Mad as Hell: Property Taxes and Financial Distress

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Abstract

Taxes on land and property are efficient in theory but uniquely unpopular in practice, and have been curtailed in 46 states. Unlike other taxes, property taxes may create financial distress when rising home values raise property tax bills but not incomes. I find that even modest tax hikes create distress: a $50 monthly tax hike increases mortgage delinquency by 9% and reduces auto consumption by $15. Homeowners report being able but unwilling to draw on housing wealth, and cite debt aversion as a key factor. Distortionary income-based relief reduces property tax animus, which is concentrated in counties that do not limit how much rising home values can raise property taxes. These findings suggest that financial distress makes efficient property taxation politically infeasible.

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"Many people don't understand that property taxes have absolutely no relation to a property owner's ability to pay... those of us in the tax movement decided that our efforts must be directed toward bringing all taxes—but especially property taxes—down to a level where most people could pay them without undue hardship"

Howard Jarvis, progenitor of CA Proposition 13, *I'm Mad as Hell* (1979)

Since the 19th century, influential economists have viewed taxes on land and immobile property as more efficient than other forms of taxation (George 1879, Tiebout 1956).[1] US property taxes provide one-third (over $500 billion) of state and local government tax revenue and directly fund many popular benefits such as public schools. Yet property taxes are America's most despised tax.[2] Starting with California's 1978 tax revolt and passage of Proposition 13, 46 states have limited the ability of local governments to tax property (Paquin 2015).[3]

In public discourse, a common rationale for limiting property taxes is that property tax increases, particularly those associated with rising home values, may occur even if homeowner income remains unchanged. Consequently, property taxes can create financial distress among liquidity-constrained homeowners. However, the idea that property taxes create financial distress is difficult to reconcile with standard economic theories. Even in models in which moving houses is costly, property taxes do not create financial distress because homeowners can convert housing wealth into liquidity by borrowing against their homes.[4]

This study is the first to simultaneously measure homeowner consumption, delinquency, and borrowing responses to property taxes using high-frequency administrative data. Quasi-experiments show that property tax hikes create financial distress. Homeowners do not borrow against their homes to pay taxes, citing debt aversion as a key reason for not doing so. Survey experiments show that income-based tax relief increases support for property taxes, suggesting that distortionary modifications to pure property taxes may be needed to ensure their political sustainability.

Guided by economic theory, research on property taxes has historically mostly ignored financial distress. In addition, studies of homeowner responses to property taxes have faced two major challenges. First, quasi-experimental variation in property tax liabilities tends to be small, limiting the use of variation over time. Second, few data sources link outcomes measuring consumption and financial distress to property tax liabilities at the individual level.

This study overcomes those challenges by using quasi-experimental variation from property reassessments in nine states between 2006 and 2015. Property reassessments are instances in which

[1] Henry George viewed taxes on land as ideal because land is immobile capital. Moreover, taxes on land supposedly encourage landlords to use the land for its most productive purpose (George 1879). Tiebout (1956) inspired the subsequently prominent "benefit view", which conceives of property taxes as producing no welfare costs because homeowners can sort across jurisdictions to select their preferred bundle of taxes and amenities (Hamilton 1975).

[2] Opinion surveys over the last fifty years have consistently shown that property taxes are more unpopular than state and federal income, payroll, sales, and gasoline taxes (Cabral and Hoxby 2012).

[3] Property tax limits often create severe revenue shortfalls: one estimate finds that California lost $30 billion in 2018 alone (Zillow 2018).

[4] This is especially true when increases in property taxes are driven by increases in house price growth. This can be seen in models that incorporate secured borrowing, house price growth, property taxes, and fixed costs from moving (e.g. Kaplan et al. 2017).

a local government updates the taxable value of property within its borders to reflect recent house price growth. Most governments conduct reassessments at a less than annual frequency. These infrequent reassessments can produce large changes to taxable property values and annual tax bills. This study analyzes consumption, delinquency, and borrowing responses to property tax increases by leveraging a novel data merge of credit bureau records, mortgage servicing records, and local property tax records. Using the monthly servicing data, I am able to isolate the precise month in which property tax payments increase for homeowners who pay their taxes in monthly installments with their mortgage payments (about four in five homeowners with mortgages).

I use an event study methodology to examine homeowner responses around the month that property taxes increase. This approach assumes that homeowners with small increases in property taxes and homeowners who have not yet experienced increases in property taxes represent a valid counterfactual for the potential outcomes of homeowners with large increases in property taxes. I find that a $50 increase in monthly tax payments generates a 9% increase in mortgage delinquency and a reduction in auto consumption with a marginal propensity to consume of 0.15 after one year. In theory, homeowners could draw on their housing wealth by taking out a second mortgage or refinancing their existing mortgage; however, I find no adjustment on these margins. Surprisingly, consumption responses are highest among homeowners with large amounts of housing wealth and with high credit scores, suggesting that credit and liquidity constraints are not solely responsible for the financial burden of property taxes. Effects on mortgage delinquency are strongest among homeowners with less housing wealth and with lower credit scores.

Why don't homeowners draw on their housing wealth in response to property tax increases? Even if property tax increases were not accompanied by increases in housing wealth, homeowners should want to avoid delinquency.[5] Standard economic reasoning suggests that financial frictions (e.g. transaction costs, limited credit supply, or information frictions) may prevent homeowners from borrowing against their housing wealth. However, it is difficult to rationalize the large consumption responses exhibited by financially unconstrained homeowners with these frictions alone. An alternative hypothesis is that homeowners may have a preference for avoiding additional indebtedness (i.e. debt aversion). I conduct a novel online survey of 3,000 US homeowners in order to test this hypothesis. 77% of respondents say they would not take out a second mortgage even if they had difficulty paying property taxes. The majority of those respondents (67%) would not do so because they feel uncomfortable being in debt. A minority of respondents name transaction costs (33%), credit supply (12%), or a lack of knowledge (4%) as reasons for not taking out a second mortgage. These findings represent an important contribution of this study: preference-based debt aversion is the key stated reason why homeowners do not draw on their housing wealth to pay their property taxes.[6]

Debt aversion also prevents homeowners from taking up a zero-interest loan to pay their property

[5]Delinquency triggers a 5% late fee in most mortgage contracts, meaning that missing mortgage payments represents a very costly form of borrowing. Prolonged delinquency ultimately results in foreclosure and eviction.

[6]Debt aversion is a very different explanation for homeowner illiquidity than those proposed in previous research, which has typically focused on the role of large fixed costs (Chetty and Szeidl 2007, Kaplan and Violante 2014).

taxes. Property tax deferrals are a common form of tax relief which allow homeowners to postpone paying property taxes (with interest) until they eventually transact their property. These policies are theoretically appealing because they allow homeowners to avoid becoming liquidity constrained without creating substantial economic inefficiencies. In the survey, 42% of respondents say that they would never defer their property taxes, even at zero interest. 61% of those who would never defer say that they would not want to feel like they were in debt, indicating that debt aversion is a key deterrent to the effectiveness of tax deferrals. These results help explain the lack of success of property tax deferral policies in the US. Thirty-one states offer taxpayers some form of property tax deferral; however, even in places where eligibility criteria are broad, take-up of property tax deferrals tends to be very low.[7]

I use the survey of homeowners to explore policies that can make property taxes less unpopular and find that aligning property taxes with homeowner incomes may substantially improve attitudes towards property taxes. I conduct a randomized information treatment that informs respondents in Michigan about their state's income-based tax relief program. This policy lowers property taxes for over one million taxpayers. Receiving randomized information about this policy reduces the probability that a respondent identifies the property tax as the worst tax by 7 percentage points (a 24 percent reduction). This finding supports the idea that financial distress among illiquid homeowners generates animus towards property taxes. If this reduction were applied to nationwide attitudes, the property tax would no longer be the most unpopular tax.

The revealed links between property taxes, financial distress, and property tax animus help to explain the historical unpopularity of property taxes. I show that enactments of statewide property tax limits are concentrated in periods of rapid local house price growth. These are precisely the circumstances under which illiquid homeowners would have experienced financial distress due to the misalignment of property taxes and income flows. Moreover, survey data indicate that property tax animus is concentrated in counties in which rapid house price growth led to higher property tax burdens, but not in similar counties where local tax policies prevented house price growth from increasing property taxes.

An influential literature argues that property tax revolts such as Proposition 13 reflected the desire of taxpayers to restrain government expenditures (Fischel 1989, Cutler et al. 1999). The survey of homeowners does not point to a misalignment of voter preferences and the size of government revenues and expenditures as a contemporary contributor to homeowner animus towards property taxes. Respondents appear to hold broadly positive attitudes towards local government. Cabral and Hoxby (2012) argue that the salient nature of property taxes makes them particularly painful compared to sales or income taxes. However, I find that property taxes cause financial distress even among homeowners who pay property taxes in less-salient monthly installments.

