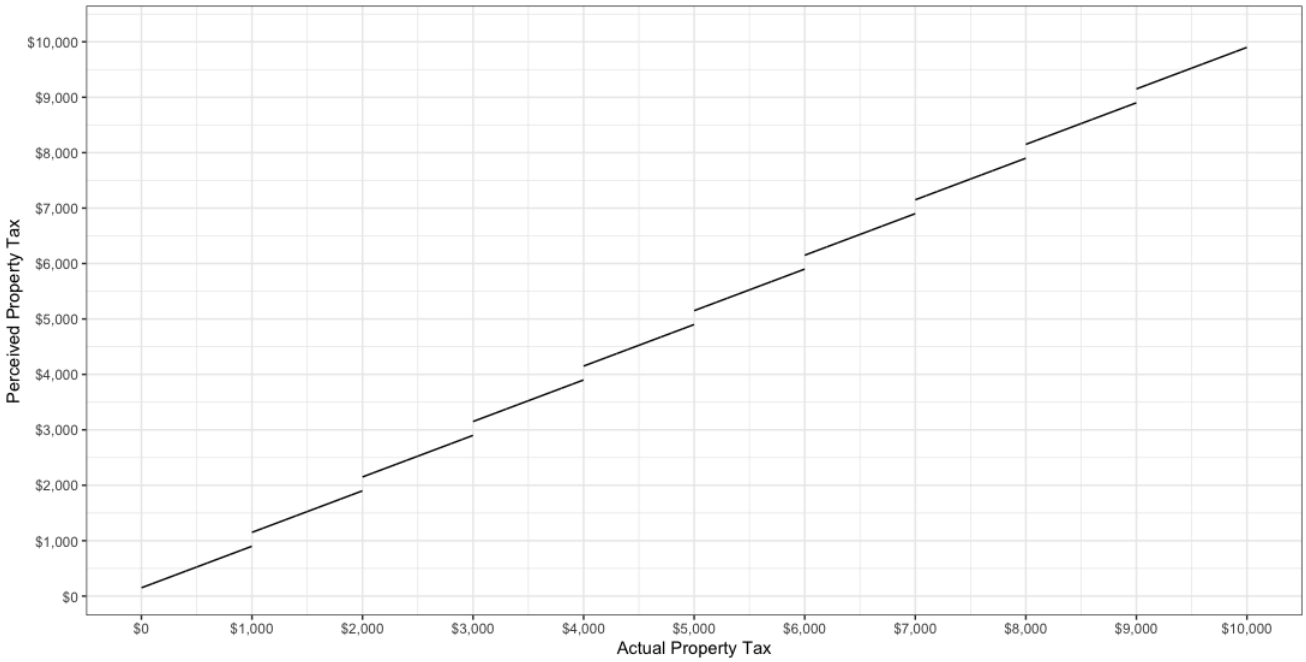


Figure 3.1: Illustration of Left Digit Bias

Due to left digit bias, an individual attempting to assess the size of the property tax bill Prop $\text{Tax}_{i,t}$ perceives the number as:

$$\widehat{\text{Prop Tax}}_{i,t} = d_H 10^H + (1-\theta)\sum_{j=1}^{H} d_{H-j} \cdot 10^{H-j} \tag{3.4.2}$$

Where H is the left-most digit of Prop $\text{Tax}_{i,t}$, d_H is the value of digit, θ is the inattention parameter (where $0 \leq \theta \leq 1$), 10^{H-j} are the remaining digits, and d_{H-j} are the values of the remaining digits. Because of the θ parameter, an individual with left digit bias would place more emphasis on the leftmost digit of the property tax bill. As a result, the sale price of the home $P_{i,t}$ will depend not on the true property tax level Prop $\text{Tax}_{i,t}$, but on the perceived property tax level $\widehat{\text{Prop Tax}}_{i,t}$. Figure 3.1 illustrates the discontinuous perception property tax levels that an individual with left digit bias would experience.

3.5 Estimation

Following the methodology for regression discontinuity estimation proposed in Lee and Lemieux (2010) the following equation is estimated:

$$\log(p_{ijt}) = \beta_0 + \beta_{j,t} \log(\text{Prop Tax}_{i,j,t-1}) + \sum_{n=1}^{15} \delta_n D[\text{Prop Tax}_{i,j,t-1} \geq n \cdot \$1,000] + \gamma X_{i,j,t} + \epsilon_{i,j,t} \quad (3.5.1)$$

Where p_{ijt} is the price at which the property is sold, j is the municipality of property i, t is the year in which the property is sold, Prop $\text{Tax}_{i,j,t-1}$ is the property tax bill one year before the property is sold, and X_i, j, t is a vector of property characteristics. The property tax level for the year prior to sale is the preferred specification because that is the property tax that is most readily available to prospective homebuyers. However, an alternative specification using the yearly property tax bill in the year of sale is also estimated.

Figure 3.2 shows a graphical representation of mean home sale prices at various property tax levels using both the property tax in the year prior to sale and the year of sale. The relationship between property taxes and sale prices appears to be fairly linear (though becoming less so above for homes with property taxes in excess of $11,000). While the prices for homes with property taxes immediately above some $1,000 thresholds appear to be lower than would be expected if the relationship were perfectly linear, it is difficult to discern given the otherwise positive relationship between property tax bills and home sale prices. For a given nominal property tax level, the mean price is slightly higher when using the property tax from the year prior to a home sale than from the year of a home sale. Given that property taxes tend to grow over time (particularly in nominal terms), this is consistent with the expected relationship.

Figure 3.4 shows the number of sales within each property tax bin. For a clearer view of

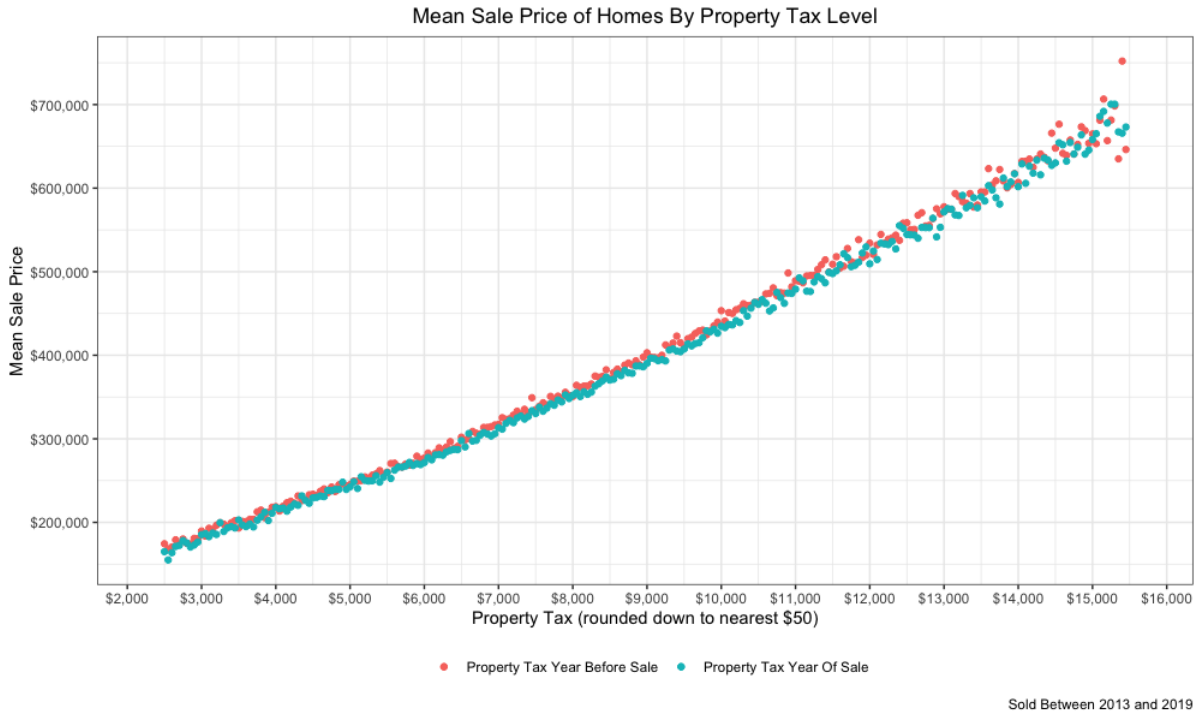


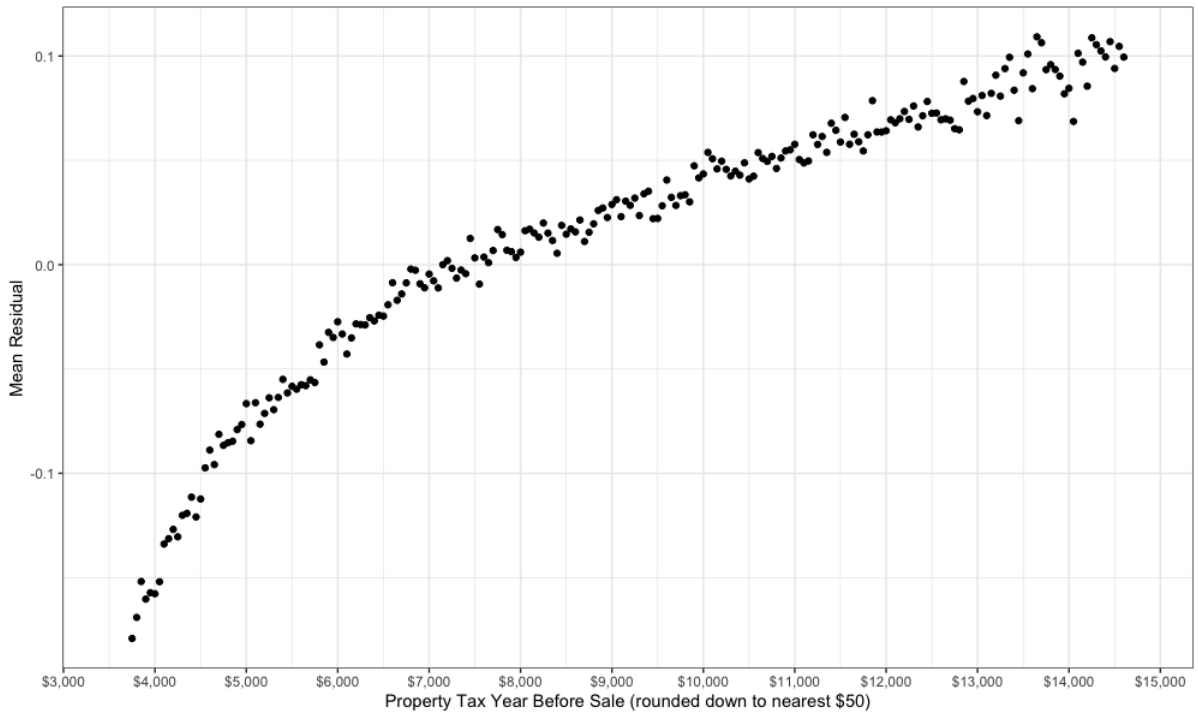
Figure 3.2: Mean Sale Price within Each $50 Property Tax Bin

the relationship between the left digit and number of homes sold, figure 3.5 shows the number of sales by each property tax level modulo $1,000. If home-owners were able to manipulate property taxes to fall immediately below particular thresholds then one might expect to see discontinuities in the number of homes sold around $1,000 thresholds. This does not appear to be the case. Figures C.1 and C.3 show the distribution of property tax levels for all homes in New Jersey (not just those which were recently sold). The overall distribution of properties is fairly similar to the distribution of properties which were sold. There does not appear to be bunching at the property tax level module $1,000 (which may be expected if, for instance, homeowners were more likely to appeal assessments which placed their property tax obligations over a particular $1,000 threshold). Figure C.2 shows that homes with higher property taxes are less likely to be sold in a particular year, but C.4 shows that there does not seem to be a relationship between the likelihood of sale and the property tax level modulo $1,000. This does not necessarily imply that there homeowners with property taxes just over a particular $1,000 are not more eager to sell their home, it may be that they

are more eager but are also less successful at finding a buyer. However, it provides some evidence that left digit bias does not drive measurable changes in which homes are sold.

Figure 3.3 shows the residuals from regressing the log of the sale price on the same observable characteristics included in equation 3.5.1 except for the property tax. There is a positive relationship between the property tax level and unexplained portion of the sale price. If it were possible to capture all relevant details of home quality and local amenities, it would not be the case that higher property tax levels would correlate with higher residual sale prices. As it is, 3.3 suggests that there are aspects of the sale price which are not explained by observable characteristics but which the local assessor is able to impute. This is a common problem in the property tax capitalization literature. This means that it is harder to assess the inattention parameter θ since the "true" relationship between property taxes and sale prices is unobserved. On the other hand, this paper provides a potential alternative way of measuring the willingness to pay for property taxes. The idea is that the behavioral response of homebuyers to changes in the left most digit of a property tax bill provides relevant information about willingness to pay that is not measurable from the overall relationship between property taxes and home prices due to omitted variable bias.

Figure 3.3: Residuals After Controlling for Observable Home Characteristics



This graph shows the residuals for log(Sale Price) after controlling for municipality, deed year, square footage of home, age of home, and acreage. The positive residuals for higher property-tax homes indicate that there are relevant home characteristics unobserved in the data set but that are observed by the assessor.