Studies of tax incidence in public economics rarely focus on financial distress. Economists have debated the incidence of the property tax for decades, but financial distress is not represented in

[7]For instance, the state of Washington offers a partial deferral of property taxes for homeowners with income less than $57,000 as well as a full deferral for elderly individuals. In 2017, total take-up statewide was less than 600 households (Oline 2018).

most models of property tax incidence. The "benefit view" holds that property taxes do not incur economic costs because households are mobile and value amenities funded by property taxes (Oates 1969, Hamilton 1975). In contrast, the "capital tax view" of property taxes identifies the existence of efficiency losses due to capital flight (Mieszkowski 1972, Zodrow 2001, 2007), but financial distress is not a source of inefficiency in this view. In both of these theories, the finding that property taxes create financial distress is surprising and suggests unmodeled sources of inefficiency.

Recent empirical studies have found evidence that property taxes meaningfully impact household finances, including impacts on labor supply (Shan 2010, Zhao and Burge 2017) and property tax non-payment (Waldhart and Reschovsky 2012, Bradley 2013). Brockmeyer et al. (2020) find that liquidity is an important factor mediating property tax compliance in Mexico City, and use survey data to show that property tax hikes reduce consumption. Most relevant for this study, Anderson and Dokko (2008) find that the timing of subprime borrowers' first property tax bill impacts mortgage delinquency, and Hayashi (forthcoming) finds evidence that tax cuts in Maryland during the height of the Great Recession modestly reduced mortgage default filings against homeowners and stimulated aggregate auto consumption.[8] I use high-frequency data on mortgage payments and a quasi-experimental research design validated by common trends to show that property tax shocks have large impacts on mortgage delinquency and default.

Property taxes are the predominant form of wealth taxation in the US. Wealth taxes have received recent interest in policy circles (Sanders 2019, Warren 2019) and academic research (Seim 2017, Jakobsen et al. 2018, Avila and Londono-Velez 2019). Opponents of wealth taxation have claimed that wealth taxes levied on both very wealthy and moderately wealthy individuals impose heavy and unfair burdens on the latter group, whose assets are relatively illiquid (Sarin and Summers 2019, Saez and Zucman 2019). This study's findings lend credence to the view that even the moderately wealthy can experience financial distress from taxes on illiquid wealth. Hence, sustaining a wealth tax may require exemptions for moderate levels of wealth or illiquid assets.[9]

The remainder of this paper proceeds as follows. Section 1 provides institutional background on property reassessments and property tax payments. Section 2 describes the dataset of merged credit bureau, mortgage servicing, and property assessment records. Section 3 discusses the empirical strategy. Section 4 presents the main empirical results. Section 5 presents results from the survey of homeowners and discusses the debt aversion mechanism. Section 6 concludes.

[8] My estimates of mortgage default are more than four times larger than those in Hayashi (forthcoming). Where Hayashi measures mortgage default using legal filings initiated by lenders (a relatively imprecise measure of borrower default), this study measures default using borrower payment decisions.

[9] Indeed, recent wealth tax proposals (Sanders 2019, Warren 2019) have set very high exemption thresholds ($32 million and $50 million, respectively). Recent proposals for annual "mark-to-market" capital gains taxes have included similar exemptions, such as requiring annual payments only on liquid-asset gains in the top 1% (e.g. Batchelder and Kamin 2019).

1 Institutional Background

1.1 Property Reassessments

Property taxes in the US provide about one-third of state and local government tax revenue, amounting to slightly more than $500 billion in 2016 (US Department of Commerce 2016b). Property taxes also represent a large share of homeownership costs: in 2016, homeowners paid an average of $3,000 in yearly property taxes (US Department of Commerce 2016b). One of the central challenges of property tax administration is repeatedly calculating the value of taxable property as it changes over time, a process known as property assessment or reassessment. Most residential property in the US is assessed by county or township governments under state-level policies that regulate property assessment. Because of the costly and time-consuming nature of the assessment process, most governments reassess property at a less than annual frequency.[10]

I focus on large-scale property reassessments in nine states: Connecticut, Illinois, Indiana, Missouri, New Hampshire, North Carolina, Ohio, Tennessee, and Washington. The goal of this study is to analyze instances in which increases in house price growth generated large increases in property tax liabilities. Each of these states conducted large-scale reassessments that are clearly identifiable in the administrative data, and in which a large number of properties were reassessed by local governments.

Reassessment protocols vary greatly across these states. In Connecticut, North Carolina, Ohio, and Tennessee (states that comprise 71% of the sample), property is assessed in regular cycles. For instance, counties in Ohio reassess all residential property every six years (with reassessment years varying by county). An example of this is shown in Figure 1, which illustrates the large changes in both assessed values and tax bills during the 2012 reassessment in Cuyahoga County, Ohio. Reassessments in the five states that do not adhere to regular cycles are more heterogeneous. For example, Indiana underwent a significant reform of assessment practices in 2006, generating large shifts in tax burdens due to reassessment. Appendix C contains a description of reassessment practices in each state.[11]

The main advantage of this setting is that it overcomes a common empirical challenge for studying homeowner responses to property taxes, which is the relative stability of property taxes over time in most other settings. Large-scale property reassessments offer ample variation in this regard. A second advantage of this setting is that it abstracts away from changes in local government revenues and expenditures. In other settings, increases in individual housing values and property tax bills correspond to increases in total government revenues and consequently in the level of

[10] Appendix Figure B1 illustrates the various frequencies at which local governments in the US are legally required to reassess property.

[11] The relationship between changes to assessed values and changes to property tax bills is positive and approximately linear. This relationship is not trivial. Hypothetically, if the value of all property within a jurisdiction were increased by a similar amount, the jurisdiction could maintain tax bills fixed by reducing property tax rates. As shown by example in Figure 1, this is often not the case due to substantial within-jurisdiction variation in house price growth. The positive and linear relationship is illustrated in Appendix Figure B3, which provides a density heat map of the relationship between changes to the tax bills and changes to assessed values for all properties in the main analysis sample.

expenditures on local public amenities, but this is not generally the case for large-scale property reassessments. Large-scale reassessments can create significant changes to individual assessed values and tax bills without greatly affecting total tax revenues. For example, in Cuyahoga County in 2012 most homeowners experienced reductions to their assessed value; however, as shown in Figure 1 the average change to property tax bills was close to zero. Because of the ability of local governments to adjust property tax rates, total local government revenues can remain relatively stable despite large changes to assessed values.

1.2 Property Tax Payments

Homeowners pay property taxes in one of two ways: directly to local taxing authorities (e.g. the county) or through escrow accounts. Escrow accounts are typically maintained by mortgage servicers and allow homeowners to pay their property taxes, homeowner's insurance, and mortgage insurance in monthly installments together with their monthly mortgage principal and interest payments. This offers homeowners the convenience of paying all of these expenses in one monthly transaction. Mortgage servicers then pay property taxes to the government on behalf of the homeowner. The share of mortgaged homeowners who pay property taxes in escrow has risen in recent years, from 70% in 2011 to 79% in 2017 (Corelogic 2017).

This study focuses on homeowners who pay property taxes through escrow accounts in order to estimate a monthly event study around the month that taxes increase. For these homeowners, I am able to isolate the timing of behavioral responses to property taxes, overcoming a key challenge faced by previous studies. By law, mortgage servicers are required to conduct an escrow analysis at least once a year. During an escrow analysis, servicers determine any account surplus or shortfall associated with changing tax or insurance amounts. Servicers then adjust the monthly escrow payment for the following twelve months accordingly. Because monthly escrow payments are constant in the twelve months between escrow updates, for most borrowers there exists a specific month in which the prior year's property tax increase begins to be reflected in monthly property tax payments. Consequently, I am able to estimate an event study around this same month.

Estimating a monthly event study for homeowners who pay their property taxes directly to the government is more challenging because it is harder to identify the exact month of the tax increase. Homeowners receive notices of assessment as well as separate tax bills many months before their tax bills are due. Moreover, tax bills often include secondary due dates. After the first due date, homeowners can pay by a later due date with a late penalty.[12] These considerations complicate the expected timing of behavioral responses for homeowners paying property taxes directly to local governments. While homeowners who pay property taxes through escrow accounts also receive multiple notifications in advance of changes to their property taxes, the results in this study demonstrate that the timing of the behavioral responses aligns with the month in which property taxes are reflected in monthly escrow payments.

Whether an individual pays their property taxes through an escrow account depends on both

[12]For instance, taxpayers in California face a 10% penalty for delinquent property taxes.

lender-specific and borrower-specific factors. Homeowners without mortgages generally do not pay property taxes through escrow accounts. Lenders are required to maintain escrow accounts for certain loans with high loan-to-value ratios and interest rates (CFPB 2019). In other cases, lenders may choose to offer escrow accounts. As discussed in Cabral and Hoxby (2012), this decision is likely to depend on the profitability of offering borrowers access to escrow accounts, and by extension on the extent of the lender's existing servicing operations. In general, the requirement to pay property taxes through an escrow account is a feature of mortgage contracts that is opaque to borrowers, and information about escrow accounts tends to be revealed late in the process of securing a mortgage (Cabral and Hoxby 2012). Particularly given the well-established lack of shopping across lenders on behalf of mortgage borrowers, there is likely little systematic self-selection of borrowers into mortgage contracts based on escrow requirements.[13]

2 Data

I analyze homeowner responses to property taxation by leveraging a novel data merge comprised of three components: credit bureau records from Equifax, McDash mortgage servicing records from Black Knight Financial Services, and property assessment and transaction records from ATTOM. The Equifax and McDash data are also known as CRISM and cover approximately 60% of the US mortgage market during the study period, 2005-2016. The Equifax credit bureau records contain a number of individual-level attributes measured at the monthly level that are used by Equifax to generate consumer credit reports. These data include information on both primary and secondary mortgages, credit card utilization, auto loans, and loan delinquency. The McDash mortgage servicing records contain loan-level characteristics such as original property value, original loan amount, and loan type. These records also contain monthly loan information including payment status, unpaid principal balance, principal and interest payment amounts, and escrow payment amounts. Together, the data from Equifax and McDash capture a wide array of individual financial behaviors.

The analysis relies on linking financial outcomes measured in CRISM with property tax liabilities measured in the ATTOM property assessment and transaction records. The ATTOM data are sourced from local property assessor and recorder offices and contain both annual property tax bills and property assessments. Loans in CRISM are merged to properties in ATTOM using a k-nearest neighbor algorithm which links records by original loan balances, property sale prices, and distress events (e.g. foreclosures).[14] This merge imbues observed annual property taxes and assessed values (the two variables used in the analysis that are derived from the ATTOM data) with measurement error. I discuss how I address the issue of measurement error in Section 3.

The main analysis sample is comprised of primary mortgage loans in the nine sample states in

[13] According to data from the National Survey of Mortgage Borrowers, almost half of borrowers only seriously considered one lender before applying for a mortgage (Alexandrov and Koulayev 2018).

[14] The transaction records from local recorder offices in ATTOM contain information on both sales and mortgages associated with properties. This merge was conducted by the Fisher Center for Real Estate and Urban Economics at the UC Berkeley Haas School of Business.

counties in which I observe the occurrence of a large-scale property reassessment.[15] Within each county, I restrict to observations in the highest tercile of merge quality associated with the k-nearest neighbors algorithm, drop observations where the percent change in the property tax bill is outside of -50% and 200%, and trim this variable at the 1% level. This process generates a sample of 261,577 unique loans across 10 reassessment years for a total of 299,545 loan-reassessment events.

Table 1 provides summary statistics on the analysis sample. As a result of the reassessment process, homeowners in the sample experience both large increases and decreases to their property tax bills: the 10th and 90th percentiles correspond to a 14% decrease and a 20% increase, respectively. When discussing results, I use "tax increases" as shorthand for "tax changes" since regression coefficients are readily interpreted in terms of tax increases.

3 Empirical Strategy

The main empirical strategy centers around estimating a monthly event study around a property tax increase. I focus on homeowners who pay property taxes through escrow accounts in order to isolate the month in which escrow payments increase to reflect tax increases after reassessment. Because escrow payment amounts are typically constant for twelve months following an annual update, it is straightforward to identify the month in which payments increase to reflect a tax increase.[16]

In order to identify the causal impact of increases in property taxes paid through escrow accounts, I use changes in annual property taxes measured in ATTOM as an instrument for changes in monthly escrow payments. Note that if one were to use observed changes to escrow payments alone, the estimates would be confounded by changes to insurance payments as well as property taxes. However, under the assumption that changes in insurance payments are uncorrelated with changes in property taxes due to reassessment, instrumenting with annual taxes isolates the causal impact of tax increases on homeowner outcomes.[17]

Formally, I estimate the causal impact of property taxes on homeowner outcomes using a two-stage least squares (2SLS) regression, in which I instrument for the level change in the monthly escrow payment using the percent change in the annual tax bill. The second stage is specified as:

$$y_{it} = \alpha_i + \gamma_{t,c(i)} + \sum_{k \neq -2} \beta_k 1[t = e_i + k](\Delta m_i) + \varepsilon_{it} \tag{1}$$

Outcomes of interest for homeowner i in month t are given by y_{it}. α_i and $\gamma_{t,c(i)}$ denote loan and county-by-month fixed effects, respectively. e_i denotes the month in which homeowner i experiences a tax increase and Δm_i denotes the dollar change in the monthly escrow payment between $k = -2$ and $k = 1$. Here, $k = 0$ corresponds to the month in which escrow accounts are updated

[15] I describe the process used to verify the occurrence of large-scale reassessments in Appendix C.1.

[16] See Appendix C.2 for a detailed explanation.

[17] This is a natural assumption given that property tax increases are not generally included as a factor in setting insurance premia.

to reflect property tax increases. I estimate Equation 1 by using $\{1[t = e_i + k](\Delta T_i)\}_{k \neq -2}$ as instruments for $\{1[t = e_i + k](\Delta m_i)\}_{k \neq -2}$, where ΔT_i denotes the percentage change in property taxes after reassessment.[18] The estimation is conducted using a monthly panel of loans balanced in $k \in [-12, 11]$.[19] Accordingly, I bin endpoints at $k = -12$ and $k = 11$ and cluster standard errors at the loan level.

The key assumption required to identify β_k, the effect of a tax increase k months after the increase occurs, is that the outcomes of homeowners with small increases in property taxes and homeowners who have not yet experienced increases in property taxes represent a valid counterfactual for the potential outcomes of homeowners who had large increases in property taxes. This assumption can be validated by evaluating the presence of common trends (i.e. whether $\hat{\beta}_k = 0$ for $k < 0$).

Beyond isolating the impact of tax increases separately from other components of escrow payments, this specification carries two advantages. First, it circumvents the issue of measurement error in ΔT_i, which is measured in the ATTOM data. With the exception of assessed values (which are used as an alternative to tax bills in robustness analyses), the remainder of the variables in Equation 1 do not carry measurement error from the data merge. Instrumenting with ΔT_i allows β_k to be interpreted without measurement error bias as the causal effect of a dollar increase in property taxes. The second advantage of this approach is that for dollar-valued outcomes, β_k can be interpreted in terms of marginal propensities to consume and borrow.[20]

The inclusion of county-by-month fixed effects restricts comparisons to homeowners within the same county. In the context of reassessments, the vast majority of the variation in property taxes within counties is driven by property reassessments rather than changes to tax rates. This can be seen when comparing the variation in property taxes in a reassessment year to that outside of a reassessment year (see Figure 1). The county-by-month fixed effects help to ensure that the analysis compares homeowners living in the same area who experienced differential changes to property assessments rather than differential changes in tax rates.

The analysis focuses on four primary sets of outcomes. The first stage regression estimates Equation 1 by OLS where the outcome is the dollar value of the monthly escrow payments. This first stage regression validates that annual property tax increases result in monthly escrow payment increases starting in the month of the escrow update. Second, I am interested in the consumption response to increases in property taxes. In order to construct a measure of consumption, I follow other studies that use credit bureau data (e.g. Di Maggio et al. 2017) and measure auto consump-

[18] The distribution of level changes in annual property taxes is highly skewed because higher valued properties experience larger level changes. Measuring ΔT_i in percentage terms better captures increases in property taxes that represent meaningful shocks to homeowner finances, relative to measuring changes in property taxes in dollar terms. The main advantage of measuring Δm_i in dollar terms is that it allows β_k to be interpreted in terms of marginal propensities to consume and borrow, simplifying the interpretation of the estimated coefficients.

[19] See Appendix C for more details on the construction of the monthly panel.

[20] An alternative approach would be to estimate a reduced form version of Equation 1 by OLS, using ΔT_i as the main regressor. I discuss the results of this exercise in the following section, which show that the results are unchanged when scaling the estimated coefficients by the first stage and that the 2SLS strategy scales effect sizes to net out measurement error.

tion as the difference in total auto balances between any two months in which auto balances increase by more than $5,000. This approach to measuring auto consumption assumes that a one-month increase in auto loan indebtedness of more than $5,000 represents the purchase of a new car.

Third, I evaluate the effects of property tax payments on mortgage delinquency and mortgage default. I define an indicator for mortgage delinquency that takes a value of 1 if the mortgage is thirty or more days past due and 0 if the mortgage is current. To measure mortgage default, I define an indicator that takes a value of 1 if the mortgage is ninety or more days past due and 0 otherwise. The distinction between mortgage delinquency and default is an important one. In the data, only a small minority (16%) of loans that are thirty days delinquent transition into deeper delinquency the following month, while almost half (47%) of loans that are ninety days delinquent transition into deeper delinquency or foreclosure.[21]

Fourth, I measure the response of home equity extraction to changes in property tax burdens. Homeowners can convert their housing wealth into liquidity through two types of loans. The first type is a junior-lien mortgage, which includes closed-end second mortgages and home equity lines of credit (HELOCs). Closed-end second mortgages offer borrowers a fixed amount of credit while HELOCs offer a rotating line of credit. Junior-lien mortgages are taken in tandem with primary mortgages and are backed by the borrower's property but carry a lien on the property that is subordinate to that of the primary mortgage. In order to measure conversion of housing wealth into liquidity through junior-lien mortgages, I define a variable that captures the total monthly balance of both closed-end second mortgages and HELOCs. The second type of loan is a cash-out refinance loan. Cash-out refinances allow borrowers to refinance their primary mortgage and to borrow more than the outstanding balance of the original loan. To capture cash-out refinances, I define a variable that measures the total monthly balance of primary mortgages.[22]

Secondary outcomes include credit card borrowing and non-mortgage delinquency. These represent alternative margins of adjustment for homeowners. I measure credit card borrowing using the dollar value of current credit card balances. Because homeowners could hypothetically generate liquidity by going delinquent on a wide range of loans, I measure non-mortgage default using the dollar value of non-mortgage accounts that are thirty or more days past due.[23]

[21] Appendix Table A2 presents a transition matrix of mortgage payment statuses from the analysis sample.