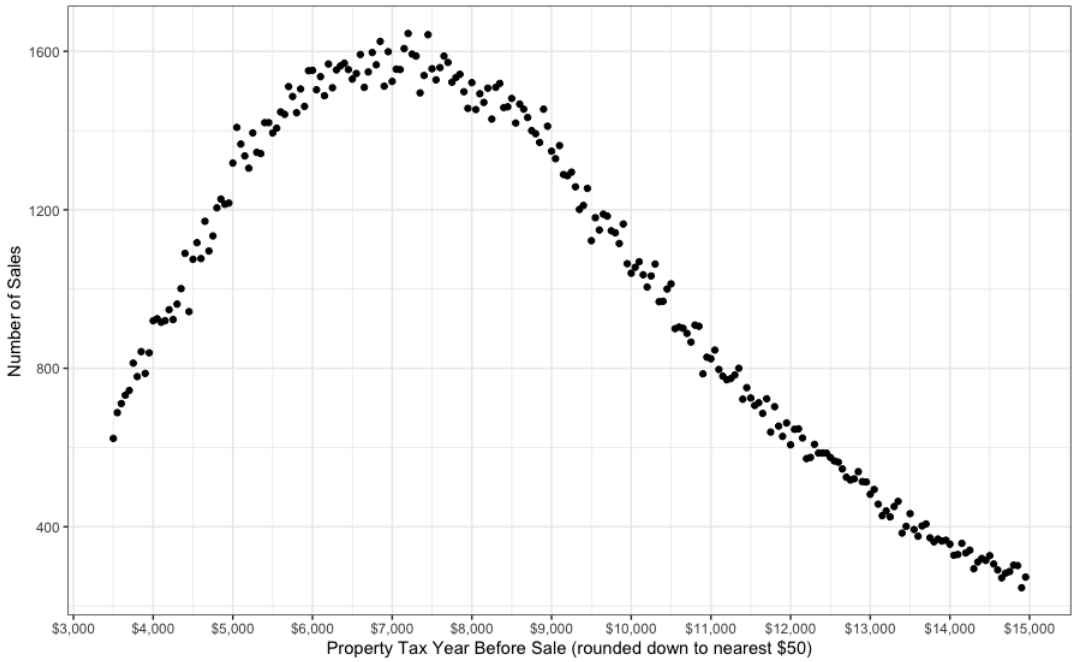


Figure 3.4: Number of Sales within Each $50 Property Tax Bin

Figure 3.5: Number of Sale within Each $10 Property Tax Bin Modulo $1,000

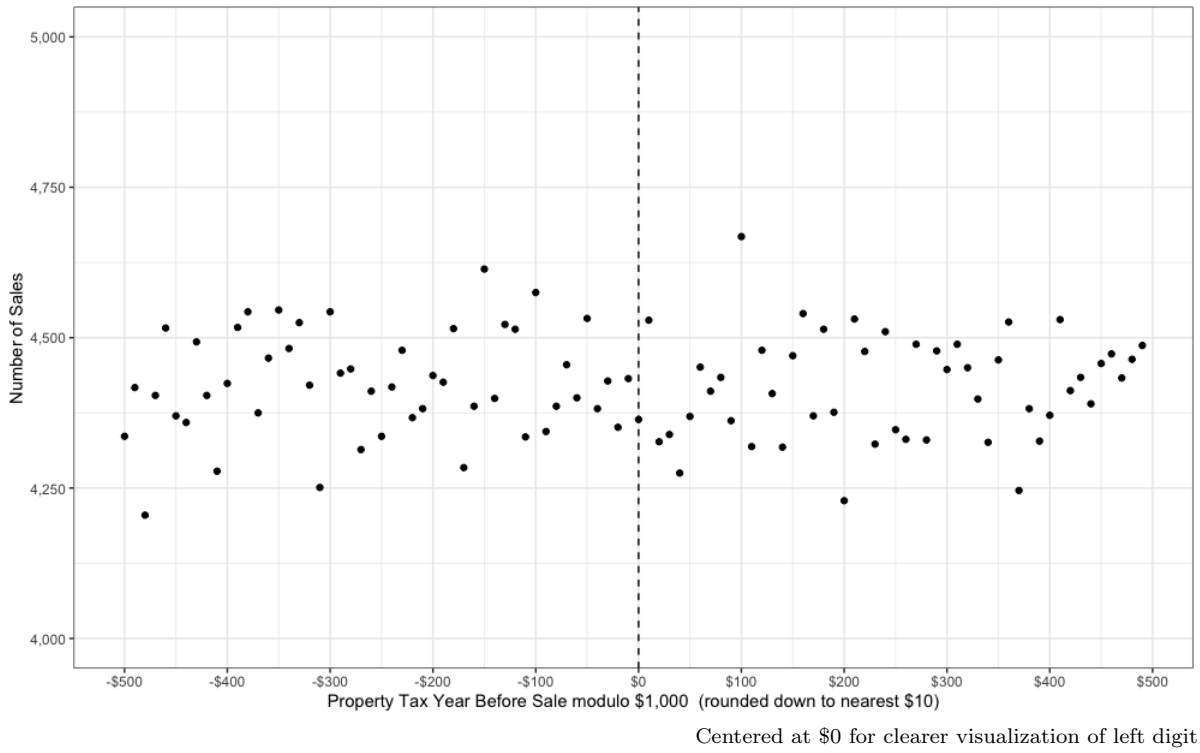
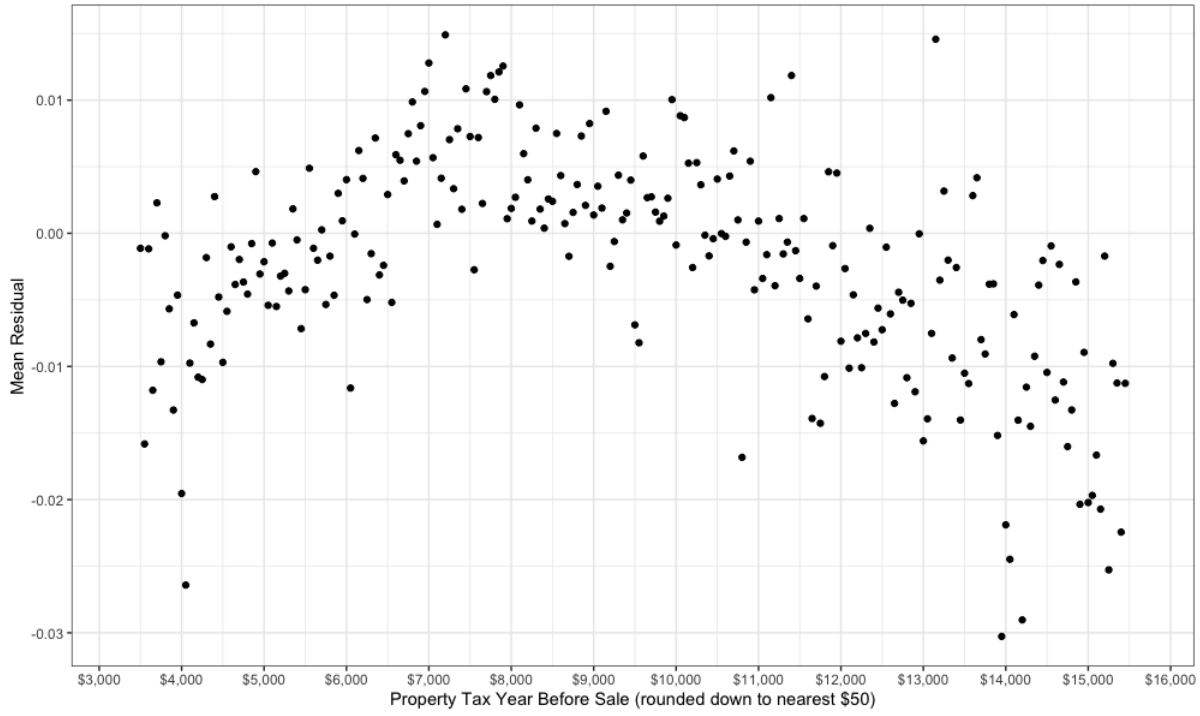


Table 3.2 shows the results of estimating equation (3.5.1). Estimates for all discontinuities are negative with the exception of property taxes over $6,000 and property taxes over $7,000. However, the estimates are only statistically significant for the estimates between property taxes over $8,000 and property taxes over $14,000. This is surprising given that home-buyers with higher property tax bills will be on average wealthier and hypothetically more financially literate. It may be that home with lower property tax bills are more likely to be rentals and that home-buyers who intend to rent out their properties are less susceptible to these cognitive biases.

Figure 3.6 shows the residuals from estimating a modified version of equation (3.5.1) which does not include the $1,000 threshold dummies. It appears that the estimation has the best at predicting the price of homes with yearly property taxes in the $6,000 to $10,000 range, which also represents 43% of the sample. Figure 3.7 shows the same results as Figure

3.6, but with the modulo $1,000 yearly property tax bill. There does not appear to be any systematic relationship between the property tax modulo $1,000 and the residual. Figure 3.8 shows the same graph but restricted to property taxes which are within $100 of $0 (mod $1,000). This graph shows a clear negative relationship between the residual and the property tax with properties beyond the $0 line showing negative mean residuals. Figure 3.8 is an illustrative version of Table 3.3 and suggests that left digit bias does appear to exist in property sale prices.

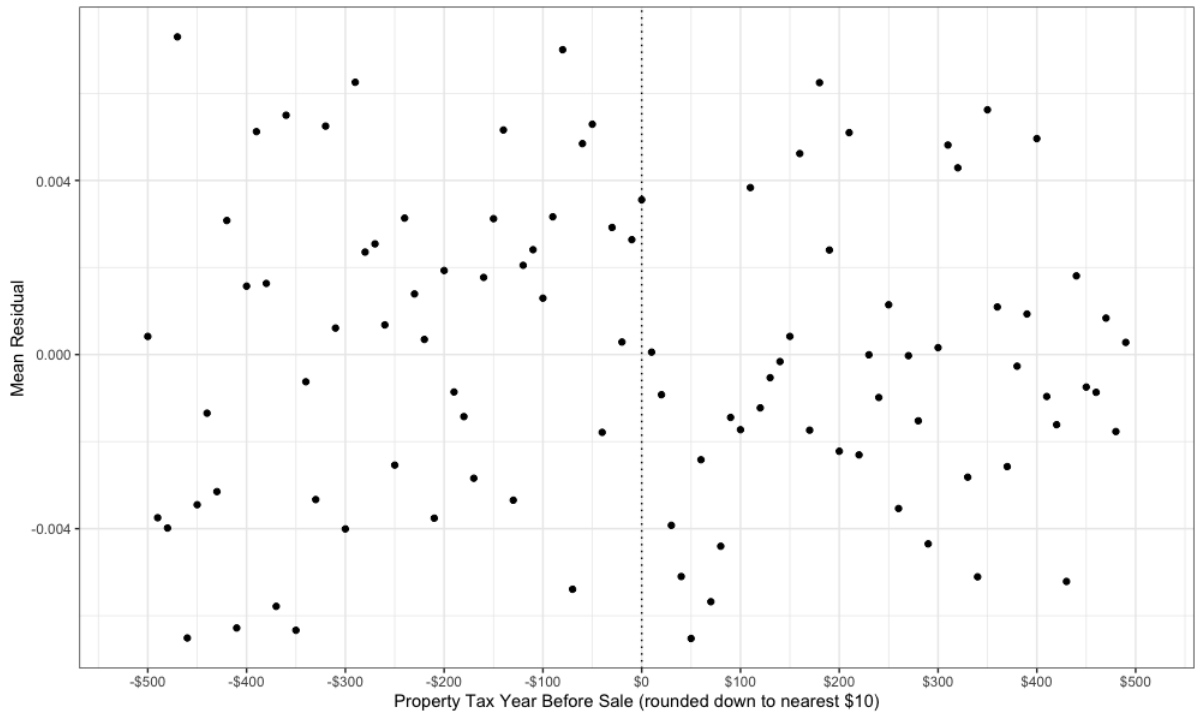
Figure 3.6: Mean Regression Residuals Within Each $50 Property Tax Bin



An alternative specification would be to not include indicators for each $1,000 property tax threshold and instead estimate the impact of being near either side of any $1,000 threshold.

$$\begin{aligned}\log(p_{ijt}) = \beta_0 + \beta_{j,t}\log(\text{Prop Tax}_{i,j,t-1}) + \delta_1 D[|(\text{Prop Tax}_{i,j,t-1} \mod \$1,000) - \$1,000| < \upsilon] \\ + \delta_2 D[\text{ Prop Tax}_{i,j,t-1} \mod \$1,000 < \upsilon] + \gamma X_{i,j,t} + \epsilon_{i,j,t}\end{aligned} \tag{3.5.2}$$

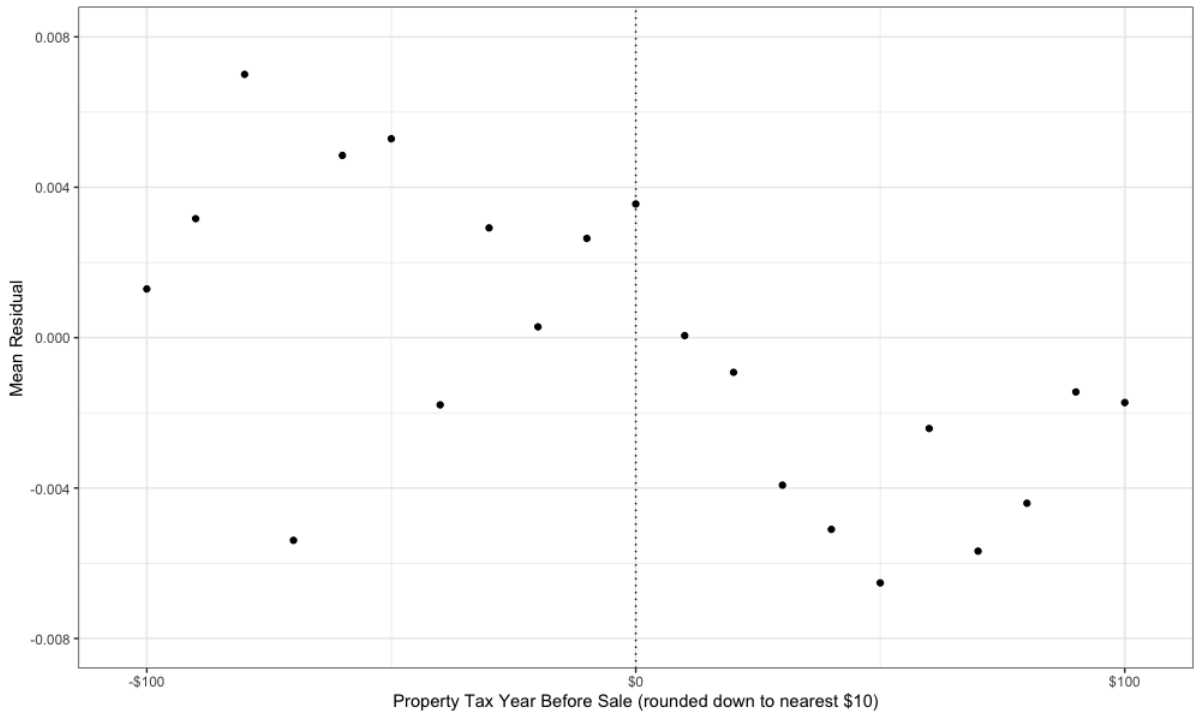
Figure 3.7: Mean Regression Residuals Within Each $10 Property Tax Bin (modulo $1,000)



In this case, δ_1 would measure the effect of being within υ of a $1,000 threshold and δ_2 would measure the effect of being over but within υ of a $1,000 threshold. Table 3.3 shows the results of estimating equation (3.5.2) with $\upsilon = \$100$. These estimates can be interpreted as the average effect on sale prices of having property taxes in the year before a sale just over any $1,000 threshold. The results suggest that having property taxes in the year before a sale just over a $1,000 threshold reduces the sale price of a home by approximately 0.5%.