[22] The Equifax data follow borrower outcomes for six months after the mortgage loan (measured in McDash) has been paid off or transferred to another servicer. This allows the total monthly balance of primary mortgages to capture new balances of refinanced loans. This unique feature of the data also helps to address the issue of attrition. Mortgages that are paid off or transferred attrit from the sample during the observation window. Properly evaluating the presence of common trends in Equation 1 requires not conditioning the sample on mortgages that survive until an escrow update around $k = 0$. For this reason, I code all flow outcomes (e.g. delinquency, auto consumption) as zero if missing and forward fill all stock outcomes (e.g. mortgage balances). To evaluate robustness to these choices, I estimate Equation 1 on a sample of mortgages that are open throughout the observation period. The results of this exercise are presented in Appendix Figure B5 and show that the estimated responses are unaffected.

[23] Non-mortgage accounts include both loans and other accounts in collections. I winsorize all dollar-valued outcomes measured in the credit bureau data at the 99th percentile of positive values.

4 Results

This section presents estimates from the event study specification in Equation 1. Figure 2, panel A plots the first stage regression, in which the main outcome variable is the dollar amount of monthly escrow payments. I estimate Equation 1 by OLS and scale ΔT_i by the mean property tax bill before reassessment ($2,893). This scaling allows the coefficients to be interpreted as the effect of a $1 increase in property taxes on the monthly escrow payment. Panel A shows that this design precisely identifies the month in which monthly escrow payments are updated to reflect new property tax payments, corresponding to event time $k = 0$. A $1 increase in the annual property tax bill measured in the ATTOM data corresponds to an increase of about $0.052 per month in escrow payments measured in the McDash data (corresponding to a $0.629 yearly increase).

These estimates imply that monthly escrow payments only increase 63% as much as they would if increases in property taxes were passed through dollar for dollar into increases in escrow payments. The primary reason for this is measurement error in ΔT_i, which naturally reduces the size of the estimated coefficient. A secondary factor may be that mortgage servicers maintain some extra balance in escrow accounts as a cushion against fluctuations in homeownership expenses. Servicers may adjust the size of this cushion in response to changes in property tax bills. If this is the case, property taxes may not pass through into escrow payments dollar-for-dollar. These issues are circumvented by estimating Equation 1 by 2SLS using the percent change in the property tax bill (ΔT_i) as an instrument for the change in the monthly mortgage payment (Δm_i). This specification allows the coefficients to be interpreted as the causal effect of property tax increases without measurement error bias.

4.1 Consumption

Homeowners substantially reduce auto consumption after a property tax increase. Figure 2, panel B plots event study coefficients estimated by 2SLS, where the outcome is the twelve-month cumulative sum of auto consumption. These estimates imply that a $1 increase in monthly escrow payments reduces auto consumption by about $3.38 after 11 months, corresponding to an MPC of 0.31. The flat trend in auto consumption leading up to the event month validates the identification assumption and supports a causal interpretation of the relationship between increases in property taxes and the observed responses. The estimates are between the large auto MPC of 0.48 measured in response to stimulus payments (Parker et al. 2013) and the relatively smaller auto MPC of 0.08 found in the context of adjustable rate mortgage resets (Di Maggio et al. 2017).[24]

The lack of anticipatory behavior is surprising. Even though mortgage servicers pay property taxes on behalf of the homeowner, local governments send homeowners both a notice of assessment and a tax bill each year many months in advance of the property tax due date. It is therefore

[24]Hayashi (forthcoming) finds that a $1,000 reduction in median property taxes from 2008 to 2009 increases ZIP-level car purchases by 10%. Comparing our estimates is somewhat challenging in light of my result that consumption responses occur only after a payment increase. This implies that some of the ZIP-level response may have occurred outside of the measurement window.

puzzling that homeowners only appear to cut consumption when they face monthly payment increases, suggesting that homeowners who pay property taxes through escrow accounts are highly inattentive to changes in property tax liabilities.

An important distinction between the results in this study and those measured in the context of changes to mortgage payments is that the cost increases in this study should correspond to increases in home values. Given tax rates on the order of 1%, increases in housing wealth are large relative to the resulting tax increases. The observed consumption responses imply that homeowners who have experienced increases in the value of their homes and comparatively small increases in their tax liabilities respond to the tax increases by reducing car purchases. Thus, despite a net increase in wealth, homeowners appear to respond strongly to changes in liquidity. This finding echoes results from studies of consumption responses to changes in housing and liquid wealth. Estimates of consumption and borrowing responses to liquid wealth (e.g. Johnson et al. 2006, Parker et al. 2013) tend to be substantially larger than responses to housing wealth (e.g. Mian and Sufi 2011, Mian et al. 2013, Cloyne et al. 2019). This pattern is at odds with theoretical predictions suggesting that responses to the two types of shocks should be more similar than is typically observed (Berger et al. 2017). The empirical responses suggest the presence of important frictions that prevent homeowners from consuming out of their housing wealth.

4.2 Financial Distress

Property tax hikes also appear to create financial distress: the estimates presented in Figure 3 indicate higher rates of mortgage delinquency and mortgage default following a property tax increase. The coefficients are scaled to reflect effects relative to a $100 increase in monthly mortgage payments. Figure 3, panel A demonstrates an immediate increase in mortgage delinquency following increases in monthly mortgage payments. Relative to the pre-event mean, a $100 monthly payment increase results in a 10% increase in delinquency the month after the payment increase, and an 18% increase after 11 months. Panel B illustrates that increases in mortgage default manifest more gradually. A $100 payment increase translates into a 30% increase in mortgage default relative to the pre-event mean of 1.4%.

Even if property tax increases were not accompanied by increased housing wealth, homeowners should still be willing to incur substantial costs to avoid delinquency and default. This is because missing mortgage payments is a costly decision: missed payments usually carry a 5% late fee as well as negative impacts on credit scores. Prolonged delinquency will ultimately result in foreclosure and eviction. Importantly, the effects on mortgage delinquency persist for many months without signs of reverting to pre-event levels. If homeowners were simply forgetting to maintain sufficient balance in their checking accounts in the month of the update but were to adjust their finances appropriately upon noticing the change, these effects would disappear in the months following the update; however, the event study coefficients indicate persistent increases in delinquency. These results provide direct evidence that property taxes generate financial distress among homeowners.

Strikingly, my estimates of mortgage default are more than four times larger than those found

in Hayashi (forthcoming), who measures mortgage default using legal filings initiated by lenders against delinquent borrowers. This measure of default may be subject to significant attenuation bias because it captures the decisions of lenders rather than borrowers, and filings do not mechanically follow borrower default. My default estimates are about twice as large as those found in Fuster and Willen (2017) who use data similar to those in this study to analyze the relationship between mortgage default and payment size in the particular context of adjustable rate mortgage resets.

The estimated magnitudes are particularly striking given that the increases in monthly payments are modest. Table 1 shows that the 90th percentile of property tax increases corresponds to a 20% annual increase. Scaled by the average tax bill, this amounts to a $50 monthly increase in tax payments. Therefore, the observed effects on financial distress (e.g. a 9% increase in mortgage delinquency for a $50 increase) are generated by very small shocks to housing costs, suggesting a high degree of financial fragility among homeowners. These results are consistent with other work showing that many Americans are exceedingly vulnerable to small shocks (Mello 2018).

4.3 Converting Housing Wealth into Liquidity

In theory, homeowners experiencing increases in home values and property tax liabilities could naturally adjust by converting housing wealth into liquidity through home equity extraction; however, homeowners do not appear to adjust along this margin. Figure 4 plots the event study results for home equity extraction. Panel A plots effects on second (i.e. junior-lien) mortgage balances, while panel B plots effects on first (i.e. primary) mortgage balances. If homeowners were to draw on their housing wealth in order to pay higher property tax bills, one would expect to see first and second mortgage balances increase; however, this behavior is absent. The confidence intervals for second mortgage balances in panel A reject large marginal propensities to borrow. First mortgage balances are substantially noisier; however, the pattern is stable over time and loan balances show no signs of increasing. These results indicate that in response to property tax increases, homeowners reduce consumption and are more likely to miss mortgage payments, but do not draw on their housing wealth in order to pay taxes.