To ensure that the effect is due to left digit bias rather than an improper estimation of the relationship between property taxes and home sale prices, equation (3.5.3) is also estimated for a variety of σ. In equation (3.5.3), δ_1 and δ_2 estimate whether there is some effect on home prices of the property tax (modulo $1,000) being on either side a threshold σ. In the left digit bias specification, $\sigma = \$0$.

Figure 3.8: Mean Regression Residuals Within Each $10 Property Tax Bin (modulo $1,000 and within $100 of $1,000 threshold)



$$\begin{aligned}\log(p_{ijt}) = \beta_0 + \beta_{j,t}\log(\text{Prop Tax}_{i,j,t-1}) + \delta_1 D[\sigma - \upsilon < (\text{Prop Tax}_{i,j,t-1} \mod \$1,000) < \sigma + \upsilon] \\ + \delta_2 D[\sigma < \text{Prop Tax}_{i,j,t-1} \mod \$1,000 < \sigma + \upsilon] + \gamma X_{i,j,t} + \epsilon_{i,j,t}\end{aligned} \tag{3.5.3}$$

Tables 3.4 and 3.5 show the results of estimating equation (3.5.3) at υ = \$100 and σ at every multiple of \$100 up to \$1,000. With the exception of σ = \$100, none of the estimations in Tables 3.4 and 3.5 are statistically significant. For σ = \$100, The estimate for δ_2 is statistically significant at the 5% level, but more importantly it is positive, which is the opposite of what would be expected in the presence of left digit bias. The estimates from Tables 3.4 and 3.5 suggest that the estimates in Tables 3.2 and 3.3 are picking up real evidence of left digit bias, rather than simply a misspecification of the relationship between property taxes and home sale prices.

Table 3.2: Results from Estimating Equation (3.5.1)

	Dependent Variable: log(Sale Price)				
	(1)	(2)	(3)	(4)	(5)
Prop. Tax > Than $4,000	-0.009499	-0.006096	-0.002538	-0.003079	-0.004214
	(0.005495)	(0.005316)	(0.005193)	(0.005141)	(0.004572)
Prop. Tax > Than $5,000	-0.002225	-0.0007702	-0.001917	-0.002006	-0.0005944
	(0.003783)	(0.003669)	(0.003442)	(0.003386)	(0.003118)
Prop. Tax > Than $6,000	0.0003213	0.0009319	0.001610	0.0007580	0.0006318
	(0.002795)	(0.002851)	(0.002777)	(0.002807)	(0.002764)
Prop. Tax > Than $7,000	0.001975	0.0009155	0.001577	0.001023	0.0001556
	(0.002614)	(0.002565)	(0.002492)	(0.002453)	(0.002416)
Prop. Tax > Than $8,000	-0.006975**	-0.007976**	-0.007404**	-0.007709**	-0.008217**
	(0.002627)	(0.002619)	(0.002651)	(0.002664)	(0.002617)
Prop. Tax > Than $9,000	-0.006929**	-0.007695***	-0.006898**	-0.007231**	-0.006768**
	(0.002338)	(0.002286)	(0.002299)	(0.002296)	(0.002396)
Prop. Tax > Than $10,000	-0.005847*	-0.006789**	-0.005713*	-0.005978*	-0.005320*
	(0.002253)	(0.002243)	(0.002266)	(0.002319)	(0.002298)
Prop. Tax > Than $11,000	-0.005255	-0.006103*	-0.006259*	-0.006388*	-0.007661**
	(0.002712)	(0.002681)	(0.002875)	(0.002860)	(0.002839)
Prop. Tax > Than $12,000	-0.007881*	-0.008445**	-0.008964**	-0.009135**	-0.009519**
	(0.003057)	(0.003128)	(0.003247)	(0.003281)	(0.003226)
Prop. Tax > Than $13,000	-0.004115	-0.004393	-0.004100	-0.004131	-0.004391
	(0.002910)	(0.002835)	(0.002816)	(0.002712)	(0.002892)
Prop. Tax > Than $14,000	-0.007200*	-0.007987*	-0.009831**	-0.009146**	-0.009358**
	(0.003513)	(0.003549)	(0.003416)	(0.003405)	(0.003315)
Prop. Tax > Than $15,000	-0.006031	-0.004910	-0.006558*	-0.006781*	-0.006724*
	(0.003175)	(0.003144)	(0.003159)	(0.003286)	(0.003172)
Muni x Deed Year F.E.	Yes	Yes	Yes	Yes	Yes
Sq. Feet and Year Built	No	Yes	Yes	Yes	Yes
log(Prop Tax) x Muni F.E.	No	No	Yes	Yes	Yes
log(Prop Tax) x Muni x Deed Year F.E.	No	No	No	Yes	Yes
Sq. Feet and Year Built x Muni x Deed Year F.E.	No	No	No	No	Yes
R2	0.8868	0.8891	0.8912	0.8925	0.8988
Number of Observations: 182,790					

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

For those properties which do seem to exhibit a cognitive bias, the effect is quite large. The results imply that homes just over the threshold sell for 0.5% less compared to homes just under the threshold. Given that the median home in this data-set has a sale price of $330,000, these results imply that left digit bias in property taxes reduces the median home price by $1,650. This is after having accounted for the relationship between property taxes and home sale prices, so this lower price cannot be attributed to disutility due to generally higher property taxes.

Table 3.3: Results from Estimating Equation (3.5.2)

	Dependent Variable: log(Sale Price)				
	(1)	(2)	(3)	(4)	(5)
Property Tax within \$100 of \$1,000 threshold	0.002139	0.001955	0.001721	0.001767	0.001928
	(0.001445)	(0.001393)	(0.001382)	(0.001401)	(0.001335)
Property Tax modulo \$1,000 under \$100	-0.005202**	-0.004891**	-0.004638*	-0.004735*	-0.004722**
	(0.001901)	(0.001830)	(0.001824)	(0.001828)	(0.001666)
Muni x Deed Year F.E.	Yes	Yes	Yes	Yes	Yes
Sq. Feet and Year Built	No	Yes	Yes	Yes	Yes
log(Prop Tax) x Muni F.E.	No	No	Yes	Yes	Yes
log(Prop Tax) x Muni x Deed Year F.E.	No	No	No	Yes	Yes
Sq. Feet and Year Built x Muni x Deed Year F.E.	No	No	No	No	Yes
R2	0.8867	0.8889	0.8910	0.8923	0.8986
Number of Observations: 182,790					

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3.4: Results from Estimating Equation (3.5.3)

	Dependent Variable: log(Sale Price)				
	(1)	(2)	(3)	(4)	(5)
	$\sigma = \$100$	$\sigma = \$200$	$\sigma = \$300$	$\sigma = \$400$	$\sigma = \$500$
$\$0 < \lvert\text{Prop Tax mod } \$1,000\rvert < \$200$	-0.003066*				
	(0.001301)				
$\$100 < \lvert\text{Prop Tax mod } \$1,000\rvert < \$200$	0.003946*				
	(0.001840)				
$\$100 < \lvert\text{Prop Tax mod } \$1,000\rvert < \$300$		0.001210			
		(0.001250)			
$\$200 < \lvert\text{Prop Tax mod } \$1,000\rvert < \$300$		-0.001340			
		(0.001446)			
$\$200 < \lvert\text{Prop Tax mod } \$1,000\rvert < \$400$			-0.0002273		
			(0.001081)		
$\$300 < \lvert\text{Prop Tax mod } \$1,000\rvert < \$400$			0.0005692		
			(0.001475)		
$\$300 < \lvert\text{Prop Tax mod } \$1,000\rvert < \$500$				0.0002821	
				(0.001199)	
$\$400 < \lvert\text{Prop Tax mod } \$1,000\rvert < \$500$				-0.001055	
				(0.001962)	
$\$400 < \lvert\text{Prop Tax mod } \$1,000\rvert < \$600$					-0.001022
					(0.001339)
$\$500 < \lvert\text{Prop Tax mod } \$1,000\rvert < \$600$					-0.0009384
					(0.002022)
Muni x Deed Year F.E.	Yes	Yes	Yes	Yes	Yes
Sq. Feet and Year Built	Yes	Yes	Yes	Yes	Yes
log(Prop Tax) x Muni F.E.	No	No	No	No	No
log(Prop Tax) x Muni x Deed Year F.E.	No	No	No	No	No
R2	0.8907	0.8907	0.8907	0.8907	0.8907
Number of Observations: 183,425					

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3.5: Results from Estimating Equation (3.5.3)

	Dependent Variable: log(Sale Price)			
	(5)	(6)	(7)	(8)
	$\sigma = \$600$	$\sigma = \$700$	$\sigma = \$800$	$\sigma = \$900$
$\$500 < \lvert\text{Prop Tax} \mod \$1,000\rvert < \$700$	-0.001821			
	(0.001399)			
$\$600 < \lvert\text{Prop Tax} \mod \$1,000\rvert < \$700$	0.002069			
	(0.001655)			
$\$600 < \lvert\text{Prop Tax} \mod \$1,000\rvert < \$800$		0.0005198		
		(0.001280)		
$\$700 < \lvert\text{Prop Tax} \mod \$1,000\rvert < \$800$		0.00005975		
		(0.001730)		
$\$700 < \lvert\text{Prop Tax} \mod \$1,000\rvert < \$900$			0.0006503	
			(0.001100)	
$\$800 < \lvert\text{Prop Tax} \mod \$1,000\rvert < \$900$			0.0004991	
			(0.001448)	
$\$800 < \lvert\text{Prop Tax} \mod \$1,000\rvert < \$1,000$				0.001367
				(0.001111)
$\$900 < \lvert\text{Prop Tax} \mod \$1,000\rvert < \$1,000$				0.001243
				(0.001775)
Muni x Deed Year F.E.	Yes	Yes	Yes	Yes
Sq. Feet and Year Built	Yes	Yes	Yes	Yes
log(Prop Tax) x Muni F.E.	No	No	No	No
log(Prop Tax) x Muni x Deed Year F.E.	No	No	No	No
R2	0.8907	0.8907	0.8907	0.8907
Number of Observations: 183,425				

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

3.6 Conclusion

This paper investigates the presence of left digit bias towards property taxes in housing markets and finds evidence that it does exist. In particular, this paper finds that homes with property taxes in the year prior to sale which are just over a $1,000 threshold sell for 0.5% less than would be expected in the absence of left digit bias. Although the magnitude of this bias is quite small relative to the sale price, it represents an average overpayment of $1,672. Furthermore, the estimated size of the left digit bias increases with the property tax level, despite the fact that homes with higher property tax levels will be generally purchased by individuals with higher incomes who might have been expected to have lower levels of cognitive biases.

The relative size of the bias estimated in this paper is small compared to some other left digit bias papers (for instance, Lacetera et al (2012) find an average $150 to $200 discontinuity in used car sale prices at 10,000 mile markers, which was 1.5% to 2% of the average used car sale price in their sample). However, the absolute size of the estimated cost of left digit bias in this paper is large. One potential explanation for this finding would be that participants in residential real estate market exhibits bounded rationality. Home purchases are complicated and homebuyers have to consider an enormous quantity of different factors when determining an appropriate price and approximate rounding of the expected property tax cost may be a sensible way of alleviating some of the cognitive burden which can be but to more efficient use evaluating other aspects of the home. However, given the other evidence of left digit bias in home purchases (such as Repetto and Solis (2019) or Cardella and Seiler (2016)), it may be worthwhile to determine the overall size of behavioral distortions in housing markets and, if it is sufficiently large to warrant concern, whether there are ways of presenting information to homebuyers and homesellers that can minimize it. These findings also have implications for economic modeling of housing markets which may benefit from incorporating the bounded rationality that has empirically been shown to exist.

APPENDICES

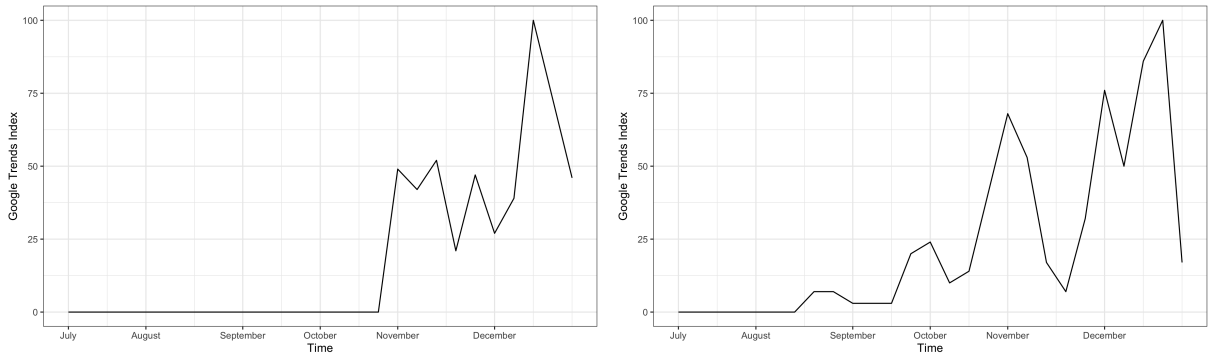
APPENDIX A

Appendix to Chapter 1

A.1 Appendix Figures

(a) Searches For "Tax Cuts and Jobs Act"

(b) Searches For "State and Local Tax Deductions"



(c) Searches For "Property Tax Deduction"

(d) Searches For "Home Mortgage Interest Deduction"

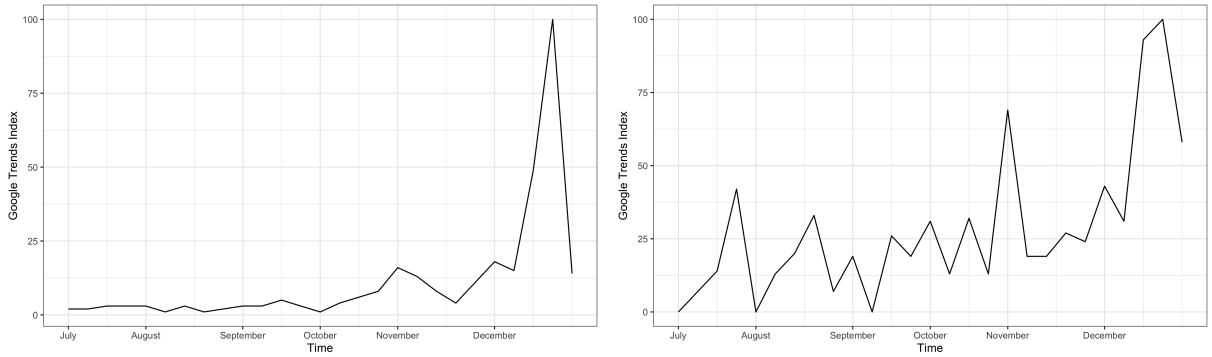
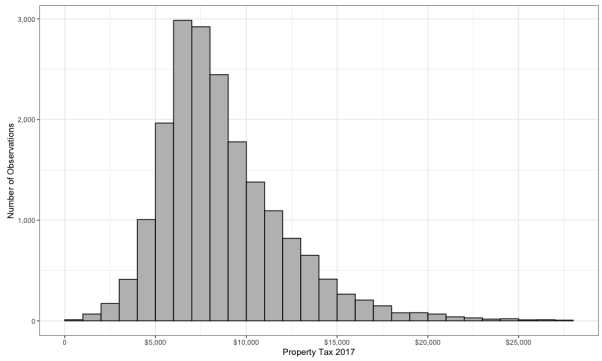


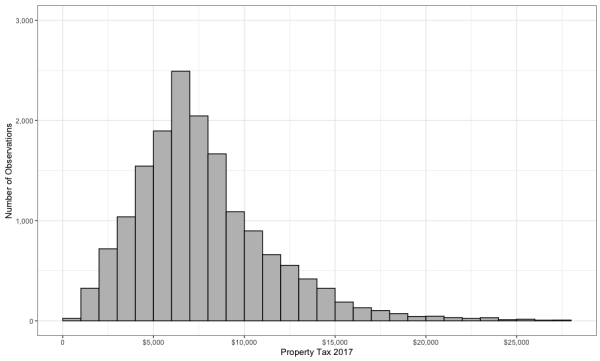
Figure A.1: Google Trends Searches in 2017

Figure A.2: Yearly 2017 Property Tax Bills

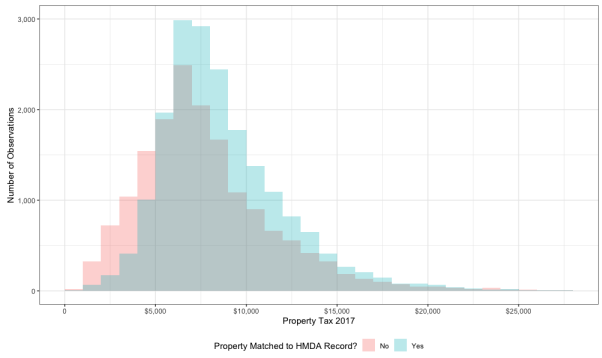
(a) Deed Matched to HMDA Record



(b) Deed Not Matched to HMDA Record



(c) Overlay Matched and Unmatched Deeds



(d) All Residential Properties in Middlesex County

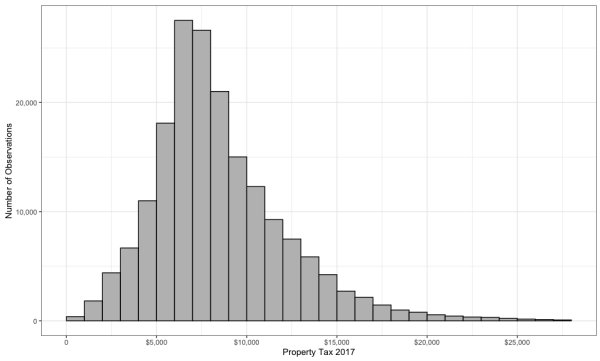
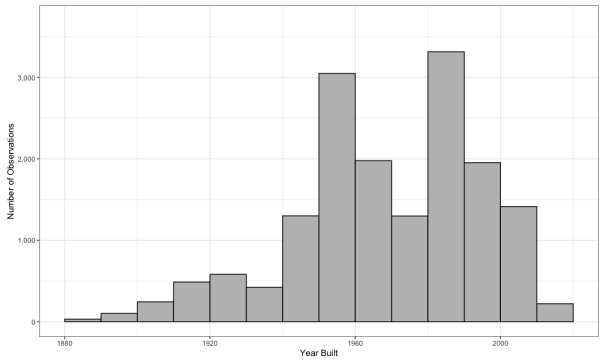
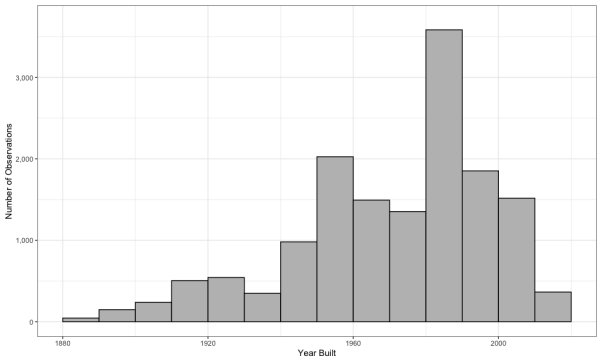


Figure A.3: Year in Which Home was Built

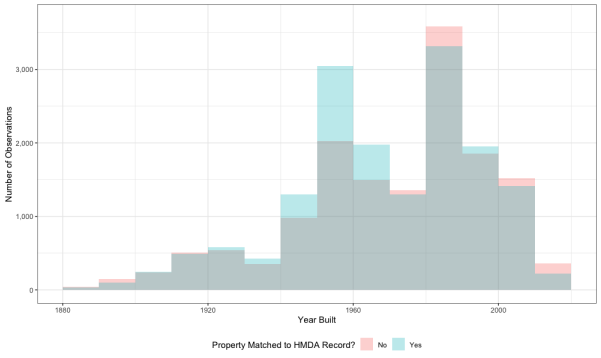
(a) Deed Matched to HMDA Record



(b) Deed Not Matched to HMDA Record



(c) Overlay Matched and Unmatched Deeds



(d) All Residential Properties in Middlesex County

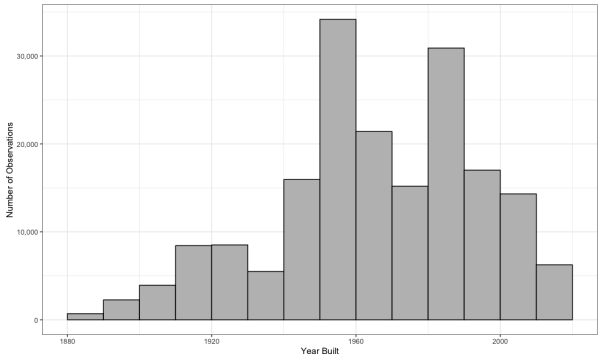
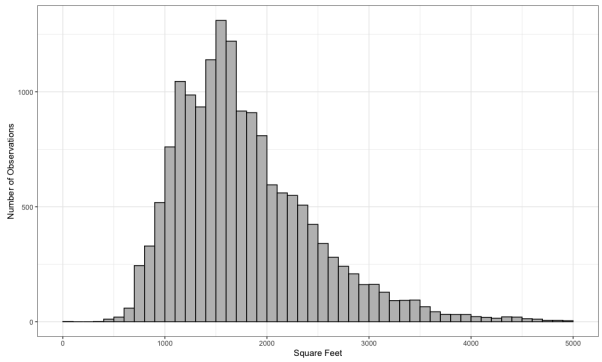
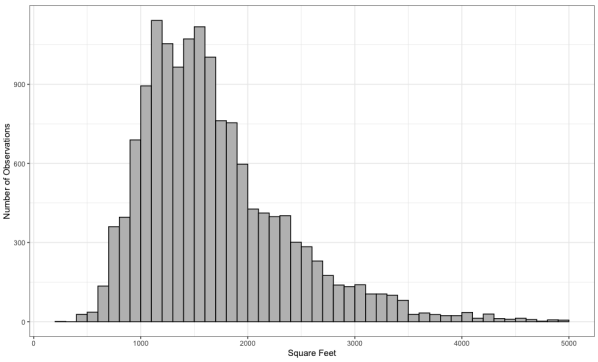


Figure A.4: Square Footage of Homes Sold Between 2014 and 2019 in Middlesex County

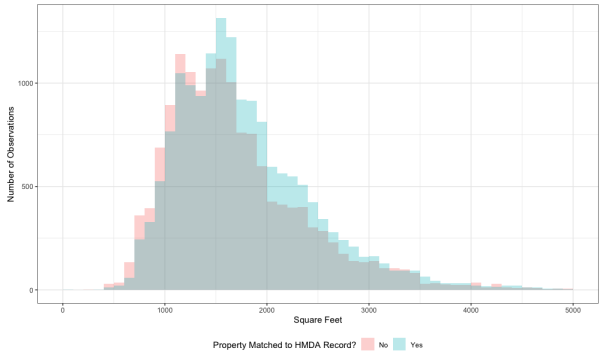
(a) Deed Matched to HMDA Record



(b) Deed Not Matched to HMDA Record



(c) Overlay Matched and Unmatched Deeds



Note: Square footage for residential properties in Middlesex County not recently sold is not available, square footage appears in the deed data but not in the property tax data.

A.2 Appendix Tables

Table A.1: Number of Sales and HMDA Loans in Middlesex County by Year

Deed Year	Total Sales	Total Fair Market Sales	Home Purchase HMDA Loans	Home Purchase HMDA Loans Owner Occupied	$\frac{\text{HMDA Loans}}{\text{Total Sales}}$
2014	8,057	5,093	6,159	5,679	0.76
2015	8,376	5,323	6,847	6,357	0.81
2016	9,537	5,915	7,747	7,173	0.82
2017	10,319	6,609	8,394	7,683	0.81
2018	9,852	6,558	7,969	7,267	0.81
2019	9,217	6,502	7,885	7,259	0.85

Total sales excludes sales which likely did not result in a new residential occupant for the property (such as transfers between immediate family members, transfers between a corporation and its subsidiary, transfers where the property was sold for less than $100.00, or transfers to a bank due to foreclosure). It does include sales where the assessor believes that the property was not sold at a fair market price (such as sales by estate executors, the first sale following a foreclosure, sales where the proceeds pay debts, or sales where significant improvements have been made since the last assessment). Home purchase HMDA loans excludes refinancing and home equity loans.