In additional results, I find no evidence of significant adjustment using credit cards or delinquency on non-mortgage accounts. These results are presented in Appendix Figure B4. While there is some indication that delinquent non-mortgage account balances increase, the estimated increase is quantitatively small relative to the reduction in auto consumption and statistically insignificant in most months. The estimated increase in the current balance of credit cards is also quantitatively small, and de-trending the balance of credit cards over this time horizon suggests no significant adjustment. Moreover, if homeowners were coping with tax increases using credit cards, one would expect a sharp increase in credit card balances immediately following the tax increase, but credit card balances trend smoothly throughout the event month.[25]

An important outstanding question is the extent to which the observed consumption, delin-

[25] While a sharp increase in credit card borrowing (rolled-over balances) could hypothetically be offset by a sharp reduction in consumption (non-rolled-over balances), this is unlikely given the lack of a trend break in either direction.

quency, and borrowing responses apply to homeowners who pay property taxes directly to local governments. Homeowners without mortgages generally pay in lump sum, often in biannual or quarterly installments. This group includes many elderly homeowners, who may be particularly financially vulnerable to increases in homeownership costs. Without escrow accounts, tax increases are not mechanically smoothed over the course of twelve months, so property taxes may create even more financial strain for these homeowners. While evaluating this possibility is of independent interest, the challenges in measuring the timing of tax increases for homeowners paying in lump sum make this empirical setting unlikely to yield accurate comparisons between the two groups.

4.4 Robustness

An important consideration for interpreting homeowner responses to property taxes is the extent to which increases in property taxes correspond to house price growth. If increases in property taxes are not correlated with higher home values, it would be less surprising that increases in property taxes generate reductions in consumption. Changes in mortgage payments have been observed to reduce consumption and increase delinquency in other settings (Di Maggio et al. 2017). In the sample states, reassessments are designed to align assessed values with market values, meaning that changes in assessed values typically reflect changes to market values. In Column 1 of Table 2, I find the same consumption and mortgage delinquency patterns when examining the direct effects of changes to property assessments instead of property taxes.[26]

A curious feature of the reassessments in many of the sample states is that despite statutory requirements to do so, many properties are not reassessed when they are transacted, raising the possibility that the observed responses might be driven by new homeowners who have not benefited from recent house price growth. Moreover, studies have found evidence that new homebuyers are inattentive to changes in property assessments (Bradley 2017). I address this concern in Column 2, where I restrict to homeowners that have lived in their houses for at least four years at the time that their monthly tax payments increase. These homeowners display similar patterns. In Column 3, I restrict the sample to the four states in the sample that conduct reassessments through regular cycles: Ohio, North Carolina, Tennessee, and Connecticut. Interestingly, while the effects on consumption are similar to other specifications, the negative impacts on mortgage delinquency and default disappear, suggesting that that there may be significant benefits to maintaining highly predictable reassessment protocols.

The main sample spans the Great Recession, a time in which many homeowners were financially distressed and in many cases underwater on their homes. This period was also characterized by contractions in credit supply. One potential concern is that property taxes only cause distress when credit access is low and house values are declining. In Column 4 of Table 2, I restrict the

[26]Note that even if inaccuracies in property reassessments exacerbate tax burdens, property taxes nonetheless appear to impose financial distress on homeowners. Reassessments are necessary in order to avoid very large distortions to the tax base over time. Moreover, as discussed later in this section when examining heterogeneous responses, even homeowners with access to cheaper means of borrowing exhibit increased rates of mortgage delinquency. This suggests that the financial distress created by property taxes is not merely a product of imperfect measurement of property values or financial constraints, but also of behavioral frictions. These are explored in Section 5.

sample to properties that were reassessed in or after 2011. Homeowners exhibit similar consumption responses outside of the Recession. While the effects on loan default are smaller and less significant, commensurate with elevated rates of mortgage default during the Great Recession, the effects on loan delinquency remain large and significant. This result implies that property taxes create meaningful financial distress even in normal times.

Lastly, I address potential econometric concerns associated with estimating Equation 1 by 2SLS. One potential issue is that the endogenous variable (monthly escrow payments) is not well-measured for loans that are paid off or refinanced before the month of the scheduled tax increase. Accordingly, I estimate Equation 1 by OLS, interacting the percent change in the tax bill with event time indicators. Appendix Figure B6 shows that the OLS estimates yield results that are very similar to the 2SLS specification.

4.5 Heterogeneity

The preceding results show that in response to property tax increases, homeowners reduce consumption and are more likely to miss mortgage payments, but do not draw on their housing wealth in order to pay property taxes. This suggests the existence of frictions that prevent homeowners from converting housing wealth into liquidity. In theory, homeowners may be prevented from drawing on housing wealth due to preference-based factors (e.g. debt aversion) or financial constraints. Recent work in economics has largely focused on the latter, typically in the form of fixed costs associated with drawing on housing wealth (Chetty and Szeidl 2007, Kaplan and Violante 2014). In addition, credit supply frictions may prevent homeowners from qualifying for the loans required to draw on housing wealth, or they may lack the knowledge to do so (i.e. information frictions). This section will explore heterogeneous responses that help to distinguish between these potential explanations.

Evaluating heterogeneous responses is informative about the extent to which housing wealth, credit access, and liquidity can explain the observed responses. Table 3 provides estimates of β_{10} from Equation 1 (i.e. effects after 11 months) broken down by subgroups. Columns 1 and 2 split the sample of homeowners by amount of housing wealth. High-housing wealth homeowners are defined as those with a pre-event combined loan-to-value ratio of below 80%. Interestingly, the estimated consumption effects for high-wealth homeowners are large and statistically significant. Moreover, the magnitude of the responses is statistically indistinguishable from that of low-wealth homeowners. The point estimates even suggest slightly larger responses for high-wealth homeowners: the estimated MPCs for high- and low-wealth homeowners are 0.42 and 0.24, respectively. Importantly, these differences are not driven by higher levels of consumption among high-wealth households. On the contrary, annual auto consumption appears to be about 25% smaller than that of low-wealth households, implying higher elasticities for high-wealth households. Less surprisingly, high-wealth homeowners exhibit somewhat more moderate delinquency responses, although default responses are similar in magnitude and statistically indistinguishable.

Similarly, homeowners with higher credit scores (and therefore more access to credit) exhibit

large consumption reductions in response to tax increases. Columns 3 and 4 of Table 3 present results split by credit score. Prime and sub-prime borrowers exhibit MPCs of 0.31 and 0.28, respectively.[27] Part of this difference may be due to the leveraged nature of auto consumption observed in the data (i.e. prime borrowers may have more access to auto loans). As with high-wealth homeowners, it is striking that responses for both groups are large and statistically indistinguishable. The delinquency and default responses are concentrated among subprime borrowers, a result that is unsurprising given that credit scores are designed to identify borrowers least likely to default.

Even homeowners who have the ability to borrow using credit cards appear to become financially distressed as a result of property tax increases. Column 5 restricts the sample to homeowners with open credit cards with less than 50% total utilization and more than $500 in unused credit limits while Column 6 restricts the sample to homeowners with more than 50% utilization or less than $500 in unused credit limits. Homeowners with the ability to borrow on their credit cards exhibit higher rates of mortgage delinquency after a tax increase. This is particularly significant because the 5% late fees associated with late mortgage payments imply that delinquency represents a much more costly form of borrowing (i.e. one with a 60% APR) than credit card borrowing.[28]

The finding that even homeowners who do not appear to be financially constrained exhibit strong consumption and delinquency responses to tax increases is surprising and implies that the financial burden of property taxes cannot be explained by financial constraints alone. This motivates an exploration of non-financial explanations for why homeowners do not draw on their housing wealth or on existing borrowing capacity. The likely importance of non-financial factors is supported by findings in Kueng (2018) and Olaffson and Pagel (2018) that show that even highly liquid individuals display large consumption responses to predictable income shocks. These studies both find that liquidity constraints alone cannot rationalize large consumption responses, suggesting behavioral explanations for these patterns. Similarly, Chetty et al. (2014) demonstrate that a large share of individuals appear to use cash-on-hand as a rule of thumb for making consumption decisions. The following section presents evidence from a survey of US homeowners indicating that preference-based debt aversion is a key factor determining homeowner responses to property taxes, which helps explain the large responses to property taxes exhibited by homeowners who do not appear to be financially constrained.

[27] Prime borrowers are defined as those with a VantageScore 3.0 of 660 or greater. VantageScore 3.0 is designed to correspond closely to the well-known FICO credit score. Both scores range from 300 to 850, with 660 being an approximate cutoff for prime borrowers.

[28] In supplementary analyses, I split the sample based on two additional proxies for liquidity. The first liquidity proxy is back-end debt-to-income ratio at loan origination (DTI). DTI measures a borrower's total monthly debt payments relative to a borrower's total monthly income. The results are similar to those in the main heterogeneity analysis: even liquid homeowners experience impacts on consumption and financial distress. Second, I restrict the sample to homeowners with a home equity line of credit. These homeowners should have extremely liquid wealth because they have already established a revolving credit line secured by their housing wealth. I find no significant effects of property tax increases on consumption, delinquency, and default for these homeowners. While this may suggest that a small share of homeowners that are willing and able to extract home equity do not experience financial hardship as a result of property tax increases, this result must be interpreted with caution given that these homeowners represent only about 15% of the sample and thus these responses are estimated imprecisely. The results of this supplementary analysis are presented in Appendix Table A3.

5 Homeowner Debt Aversion

This section evaluates non-financial frictions that may allow property taxes to create financial distress. The existence of these frictions is implied by the finding in the previous section that homeowners without financial constraints exhibit large consumption and delinquency responses to property tax increases. I provide survey evidence showing that preference-based debt aversion is a key friction in this setting. I conclude by examining historical data and showing that these mechanisms can help explain why property taxes in the US have been historically unpopular.