APPENDIX B

Appendix to Chapter 2

Figure B.1: Threshold Estimation μ_{2t} Coefficients With County Fixed Effects

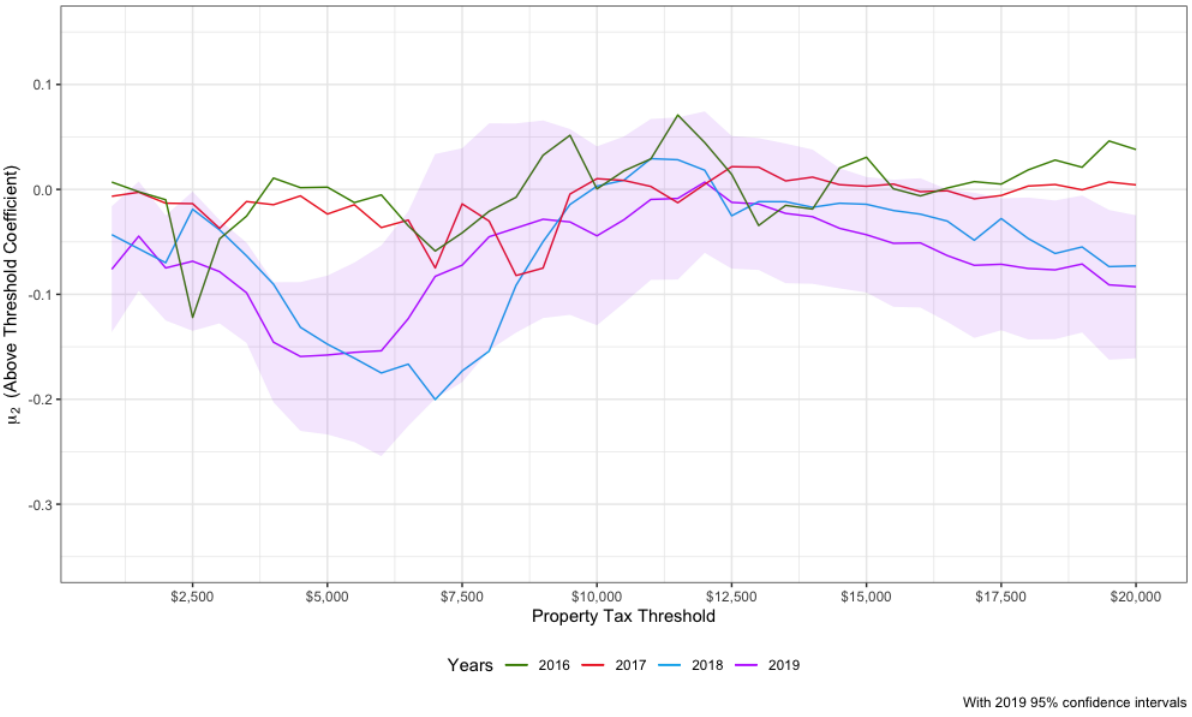


Figure B.2: Threshold Estimation μ_{2t} Coefficients With County Fixed Effects

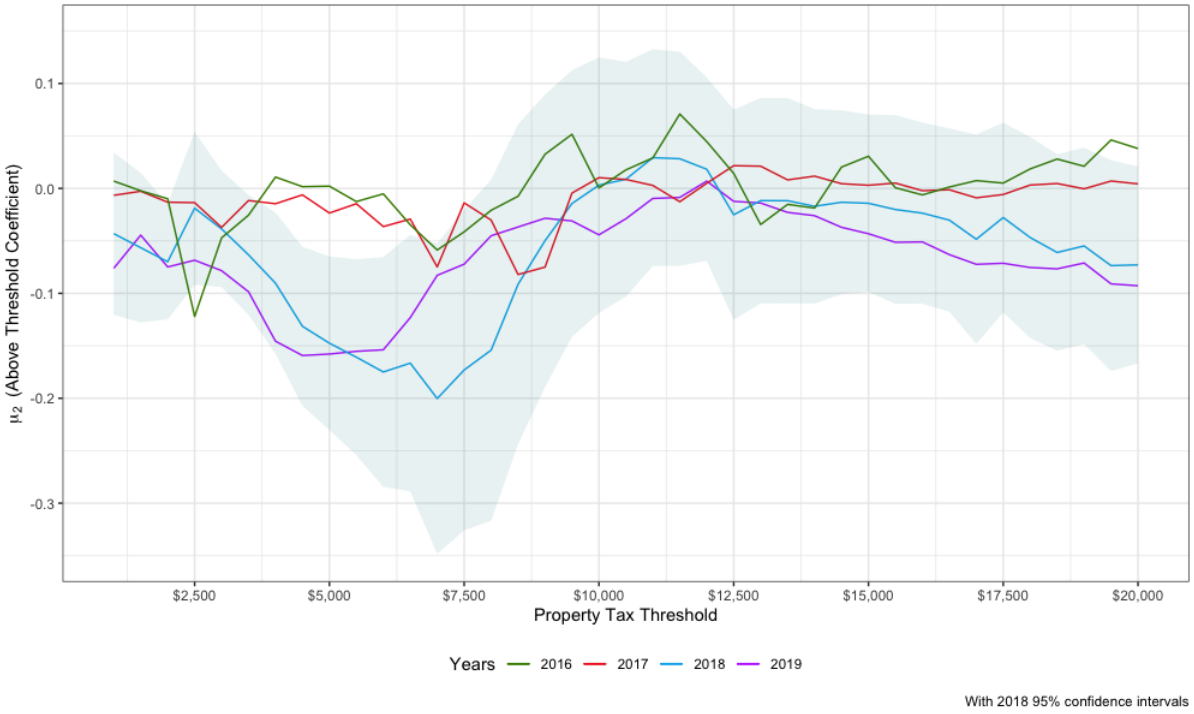


Figure B.3: Threshold Estimation μ_{1t} Coefficients With Municipality Fixed Effects

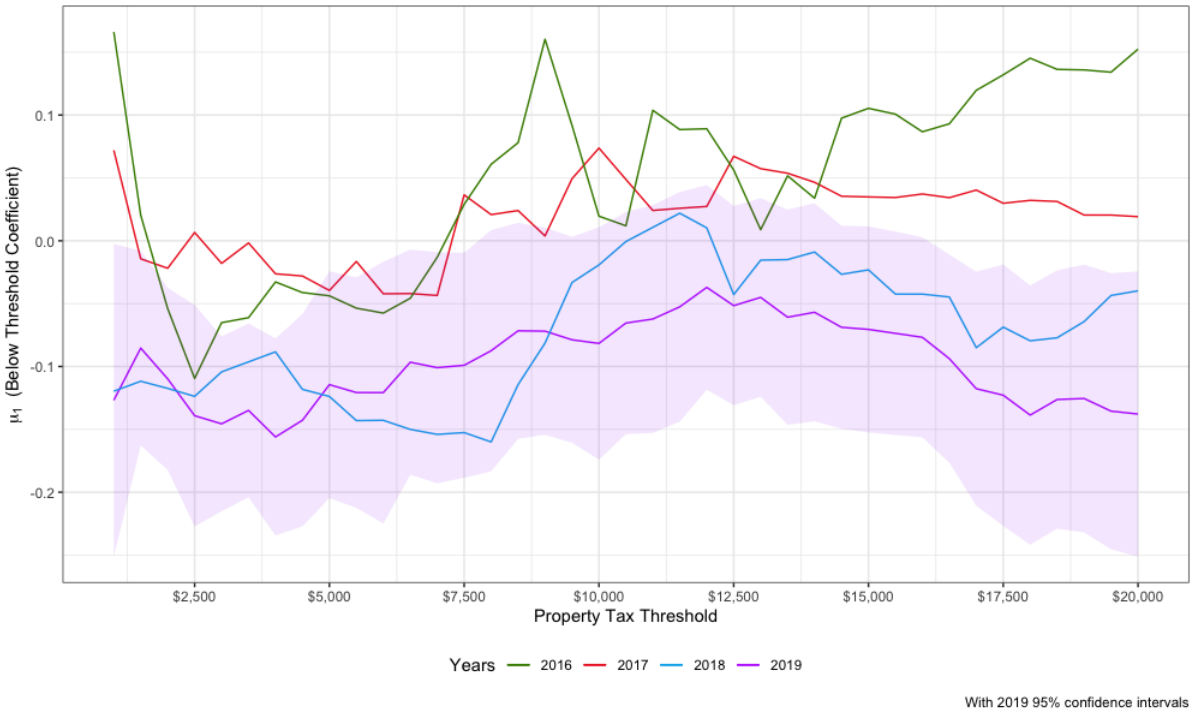


Figure B.4: Threshold Estimation μ_{1t} Coefficients With Municipality Fixed Effects

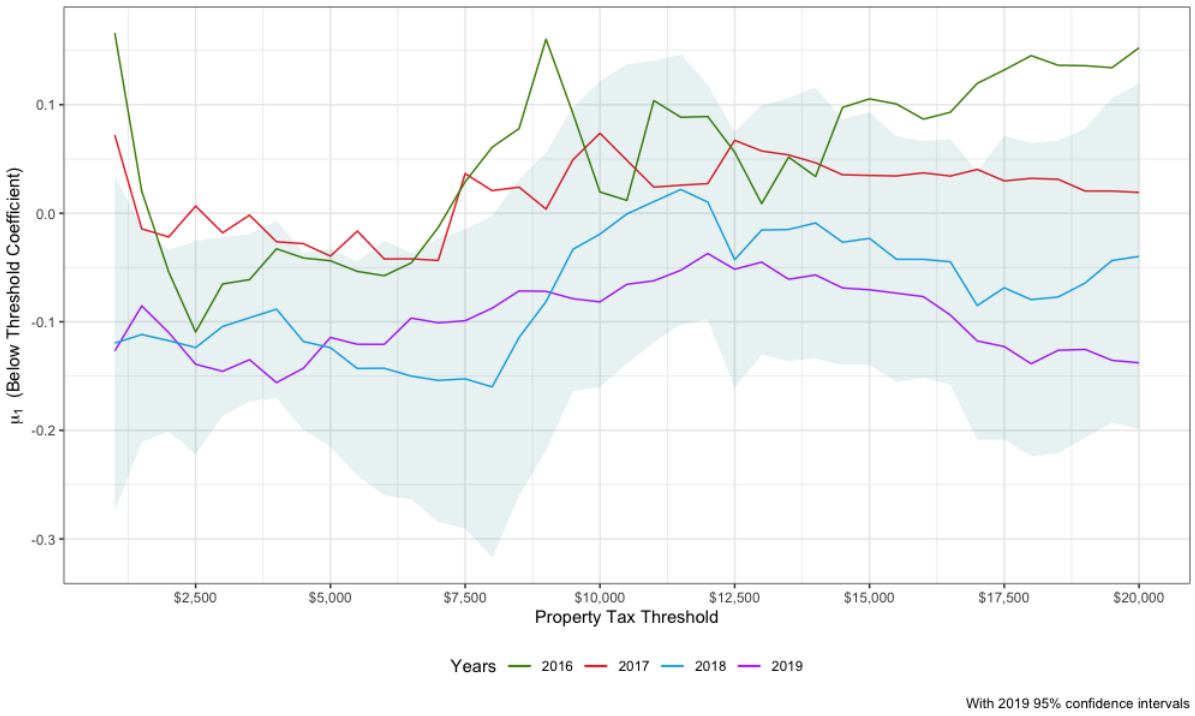
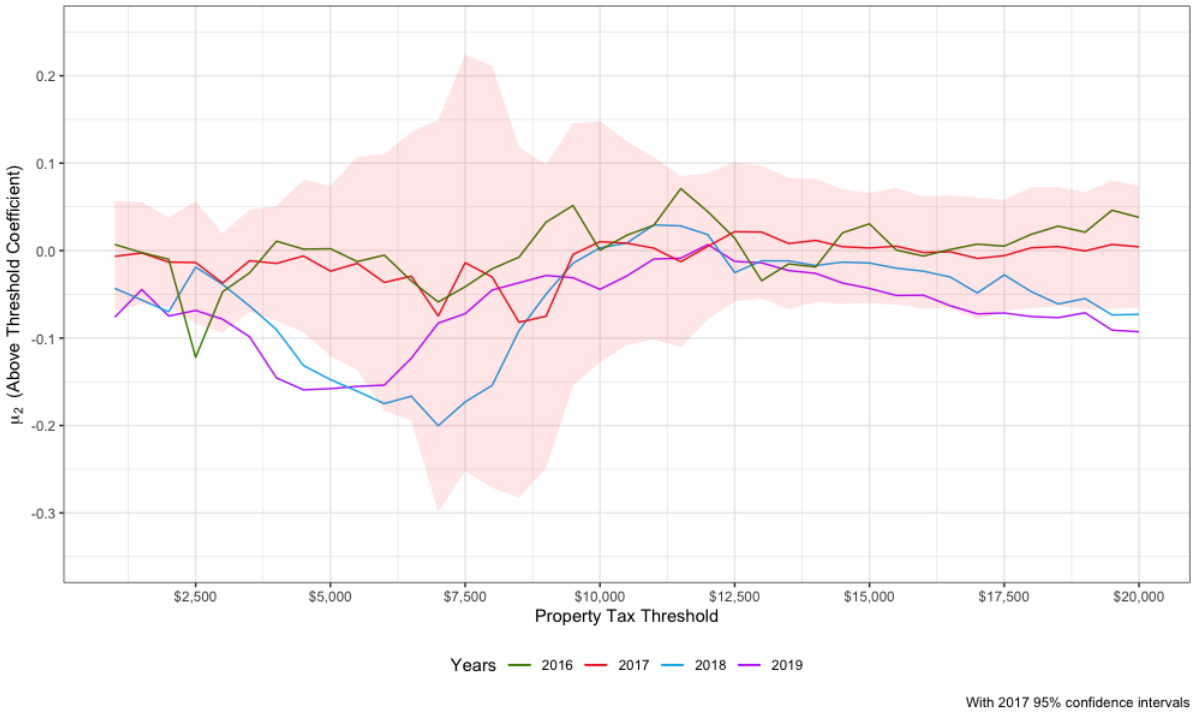
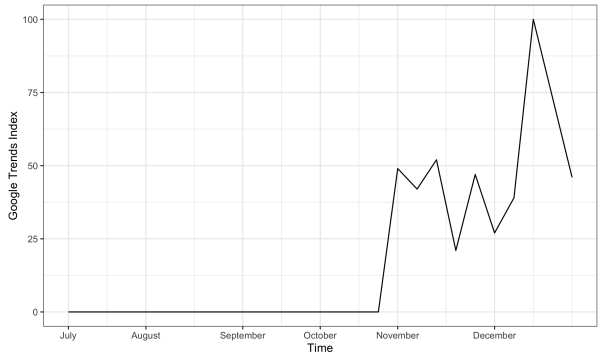


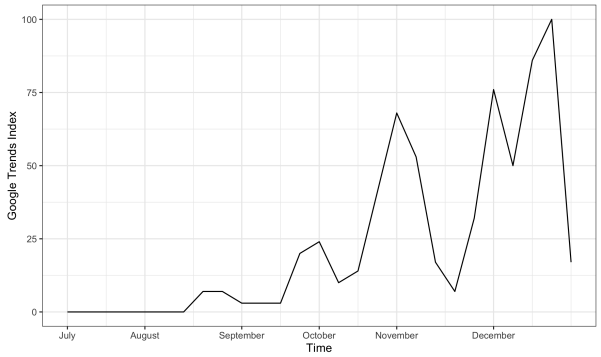
Figure B.5: Threshold Estimation μ_{2t} Coefficients With County Fixed Effects



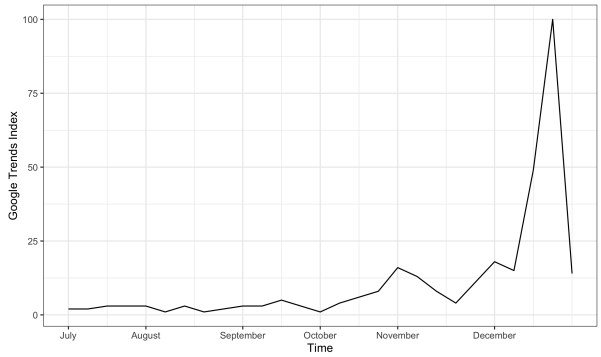
(a) Searches For "Tax Cuts and Jobs Act"



(b) Searches For "State and Local Tax Deductions"



(c) Searches For "Property Tax Deduction"



(d) Searches For "Home Mortgage Interest Deduction"

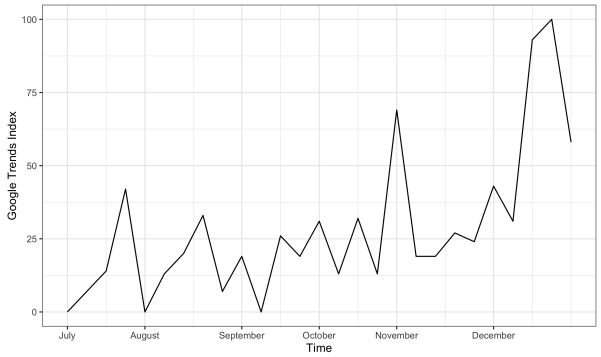


Figure B.6: Google Trends Searches in 2017

B.1 Appendix Tables

Table B.1: Itemization Statistics by State (plus DC and US overall) in 2017

	Rank By Itemization	Fraction Itemizing	Mean Total Deductions	Mean Real Estate Tax Deductions	Mean Income Tax Deductions	Mean Mortgage Interest Deductions
Maryland	1	0.47	$29,400	$3,800	$9,600	$6,800
New Jersey	2	0.42	$33,100	$9,000	$9,800	$6,000
Connecticut	3	0.42	$35,700	$7,600	$12,600	$6,100
District of Columbia	4	0.41	$35,800	$3,600	$13,900	$7,200
Virginia	5	0.38	$28,400	$3,800	$7,600	$7,600
Massachusetts	6	0.38	$31,800	$6,200	$10,000	$6,800
Oregon	7	0.38	$28,200	$4,000	$9,400	$6,300
Utah	8	0.36	$27,600	$2,400	$6,500	$6,600
California	9	0.36	$39,100	$5,400	$14,200	$8,500
Minnesota	10	0.35	$27,500	$3,800	$9,700	$5,800
New York	11	0.35	$38,800	$6,900	$16,500	$5,000
Georgia	12	0.34	$28,200	$2,800	$6,700	$5,500
Colorado	13	0.34	$27,000	$2,800	$6,600	$7,900
Rhode Island	14	0.33	$25,200	$5,300	$7,000	$5,800
Delaware	15	0.33	$24,700	$2,700	$6,900	$6,700
Illinois	16	0.32	$27,600	$6,900	$6,200	$5,500
New Hampshire	17	0.32	$24,100	$7,300	$2,600	$6,300
Wisconsin	18	0.32	$23,800	$4,600	$7,200	$4,500
Washington	19	0.31	$26,700	$4,700	$900	$8,200
United States	20	0.31	$29,800	$4,700	$7,800	$6,100
Iowa	21	0.31	$23,400	$3,700	$6,700	$4,100
Hawaii	22	0.31	$27,400	$2,000	$8,100	$8,800
Arizona	23	0.30	$25,500	$2,600	$4,500	$6,700
Montana	24	0.30	$24,200	$2,900	$6,600	$5,400
Idaho	25	0.29	$25,400	$2,600	$6,900	$5,800
Pennsylvania	26	0.29	$25,100	$4,900	$6,600	$5,300
North Carolina	27	0.29	$25,400	$2,800	$6,700	$5,700
Nebraska	28	0.28	$25,900	$4,300	$6,900	$4,300
South Carolina	29	0.28	$25,100	$2,100	$6,500	$5,600
Vermont	30	0.28	$25,500	$5,900	$6,900	$5,200
Maine	31	0.27	$24,300	$4,500	$7,100	$5,200
Michigan	32	0.27	$23,600	$4,000	$5,900	$4,800
Alabama	33	0.27	$23,700	$1,200	$4,400	$5,000
Missouri	34	0.27	$25,400	$2,900	$6,800	$4,900
Kentucky	35	0.27	$23,000	$2,300	$7,600	$4,600
Nevada	36	0.27	$28,900	$2,600	$1,900	$6,900
Ohio	37	0.26	$22,900	$4,200	$6,300	$4,500
Kansas	38	0.26	$25,700	$3,600	$6,000	$4,600
Florida	39	0.26	$29,600	$4,300	$1,800	$5,700
Texas	40	0.26	$29,200	$5,800	$600	$5,300
Mississippi	41	0.24	$23,800	$1,700	$3,900	$4,000
Louisiana	42	0.24	$25,600	$1,900	$4,700	$5,000
Oklahoma	43	0.24	$27,900	$2,400	$5,400	$4,600
Indiana	44	0.23	$23,200	$2,300	$6,600	$4,800
Alaska	45	0.23	$21,400	$4,400	$400	$7,800
Arkansas	46	0.23	$29,500	$1,700	$7,300	$4,500
New Mexico	47	0.23	$23,500	$2,500	$4,700	$5,700
Wyoming	48	0.22	$31,900	$2,800	$2,400	$6,600
Tennessee	49	0.20	$24,700	$2,600	$1,200	$5,900
North Dakota	50	0.20	$24,600	$3,300	$2,900	$5,400
South Dakota	51	0.18	$27,000	$3,700	$1,200	$5,100
West Virginia	52	0.17	$22,900	$1,600	$7,500	$4,900

Source: IRS Statistics of Income
(Data Rounded to nearest $100)

Table B.2: Itemization Statistics by State (plus DC and US overall) in 2018

	Rank By Itemization	Fraction Itemizing	Mean Total Deductions	Mean Real Estate Tax Deductions	Mean Income Tax Deductions	Mean Mortgage Interest Deductions
Maryland	1	0.24	$30,300	$4,600	$11,100	$9,900
District of Columbia	2	0.22	$36,600	$4,300	$17,200	$12,100
Virginia	3	0.18	$32,600	$4,900	$9,700	$11,200
California	4	0.18	$39,100	$6,800	$18,500	$13,500
New Jersey	5	0.17	$32,300	$9,900	$13,200	$9,800
Connecticut	6	0.15	$38,100	$8,700	$18,400	$9,800
Utah	7	0.15	$37,900	$3,100	$8,400	$9,300
Massachusetts	8	0.15	$37,700	$7,100	$13,700	$11,000
Oregon	9	0.15	$31,500	$5,000	$12,500	$9,400
Hawaii	10	0.14	$32,400	$2,600	$9,800	$14,100
Georgia	11	0.14	$36,800	$3,900	$8,700	$8,100
Colorado	12	0.13	$35,700	$3,500	$9,000	$11,600
Washington	13	0.13	$36,700	$6,500	$1,200	$11,900
New York	14	0.12	$42,700	$9,300	$25,500	$9,900
Delaware	15	0.12	$30,200	$3,400	$9,500	$9,400
United States	16	0.11	$36,900	$6,000	$11,400	$9,800
Illinois	17	0.11	$35,800	$7,700	$10,700	$8,500
Minnesota	18	0.11	$33,000	$4,400	$14,000	$8,700
Arizona	19	0.11	$35,400	$3,400	$6,500	$9,700
Rhode Island	20	0.11	$29,200	$6,000	$9,200	$8,700
North Carolina	21	0.10	$33,800	$3,700	$9,400	$8,400
New Hampshire	22	0.10	$33,300	$8,500	$3,700	$9,000
Nevada	23	0.10	$44,500	$3,800	$3,100	$9,900
South Carolina	24	0.09	$34,400	$3,000	$9,000	$8,500
Texas	25	0.09	$39,400	$7,700	$1,000	$8,200
Florida	26	0.09	$43,400	$6,300	$3,100	$9,000
Idaho	27	0.09	$35,400	$3,600	$9,000	$8,600
Montana	28	0.09	$33,800	$3,800	$9,600	$8,100
Pennsylvania	29	0.09	$33,400	$6,200	$9,300	$8,100
Alabama	30	0.09	$35,500	$2,000	$6,800	$7,400
Oklahoma	31	0.08	$41,700	$3,300	$7,600	$6,200
Kansas	32	0.08	$37,400	$4,600	$10,500	$6,500
Wisconsin	33	0.08	$32,600	$5,400	$11,100	$6,700
Louisiana	34	0.08	$35,500	$2,600	$6,900	$7,300
Missouri	35	0.08	$37,300	$4,100	$9,300	$7,000
Mississippi	36	0.08	$32,600	$2,400	$5,700	$5,700
Alaska	37	0.08	$31,800	$5,500	$500	$10,100
Nebraska	38	0.08	$35,600	$4,500	$6,700	$5,900
Michigan	39	0.08	$34,000	$5,300	$9,000	$7,100
Iowa	40	0.08	$33,700	$4,300	$9,600	$5,600
Maine	41	0.07	$30,200	$5,400	$9,800	$7,800
New Mexico	42	0.07	$32,600	$3,300	$6,300	$8,100
Vermont	43	0.07	$32,700	$6,900	$11,400	$7,500
Arkansas	44	0.07	$54,900	$2,500	$11,400	$6,600
Ohio	45	0.07	$32,600	$5,100	$9,700	$6,600
Tennessee	46	0.07	$39,800	$3,600	$1,800	$8,600
Kentucky	47	0.07	$32,800	$3,400	$11,300	$7,100
Wyoming	48	0.06	$58,100	$4,500	$4,200	$8,800
Indiana	49	0.06	$35,300	$3,200	$10,400	$6,800
North Dakota	50	0.06	$42,000	$4,000	$5,100	$7,100
South Dakota	51	0.05	$49,800	$4,300	$2,000	$6,700
West Virginia	52	0.04	$31,200	$2,200	$10,800	$7,400

Source: IRS Statistics of Income
(Data Rounded to nearest $100)

Table B.3: Characteristics of Sales by Loss or Gain Relative to Prior Sale

	Sale Price		Previous Sale Price		Previous Sale Year		Number of Sales	
Deed Year	Loss	Gain	Loss	Gain	Loss	Gain	Loss	Gain
2014	$322,322	$447,447	$382,382	$379,379	2007	2007	2,422	2,397
2015	$318,318	$440,440	$371,371	$370,370	2009	2007	2,626	3,112
2016	$307,307	$426,426	$359,359	$357,357	2010	2007	2,638	3,941
2017	$300,300	$421,421	$349,349	$351,351	2011	2007	2,499	5,269
2018	$305,305	$416,416	$353,353	$344,344	2011	2007	2,849	6,924
2019	$313,313	$399,399	$358,358	$331,331	2012	2007	3,050	8,099

Table B.4: Alternative Minimum Tax Schedule

	Type of Filer			
	Single	Married Filing Jointly	Head of Household	Married Filing Separately
	Pre Tax Cuts and Jobs Act (2017)			
Exemption	$54,300	$84,000	$54,300	$42,250
26% Bracket Maximum	$187,800	$187,800	$187,800	$93,900
28% Bracket	>$187,800	>$187,800	>$187,800	>$93,900
Exemption Phaseout Threshold	$120,700	$160,900	$120,700	$80,450
	Post Tax Cuts and Jobs Act (2018)			
Exemption	$72,900	$113,400	$72,900	$56,700
26% Bracket Maximum	$197,900	$197,900	$197,900	$98,950
28% Bracket	>$197,900	>$197,900	>$197,900	>$98,950
Exemption Phaseout Threshold	$518,400	$1,036,800	$518,400	$518,400

APPENDIX C

Appendix to Chapter 3

C.1 Appendix Figures

Figure C.1: Number of New Jersey Residential Homes in 2018 By Property Tax Level

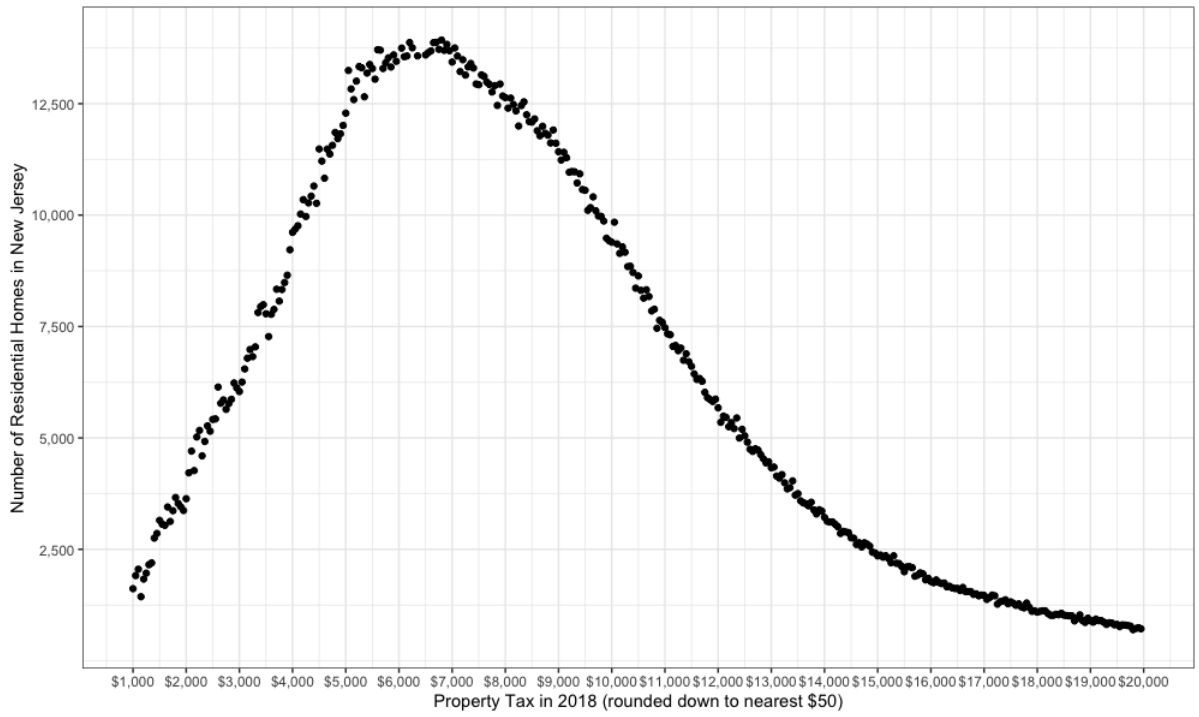


Figure C.2: Percent of New Jersey Residential Homes Sold in 2018 By Property Tax Level