I conduct a novel survey of US homeowners, collected between September and November 2019 in two waves. The first wave contains responses from 2,000 homeowners over the age of 18 across the US. The second wave contains responses from 1,040 homeowners over the age of 18 living in Michigan. Respondents were identified by Qualtrics and surveys were completed electronically using Qualtrics' online platform. The survey instrument elicits a broad range of attitudes and behaviors associated with property taxes, as well as an array of demographic questions. The full survey instrument is presented in Appendix D.

The survey employs several measures to improve data quality. First, in contrast to samples drawn from Amazon mTurk, Qualtrics screens survey respondents to verify their characteristics, including US residency. Second, respondents failing a basic attention check are dropped from the analysis sample.[29] Third, halfway through the survey, respondents are asked whether they have devoted their full attention to the survey. This question has been shown to improve the quality of subsequent responses (Alesina et al. 2018, Meade and Craig 2012). Fourth, respondents are dropped from the analysis sample if they complete the survey faster than 50% of the median completion time, as well as faster than 50% of the median time after dropping the 20% of pages on which respondents spent the most time. Lastly, the survey follows the approach used in Alesina et al. (2018) and includes a warning against responding without adequate effort, as well as an appeal to respondents' intrinsic motivation.

Table 4 provides summary statistics from Wave 1 of the survey sample. Respondents in Wave 1 were sampled from across the US with quotas targeting respondents by age, gender, race, and location to ensure broad representation. Compared to demographic statistics from the 2013-2017 American Community Survey (ACS) 5-year estimates, respondents are somewhat more educated, more female, and less likely to be employed; however, these differences do not appear to meaningfully affect the results. To demonstrate robustness to demographic composition, I present statistics reweighted to match average homeowner characteristics from the ACS alongside unweighted results.

5.1 Survey Responses Corroborate Quasi-Experimental Results

I use the survey to confirm that homeowners perceive that property taxes create financial distress. Quasi-experimental results in Section 4 demonstrate that increases in property taxes create financial distress. Because property taxes are paid with monthly mortgage payments, homeowners might

[29] The attention check is similar to that applied in Berinsky et al. (2014).

perceive mortgage payments, rather than property taxes, as the source of financial hardship. Table 5 presents responses to several survey questions that clarify this distinction. Column 1 presents statistics from the raw sample, while Column 2 presents statistics weighted to match ACS estimates of homeowners demographics by age, gender, education, employment, and race. 45% of respondents indicate having had difficulty finding the money to pay property taxes at some point in the past, confirming that homeowners associate property taxes with financial distress.

The survey corroborates the specific margins of adjustment exhibited by homeowners in the administrative data. The results presented in Section 4 indicate that even homeowners who have high levels of liquidity, wealth, and credit access exhibit large consumption responses to property tax increases. Homeowners in the survey are asked how they would deal with a $500 property tax increase. Figure 5, panel A presents responses split by the self-reported liquidity available to the respondent, where liquid homeowners are defined as those who have more than $500 left over at the end of a typical month. Responses replicate key findings from the administrative data. Panel A shows that homeowners are most likely to respond by drawing out of liquid assets and cutting back on durable consumption. While 75% of liquid homeowners would draw on their liquid assets to pay this expense, 34% would still cut back on durable consumption, consistent with the quasi-experimental finding of large effects on durable consumption for both financially constrained and unconstrained homeowners.

A second finding corroborated by Figure 5, panel A is that a significant share (16%) of illiquid homeowners would respond to a tax increase by skipping bills. Moreover, homeowners do not draw on their housing wealth in order to pay their property taxes. Less than 4% of respondents report that they would borrow against their homes in order to pay the tax increase. These results confirm the quasi-experimental result that even homeowners with substantial amounts of liquidity cut back on consumption in response to property tax increases, and that homeowners generally do not draw on housing wealth in order to pay property taxes.[30]

5.2 Debt Aversion Creates Housing Wealth Illiquidity

Why don't homeowners draw on their housing wealth by taking out second mortgages or refinancing? The survey distinguishes between three hypotheses. First, homeowners may have a preference-based aversion to indebtedness. The presence of debt aversion has been demonstrated in other settings such as student loans (Field 2009) and reverse mortgages for elderly homeowners (Davidoff et al. 2017). Two alternative hypotheses are that the fixed costs of drawing on housing wealth are too high, or that homeowners are not able to borrow against their housing wealth due to either credit supply or information frictions.

In the survey, homeowners report being able but unwilling to draw on housing wealth, and cite debt aversion as a key reason for not doing so. Table 5 shows that only 23% of respondents would consider taking out a second mortgage if they had a difficult time finding the money to pay

[30]To confirm that these responses are not specific to the hypothetical nature of this particular question, the survey contains similar questions concerning past experiences with property taxes, and again finds that homeowners reduce consumption but do not increase borrowing. These results are presented in Appendix Figure B7.

property taxes. This preference appears to be strong: 65% of respondents would rather skip bills than take out a second mortgage. Figure 5, panel B tests between different explanations for this behavior by asking homeowners why they would not take out a second mortgage. The results show that the majority of respondents (67%) indicate that the reason they would not take out a second mortgage is because they are uncomfortable being in debt. Only 33% refer to up-front fixed costs, only 12% indicate that they would not qualify for a loan, and only 4% indicate that they do not know how to take out a loan. Debt aversion is the key stated factor in this setting.

Additional survey responses also suggest that credit supply frictions and information frictions are less important than debt aversion in this setting. When asked, 63% of respondents report that it would be easy or very easy to take out a second mortgage, suggesting that credit supply frictions are not binding. To test for information frictions, I conduct a randomized information treatment that provides a randomly selected set of respondents with additional information on home equity extraction. While the information treatment significantly increases the likelihood that respondents correctly answer a set of factual questions about second mortgages, the information does not substantially increase take-up of mortgage borrowing. Appendix E discusses the design and results of this experiment in more detail.

Debt aversion prevents a first-best policy solution from providing effective large-scale property tax relief. Property tax deferrals, currently offered by 31 states, offer homeowners an implicit loan by postponing property tax payments (with interest) until homeowners eventually transact their property (Lincoln 2020a). Viewed through the lens of economic theory, property tax deferrals represent a highly appealing property tax relief policy. Tax deferrals avoid negative shocks to liquidity due to property tax increases without creating substantial economic inefficiencies or reducing government revenue in the long run. Notably, even in cases where eligibility criteria are relatively broad, take-up of property tax deferrals tends to be very low.[31]

While a variety of issues such as imperfect administration and high interest rates may play a role in the low take-up of tax deferrals, survey responses indicate that debt aversion makes tax deferrals generally unappealing to homeowners. Survey respondents are asked what they would do if offered the opportunity to defer property taxes with zero interest.[32] Table 5 shows that 42% of respondents indicate that they would never defer their property taxes, while only 16% of respondents indicate they would defer their property taxes immediately. Figure 5, panel C presents respondents' stated reasons for never deferring property taxes. Homeowners appear to also be debt averse in this context: 61% of respondents indicate that they would never defer their property taxes because they don't want to feel in debt. In standard economic models, the decision to reject a zero-interest tax deferral is equivalent to rejecting a zero-interest loan. Therefore, all homeowners should be willing to take up the tax deferral. According to respondents' stated reasoning, debt

[31]For instance, the state of Washington allows homeowners with incomes less than $57,000 to receive a partial property tax deferral at an interest rate of about 4% and elderly homeowners with low disposable income to receive a full property tax deferral at an interest rate of 5% (Washington Department of Revenue 2019). Despite broad eligibility criteria, statewide only 64 low-income homeowners took up the former deferral and only 508 elderly homeowners took up the latter in 2017 (Oline 2018).

[32]This proposition is not entirely unrealistic. Washington, DC offers a zero-interest tax deferral (Lincoln 2020b).

aversion prevents homeowners from taking on debt to pay their property taxes even in the absence of significant fixed costs or interest.

The existence of debt aversion revealed by the survey informs the interpretation of the quasi-experimental results in Section 4. The event study estimates indicate that homeowners cut their consumption only after the month of a property tax increase, despite receiving multiple notices in the mail in the preceding months. In theory, forward-looking homeowners should adjust their consumption upon receiving news of a tax increase and not in the month that it occurs. This suggests that homeowners exhibit high levels of inattention to tax increases. The event study estimates also show increases in mortgage delinquency following a tax increase. Moreover, in any given month approximately 2.5% of mortgages are one month past due. In most mortgage contracts, a missed payment triggers an automatic 5% late fee, meaning that delinquency represents a highly costly form of borrowing (i.e. one with a 60% annualized interest rate). Willingness to borrow at these interest rates suggests high levels of impatience (i.e. low discount factors), which would imply high levels of borrowing in theory. However, the vast majority of homeowners tend to accrue housing wealth over time, rather than drawing it down to finance present consumption. Debt aversion can help to resolve this puzzle. If homeowners are averse to borrowing against their homes, then they can be impatient and illiquid enough to miss mortgage payments but simultaneously maintain large holdings of housing wealth.[33] In order to adequately fit the observed empirical responses to property taxes, models of homeowner behavior should jointly incorporate inattention, impatience, and debt aversion. An example of such a model is presented in Appendix F.

Debt aversion represents a very different explanation for homeowner illiquidity than those proposed in existing economic models. Previous work has focused on the role of large transaction costs (Chetty and Szeidl 2007) and higher returns to illiquid wealth (Kaplan and Violante 2014); however, survey responses indicate that neither of these factors is as important as debt aversion in this setting. The presence of debt aversion has important implications for economic models of homeowner responses to housing wealth. In particular, debt aversion may be an important factor driving the excess sensitivity of consumption among high-wealth households.

5.3 Explaining Property Tax Animus

In this section, I show that financial distress can help explain the historical unpopularity of property taxes. In particular, I provide evidence that property taxes, especially when increased by rising house prices, create property tax animus and motivate property tax revolts. I refer to this as the "financial distress" hypothesis.[34] In contrast, I show that the data do not support two prominent alternative hypotheses: the "misalignment" hypothesis, which argues that property tax revolts

[33] It remains puzzling why homeowners are averse to borrowing against their homes but not averse to the implicit borrowing associated with mortgage delinquency. Given the risk of foreclosure and eviction, mortgage delinquency carries an urgent imperative to repay quickly. One possibility is that debt aversion serves as a preference-based commitment device to avoid further indebtedness and maintain large amounts of savings through housing wealth.

[34] This hypothesis is supported by an abundance of anecdotal evidence. For examples of news coverage of homeowners expressing financial difficulties and frustration with the property tax system, see Hodges (2019), Carroll (2019), and KPLC (2012).

were meant to constrain inefficient government; and the "salience" hypothesis, which argues that property taxes are unpopular because they are more salient than other taxes.

Distinguishing between these hypotheses is important in light of the uniquely fraught history of the property tax. Since 1972, opinion polls have consistently shown that the property tax is the most unpopular tax (Cabral and Hoxby 2012). In a series of property tax revolts over the last forty years, voters have enacted policies that have severely curtailed property taxes. Currently, 46 states and the District of Columbia have some form of property tax limit (Paquin 2015). These limits have produced massive revenue shortfalls, straining the finances of local governments and weakening public school systems (Zillow 2018, Downes and Figlio 1999).[35]

The misalignment hypothesis asserts that property tax revolts occurred because voters wanted to constrain inefficient local governments and gain more control over expenditures (Fischel 1989, Cutler et al. 1999). This implies that voters' preferences are misaligned with local government expenditures; however, survey responses indicate that this is not the case. Table 5 shows that when asked which level of government they would least like to see expanded, 63% of respondents identified the federal government, while only 21% identified local government.[36] Thus, it appears that misalignment of voter preferences and the size of government revenues and expenditures is not a contemporary contributor to property tax animus.

The salience hypothesis asserts that property taxes are unpopular because they are highly salient for homeowners who do not pay property taxes through escrow accounts (Cabral and Hoxby 2012). Homeowners with escrow accounts do have more favorable attitudes towards property taxes: Figure 6, panel A regresses an indicator that the respondent names the property tax as the worst tax on a set of respondent characteristics, and shows that paying property taxes through an escrow account is associated with a 5 percentage point improvement in attitudes. However, while salience may have an impact on property tax attitudes, it cannot fully explain the unpopularity of property taxes. The quasi-experimental results show that property tax increases cause financial distress for homeowners who pay taxes through escrow accounts, implying that property taxes are painful even when they are not highly salient.[37]

I present four pieces of evidence in support of the financial distress hypothesis. First, Figure 6, panel A demonstrates that property taxes are substantially less unpopular among homeowners who have never struggled to pay them in the past: they are 10 percentage points less likely to name the property tax as the worst tax. This effect is large relative to the 33% of respondents overall who name the property tax as the worst tax.

Second, I show that providing tax relief to homeowners who are at risk of experiencing fi-

[35]Property taxes are still highly unpopular. Table 5 shows that the plurality (33%) of respondents in my survey indicate that the property tax is the worst tax. Specifically, respondents were asked "Which do you think is the worst tax—that is, the least fair?" and chose among federal income tax, federal Social Security tax, state income tax, state sales tax, local property tax.

[36]These results parallel responses to other surveys that have found generally positive attitudes towards local government and the value received from property taxes (Cabral and Hoxby 2012).

[37]Some of the difference in attitudes between homeowners with and without escrow accounts may in fact be attributable to financial distress. Homeowners with escrow accounts are likely less financially exposed to property tax hikes because escrow accounts smooth tax hikes over the course of twelve months.

nancial distress can improve attitudes towards property taxes. Wave 2 of the survey, comprised of homeowners living in Michigan, randomly provides respondents with information about one of two property tax relief policies in their state. The first policy is an income-based property tax reduction, while the second policy is an assessment limit that caps the growth of taxable property value over time.[38] Importantly, income-based tax reductions specifically target illiquid homeowners (i.e. those most likely to experience financial distress), while assessment limits do not.[39] Figure 6, panel B presents the randomized treatment effects and shows that information about income-based tax reductions substantially reduces animus towards property taxes: respondents are 7 percentage points less likely to name the property tax as the worst tax. If this reduction were applied to nationwide attitudes, the property tax would no longer be the most unpopular tax. There is no corresponding effect for information on assessment limits. These findings are notable because they suggest that politically sustaining property taxes may require tax relief that, in theory, creates economic distortions.

Third, I connect financial distress and property tax revolts. The quasi-experimental results show that when house price growth increases property taxes, homeowners experience financial distress. Therefore, a prediction of the financial distress hypothesis is that property tax revolts should be more likely to occur in times of rapid house price growth. Figure 7 plots the passage of state-enacted limits to property taxes between 1978 and 2015 alongside state and national house price growth. The original wave of property tax revolts initiated by California's Proposition 13 in 1978 occurred in the context of rapid house price growth—California itself experienced particularly high house price growth prior to Proposition 13. Over the last forty years, property tax limits have typically been enacted in states where house price growth was high relative to the national trend. These are precisely the conditions under which debt averse homeowners facing rising tax bills would have experienced financial distress and created political pressure to limit property taxes.

Fourth, I test whether policies that prevent house price growth from increasing property taxes (and from subsequently creating financial distress) can reduce property tax animus. The closest such policy is an assessment limit. Assessment limits are enacted by state and local governments and restrict the growth of taxable property value, mechanically preventing increases in home values from raising property taxes and creating financial distress.

The financial distress hypothesis predicts that property taxes will be more popular in the presence of assessment limits because homeowners will not be burdened by rising property taxes when house prices increase. Confirming this prediction, Table 6, panel A shows that homeowners living in counties with an assessment limit are 7 percentage points less likely to name the property tax as the worst tax ($p < 0.01$).[40] This difference is robust to the inclusion of a variety of individual-

[38] The interventions are discussed in more detail in Appendix E.

[39] Michigan's Homestead Property Tax credit provides households with income below $60,000 a refundable credit on their state income taxes. The credit phases out with income but is typically about 60% of the amount that property taxes exceed 3.5% of income (MLPP 2019). Over 1 million taxpayers receive the credit, which provides a $500 reduction on average (Michigan Department of Treasury 2018). Michigan also limits the growth of assessed value of property to the lower of 5% or inflation, giving homeowners with longer tenures large tax advantages.

[40] For this exercise, I pool survey responses from Gallup polls conducted in 2003 and 2005 with my survey of

and local-level controls.

The financial distress hypothesis further predicts that assessment limits should prevent more financial distress and make property taxes seem more fair when home values are increasing quickly. I show that property tax animus is concentrated in counties where rapid house price growth led to higher property tax burdens, but not in similar counties where local assessment limits prevented house price growth from increasing property taxes. To show this, I regress an indicator for naming the property tax as the worst tax on an indicator for living in a county with an assessment limit, the county's preceding 5-year average annual house price growth, and their interaction. Table 6, panel B shows that the interacted coefficient is negative and statistically significant ($p = 0.032$). Coefficients imply that the difference in attitudes between homeowners with and without assessment limits is close to zero for low levels of house price growth and approaches 15 percentage points under double-digit house price growth.

When house price growth drives up property taxes but homeowners are unwilling to convert their new housing wealth into liquidity, property taxes can create financial distress. The preceding results provide evidence that financial distress generates property tax animus and motivates property tax revolts. If this is the case, pure property taxes may be politically infeasible. I find that tax relief can meaningfully reduce property tax animus, suggesting that distortionary modifications to property taxes may be necessary to ensure their political sustainability.

6 Conclusion

US property taxes are highly unpopular and have been subject to a series of property tax revolts that greatly diminished the ability of state and local governments to collect property tax revenue. This study shows that property taxes create financial distress among American households. I leverage a novel merge between credit bureau records, mortgage servicing records, and property records and estimate event studies around the month in which homeowners' property taxes increase to reflect updated property assessments. I demonstrate that increases in property taxes generate sharp reductions in consumption and increases in mortgage delinquency. Strikingly, consumption responses are equally strong for homeowners who have higher amounts of housing wealth and better access to credit, suggesting that the frictions creating financial distress are not purely financial.