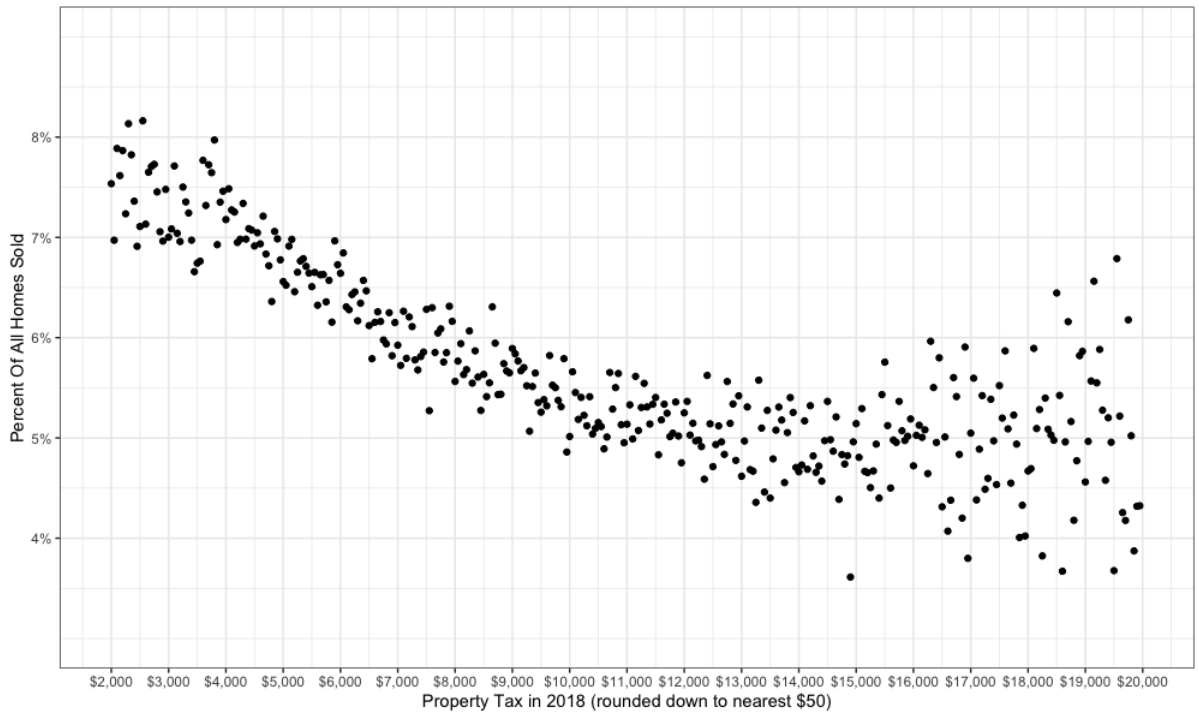


Figure C.3: Number of New Jersey Residential Homes in 2018 By Property Tax Level Modulo $1,000

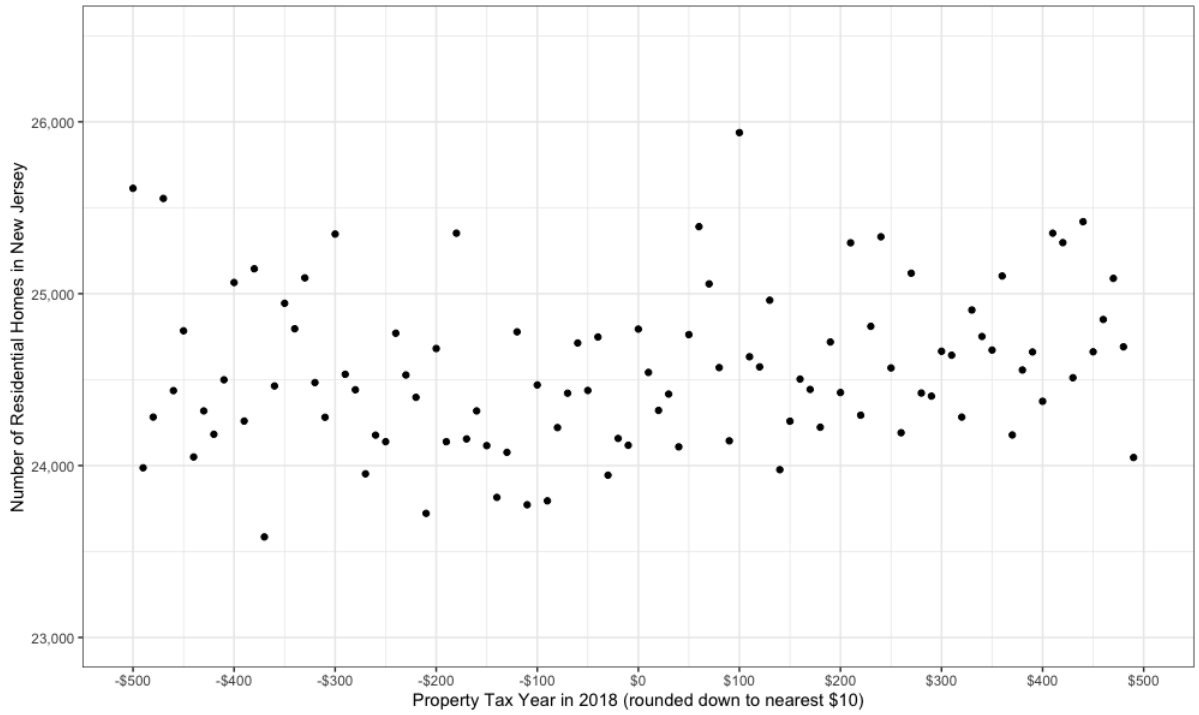


Figure C.4: Percent of New Jersey Residential Homes Sold in 2018 By Property Tax Level Modulo $1,000

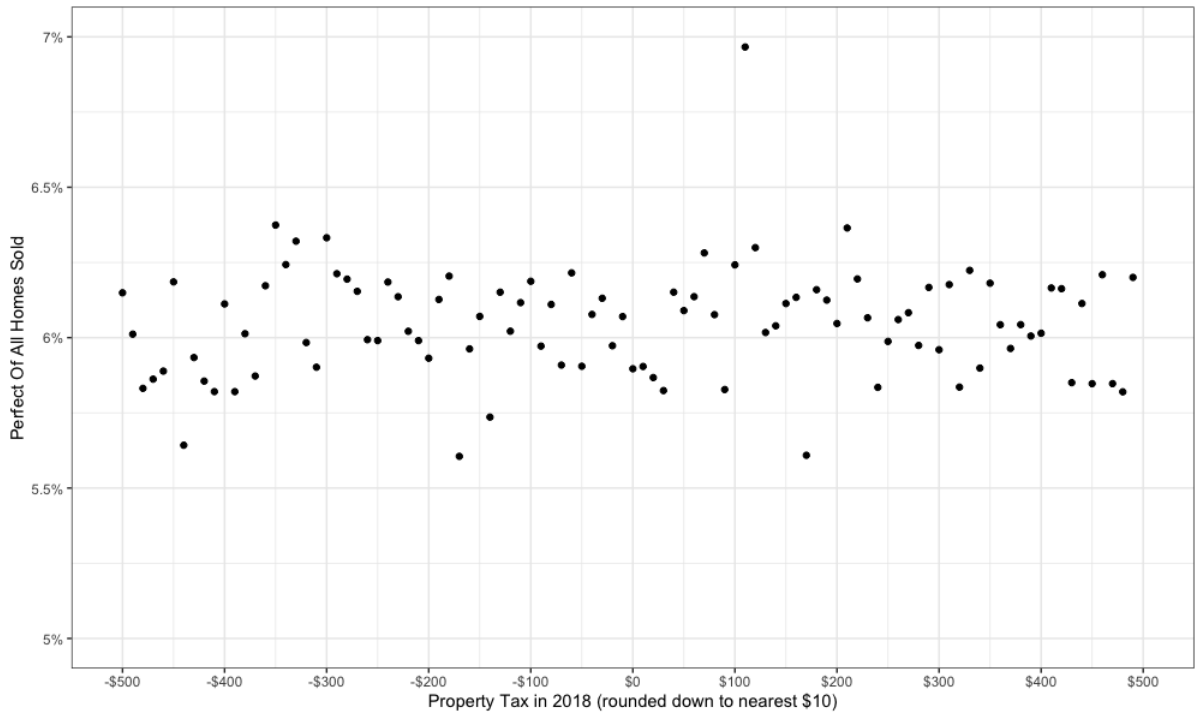
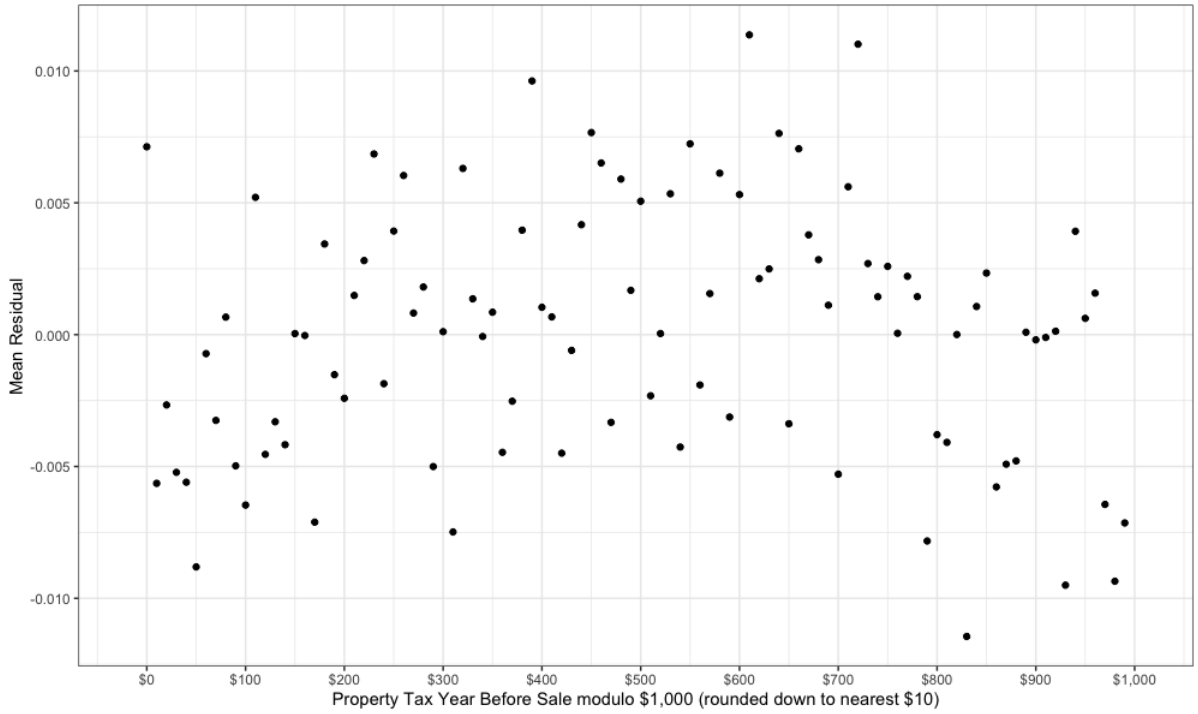


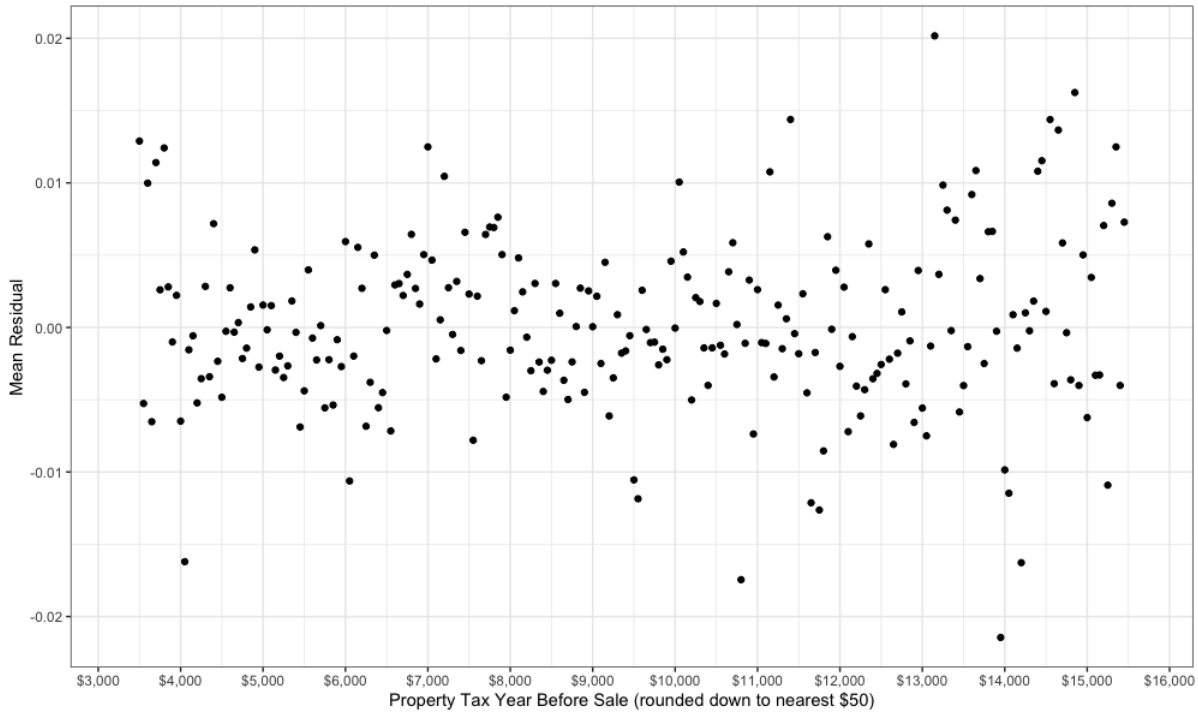
Figure C.5: Mean Residuals After Controlling for Observable Home Characteristics

By Property Tax Level Modulo $1,000



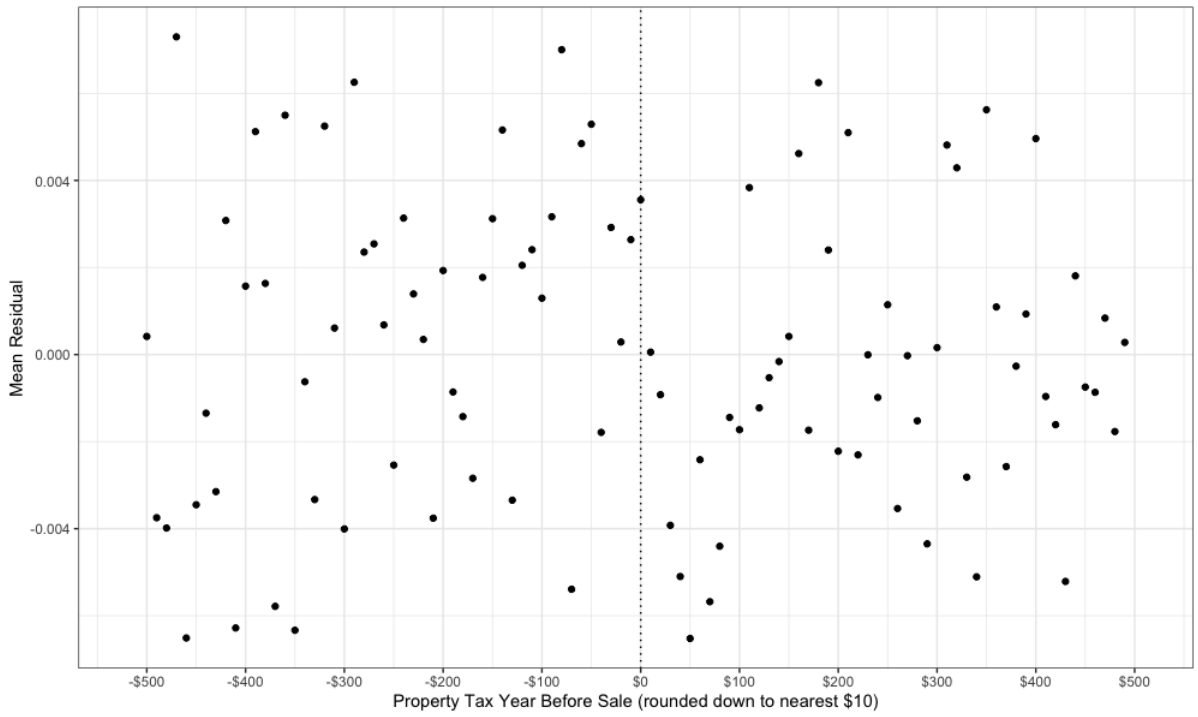
This figure uses the same data as figure 3.3 except that only the last three digits of the property tax are included (so it is the property tax modulo $1,000). There appears to either be no relationship between the residual and the property tax modulo $1,000 or perhaps a small inverse U-shaped relationship, where property taxes near the nearer to the edge of $1,000 have somewhat lower residuals.

Figure C.6: Mean Regression Residuals Fourth Order Polynomials Within Each $50 Property Tax Bin



To address potential misspecification issues, Figure C.6 shows the residuals from estimating 3.5.1 with additional fourth order log(Prop $\text{Tax}_{i,j,t-1}$) polynomial terms and without the $1,000 property tax dummies. It is the alternative specification equivalent to Figure 3.6. The inverse U-shaped relationship that existed in 3.6 is no longer present in this case.

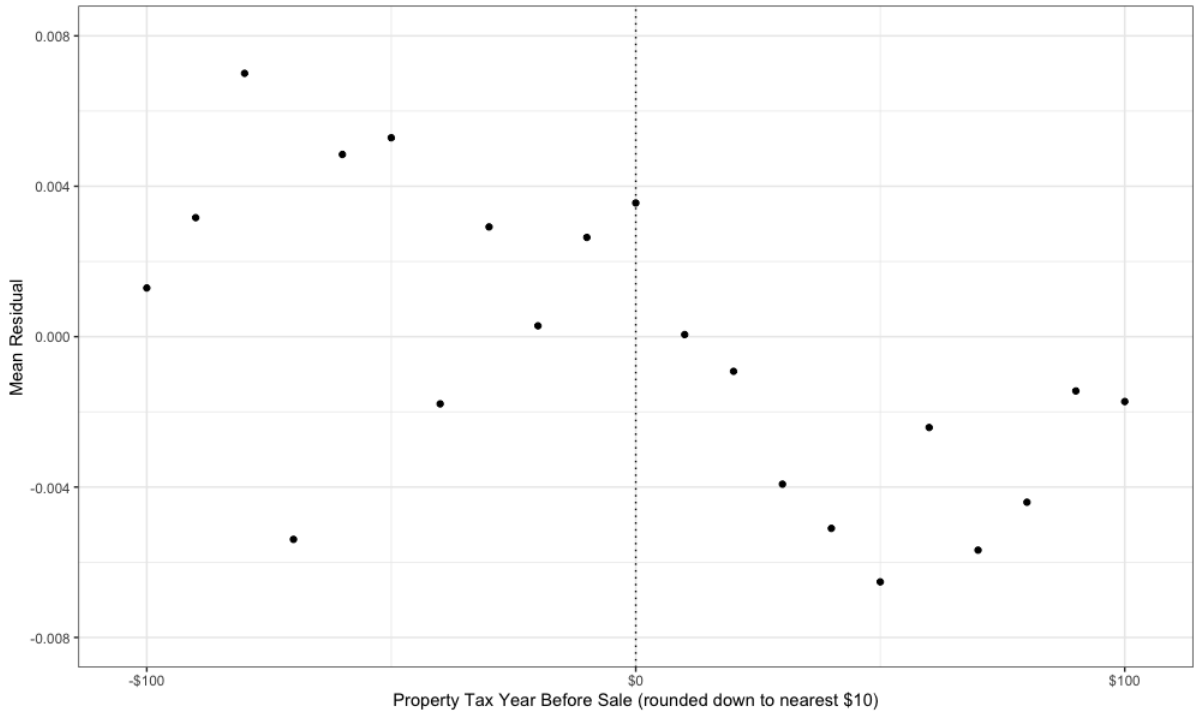
Figure C.7: Mean Regression Residuals Within Each $10 Property Tax Bin (modulo $1,000)



Centered at $0 for clearer visualization of left digit

To address potential misspecification issues, Figure C.7 shows the residuals from estimating equation 3.5.1 with additional fourth order $\log(\text{Prop Tax}_{i,j,t-1})$ polynomial terms and without the $1,000 property tax dummies. It is the alternative specification equivalent to Figure 3.7. As in Figure 3.7, there does not appear to be a systematic relationship between the last three digits of a home's property tax and the unexplained portion of the sale price.

Figure C.8: Mean Regression Residuals Within Each $10 Property Tax Bin (modulo $1,000 and within $100 of $1,000 threshold)



Centered at $0 for clearer visualization of left digit

To address potential misspecification issues, Figure C.8 shows the residuals from estimating equation 3.5.1 with additional fourth order $\log(\text{Prop Tax}_{i,j,t-1})$ polynomial terms and without the $1,000 property tax dummies. It is the alternative specification equivalent to Figure 3.7. As in Figure 3.7, homes with property taxes just under a thousand dollar threshold have average higher residuals than homes with property taxes just over a thousand dollar threshold.

C.2 Appendix Tables

Table C.1: Estimating Equation 3.5.2 With Additional Polynomial Terms

	Dependent Variable: log(Sale Price)				
	(1)	(2)	(3)	(4)	(5)
Property Tax within $100 of $1,000 threshold	0.002114	0.001930	0.001850	0.002232	0.002467
	(0.001438)	(0.001383)	(0.001374)	(0.001432)	(0.001353)
Property Tax modulo $1,000 under $100	-0.005149**	-0.004865**	-0.004640*	-0.005013**	-0.005099**
	(0.001890)	(0.001816)	(0.001821)	(0.001849)	(0.001674)
Muni x Deed Year F.E.	Yes	Yes	Yes	Yes	Yes
Sq. Feet and Year Built	No	Yes	Yes	Yes	Yes
log(Prop Tax) x Muni F.E.	No	No	Yes	Yes	Yes
log(Prop Tax) x Muni x Deed Year F.E.	No	No	No	Yes	Yes
Sq. Feet and Year Built x Muni x Deed Year F.E.	No	No	No	No	Yes
R2	0.8868	0.8891	0.8925	0.8950	0.9011
Number of Observations: 182,790					

To address potential misspecification issues, Table C.2 shows the results from estimate equation 3.5.2 with additional fourth order log(Prop $\text{Tax}_{i,j,t-1}$) polynomial terms. The results are very similar as in 3.3 and continue to be statistically significant.

Table C.2: Estimating Equation 3.5.1 With Additional Polynomial Terms

	Dependent Variable: log(Sale Price)				
	(1)	(2)	(3)	(4)	(5)
Prop. Tax > Than $4,000	-0.01113	-0.01219*	-0.01295*	-0.01670**	-0.01625**
	(0.006113)	(0.005812)	(0.006001)	(0.006094)	(0.005696)
Prop. Tax > Than $5,000	-0.006043	-0.006321	-0.005659	-0.007030	-0.005626
	(0.004676)	(0.004518)	(0.004190)	(0.004187)	(0.003866)
Prop. Tax > Than $6,0001	-0.002823	-0.001740	0.0007887	0.0004705	0.00003448
	(0.003010)	(0.003032)	(0.002946)	(0.002864)	(0.002681)
Prop. Tax > Than $7,000	0.0006145	0.0008955	0.001859	0.002495	0.001207
	(0.002456)	(0.002390)	(0.002315)	(0.002331)	(0.002180)
Prop. Tax > Than $8,000	-0.006277**	-0.005697*	-0.005783*	-0.004715*	-0.005399*
	(0.002357)	(0.002396)	(0.002435)	(0.002381)	(0.002277)
Prop. Tax > Than $9,000	-0.004272	-0.003542	-0.003836	-0.003394	-0.002883
	(0.002281)	(0.002116)	(0.002059)	(0.002074)	(0.002026)
Prop. Tax > Than $10,000	-0.001370	-0.001020	-0.0009965	-0.0009655	-0.0002686
	(0.002213)	(0.002219)	(0.002305)	(0.002278)	(0.002228)
Prop. Tax > Than $11,000	0.0008553	0.001019	-0.0002435	-0.001004	-0.002061
	(0.002796)	(0.002750)	(0.002795)	(0.002741)	(0.002550)
Prop. Tax > Than $12,000	-0.0003002	-0.0001584	-0.002514	-0.003462	-0.003686
	(0.003352)	(0.003318)	(0.003124)	(0.003231)	(0.003358)
Prop. Tax > Than $13,000	0.004575	0.004684	0.003914	0.002136	0.002220
	(0.003317)	(0.003339)	(0.003245)	(0.003031)	(0.003067)
Prop. Tax > Than $14,000	0.002719	0.002023	0.00004429	-0.001592	-0.002169
	(0.004668)	(0.004556)	(0.004230)	(0.004421)	(0.004188)
Prop. Tax > Than $15,000	0.002243	0.003247	0.0009307	-0.001679	-0.001937
	(0.003885)	(0.003878)	(0.004045)	(0.004226)	(0.004086)
Muni x Deed Year F.E.	Yes	Yes	Yes	Yes	Yes
Sq. Feet and Year Built	No	Yes	Yes	Yes	Yes
log(Prop Tax) x Muni F.E.	No	No	Yes	Yes	Yes
log(Prop Tax) x Muni x Deed Year F.E.	No	No	No	Yes	Yes
Sq. Feet and Year Built x Muni x Deed Year F.E.	No	No	No	No	Yes
R2	0.8868	0.8891	0.8925	0.8950	0.9011
Number of Observations: 182,790					

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

To address potential misspecification issues, Table C.2 shows the results from estimate equation 3.5.1 with additional fourth order log(Prop $\text{Tax}_{i,j,t-1}$) polynomial terms. Adding this term does reduce the number of statistically significant coefficients, but overall all but three coefficients have negative signs. However, Table shows that the discontinuity results are essentially the same as in the non-polynomial estimation.

Table C.3: Estimating Equation 3.5.2 By Prevalence of Rentals

	Dependent Variable: log(Sale Price)		
	High Fraction Rentals	Middle Fraction Rentals	Low Fraction Rentals
	(1)	(2)	(3)
Property Tax within $100 of $1,000 threshold	0.002308	0.001925	0.002480
	(0.003470)	(0.001785)	(0.001574)
Property Tax modulo $1,000 under $100	-0.005851	-0.001637	-0.005504*
	(0.003712)	(0.002407)	(0.002661)
Fraction Of Homes Tenant Occupied	$> 40\%$	15-40%	$< 15\%$
Muni x Deed Year F.E.	Yes	Yes	Yes
Sq. Feet and Year Built	Yes	Yes	Yes
log(Prop Tax) x Muni F.E.	Yes	Yes	Yes
log(Prop Tax) x Muni x Deed Year F.E.	Yes	Yes	Yes
Sq. Feet and Year Built x Muni x Deed Year F.E.	Yes	Yes	Yes
R2	0.8755	0.9229	0.9101
Number of Observations	53,046	63,352	67,027

Table C.3 shows the results from estimating Equation 3.5.2 separately by the fraction of residential homes that were tenant-occupied (rather than owner-occupied) in the observed home's municipality in the year of the home sale as estimated by the American Community Survey Five Year Estimates. The estimates have been divided approximately into thirds. Only the low rentals estimate is statistically significant from zero. This suggests that households purchasing a home maybe more susceptible to this form of left digit bias than professional landlords.

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