I conduct a novel survey of homeowners to evaluate the role of non-financial frictions. Survey responses show that homeowners are reluctant to draw on their housing wealth because of a preference-based aversion to being in debt. Homeowner debt aversion precludes the first-best policy solution to homeowner illiquidity: if given the opportunity, homeowners would not defer property taxes even at zero interest. I show that distortionary income-based tax relief that targets illiquid households reduces property tax animus. In addition, I provide evidence that property tax animus is concentrated in areas in which rising home values lead to higher property taxes, creating financial

homeowners. The Gallup polls were conducted as part of Gallup's Economy and Personal Finance Poll and collect responses from 2,082 respondents. Importantly, the question that asks respondents to name the worst/least fair tax in my survey is identical to the question asked in the Gallup surveys.

distress. Taken together, these findings imply that the efficiency of pure property taxes is limited by the occurrence of financial distress and that distortionary tax relief may be necessary to ensure the political sustainability of property taxes.

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Table 1: Summary Statistics for the Main Analysis Sample

	Mean	SD	p10	p90
Annual property tax ($)	2968	2425	1072	5453
Escrow payment ($)	361	229	168	608
Principal and interest payment ($)	886	567	420	1460
Assessed value ($)	76728	89327	17179	177544
%Δ assessed value (reassessment)	1.45	20.51	-19.34	26.44
%Δ property tax (reassessment)	3.02	17.34	-13.86	19.50
Loan-to-value ratio (%)	81.63	20.19	55.82	101.42
Credit score	686	87	562	799
Indicator: Has second mortgage	0.201			
Indicator: 30+ days delinquent	0.034			
Indicator: 90+ days delinquent	0.007			

Notes: This table lists summary statistics for homeowners in this paper's main analysis sample: a panel of merged property records, mortgage servicing records, and credit bureau records. This panel is merged at the loan level. The statistics in this table are calculated for 299,545 loans and are computed twelve months before a property tax change due to reassessment (i.e. event time -12). Annual property taxes and assessed values are observed in the property records at the property by year level. Escrow payments, principal and interest payments, loan-to-value ratio, and delinquency indicators are measured in the mortgage servicing records at the loan by month level. Credit scores (Vantage 3.0) and second mortgage indicators are measured in the credit bureau data at the month by individual level.

Table 2: Robustness

	Assessed Value Regressor	Old Loans	Regular Reassessments	Post-2011
	(1)	(2)	(3)	(4)
Panel A (OLS)				
Escrow Payment	0.028	0.041	0.046	0.051
	(0.001)	(0.001)	(0.001)	(0.001)
	[329.831]	[317.944]	[315.611]	[346.943]
Panel B (2SLS)				
Auto Consumption	-4.20	-4.21	-2.66	-2.73
	(1.23)	(1.52)	(1.24)	(1.27)
	[3971.25]	[3591.14]	[4096.00]	[4194.08]
Loan 30+ Past Due	0.0068	0.0082	0.0029	0.0067
	(0.0024)	(0.0034)	(0.0022)	(0.0023)
	[0.0484]	[0.0612]	[0.0465]	[0.0507]
Loan 90+ Past Due	0.0032	0.0035	0.0001	0.0013
	(0.0018)	(0.0024)	(0.0015)	(0.0015)
	[0.0142]	[0.0174]	[0.0132]	[0.0131]
N	299922	152306	218059	179755

Notes: This table presents event study coefficients from 16 separate regressions estimated using subsamples of the main analysis sample. Each row corresponds to a different outcome variable. Each column corresponds to a different specification or subsample. Reported coefficients correspond to event time 10 and capture the effect of a property tax increase after 11 months (i.e. β_{10} in Equation 1). Panel A presents coefficients from the first stage: a regression of the escrow payment (i.e. monthly tax and insurance payment in dollars) on the percent change in the annual property tax bill interacted with a set of event time indicators estimated by OLS. Coefficients are scaled by the mean tax bill and yield an interpretation in levels. For example, in Column 2 a 1 dollar increase in property taxes increases monthly payments by 4 cents after 11 months. Panel B presents second stage coefficients estimated by 2SLS. The percent change in the annual tax bill is used as an instrument for the level change in the monthly escrow payment, interacted with event time indicators. Auto Consumption is defined as the 12-month running sum of monthly auto consumption. Loan 30+ Past Due is defined as an indicator that the primary mortgage is 30 or more days past due. Loan 90+ Past Due is defined as an indicator that the primary mortgage is 90 or more days past due. Auto Consumption coefficients can be interpreted as effects of 1 dollar increase in monthly payments. Loan payment coefficients are scaled by 100 and can be interpreted as effects of 100 dollar increase in monthly payments. Column 1 interacts percent change in the assessed value with event time indicators instead of the percent change in the tax bill. Column 2 restricts the sample to loans that have been open for at least 4 years at event time 0. Column 3 restricts the sample to states where properties are reassessed on a regular schedule. Column 4 restricts the sample to reassessments occurring in or after 2011. All specifications include loan fixed effects and county-by-month fixed effects. Standard errors are clustered at the loan level.

Table 3: Heterogeneous Responses Across Homeowners

	Housing Wealth		**Credit Score**		**Borrowing Capacity**	
	High	Low	Prime	Subprime	High	Low
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A (OLS)						
Escrow Payment	0.044	0.043	0.045	0.044	0.045	0.046
	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
	[347.623]	[322.166]	[340.633]	[314.408]	[341.921]	[324.157]
Panel B (2SLS)						
Auto Consumption	-4.60	-2.59	-3.40	-3.07	-2.22	-2.91
	(1.56)	(1.26)	(1.18)	(1.71)	(1.24)	(1.91)
	[3270.88]	[4341.53]	[3923.81]	[4060.14]	[3952.02]	[4360.53]
Loan 30+ Past Due	0.0021	0.0131	0.0024	0.0200	0.0076	0.0092
	(0.0025)	(0.0028)	(0.0014)	(0.0048)	(0.0018)	(0.0047)
	[0.0298]	[0.0576]	[0.0121]	[0.1070]	[0.0155]	[0.0763]
Loan 90+ Past Due	0.0044	0.0047	-0.0008	0.0140	0.0011	0.0098
	(0.0018)	(0.0022)	(0.0009)	(0.0039)	(0.0013)	(0.0038)
	[0.0075]	[0.0175]	[0.0030]	[0.0322]	[0.0044]	[0.0213]
N	101657	196418	185287	114258	162823	96587

Notes: This table presents event study coefficients from 24 separate regressions estimated using subsamples of the main analysis sample. Each row corresponds to a different outcome variable. Each column corresponds to a different specification or subsample. Reported coefficients correspond to event time 10 and capture the effect of a property tax increase after 11 months (i.e. β_{10} in Equation 1). Panel A presents coefficients from the first stage: a regression of the escrow payment (i.e. monthly tax and insurance payment in dollars) on the percent change in the annual property tax bill interacted with a set of event time indicators estimated by OLS. Coefficients are scaled by the mean tax bill and yield an interpretation in levels. For example, in Column 2 a 1 dollar increase in property taxes increases monthly payments by 4 cents. Panel B presents second stage coefficients estimated by 2SLS. The percent change in the annual tax bill is used as an instrument for the level change in the monthly escrow payment, interacted with event time indicators. Auto Consumption is defined as the 12-month running sum of monthly auto consumption. Loan 30+ Past Due is defined as an indicator that the primary mortgage is 30 or more days past due. Loan 90+ Past Due is defined as an indicator that the primary mortgage is 90 or more days past due. Auto Consumption coefficients can be interpreted as effects of 1 dollar increase in monthly payments. Loan payment coefficients are scaled by 100 and can be interpreted as effects of 100 dollar increase in monthly payments. Column 1 restricts the sample to loans with a combined loan-to-value ratio (CLTV) of less than 80% at t=-12. Column 2 restricts the sample to loans with CLTV greater than or equal to 80%. Column 3 restricts the sample to loans with a credit score greater than or equal to 660 at t=-12. Column 4 restricts the sample to loans with a credit score of less than 660. Column 5 restricts the sample to borrowers with open credit cards with less than 50% utilization and at least 500 dollars of unused credit limits. Column 6 restricts the sample to borrowers with open credit cards with more than 50% utilization or less than 500 dollars in unused credit limits. All specifications include loan fixed effects and county-by-month fixed effects. Standard errors are clustered at the loan level. The results presented in this table imply that consumption responses are larger for individuals with higher amounts of wealth (Column 1) and higher credit scores (Column 3). Delinquency and default responses are stronger among homeowners with lower amounts of wealth and less access to credit.

Table 4: Summary Statistics from Survey Sample Wave 1

	Survey Wave 1 (1)	ACS (2)
Panel A. Variables used for weighting		
Female share	0.60	0.51
Mean age	53.58	50.61
College educated share	0.42	0.32
Employed share	0.49	0.61
White only share	0.70	0.72
Black only share	0.13	0.08
Hispanic share	0.08	0.12
Panel B. Other demographics		
Share with children	0.30	0.34
Midwest share	0.23	0.23
Northeast share	0.17	0.18
South share	0.39	0.38
West share	0.20	0.22
Median household income	55000	87292
Median house value	187500	215465
N	2,000	8,551,469

Note: This table provides summary statistics for Wave 1 of the online survey of homeowners alongside nationally representative statistics from the 2013-2017 American Community Survey (ACS). Column 1 contains statistics from the raw survey sample for Wave 1, which samples homeowners across all US states. Column 2 contains the corresponding statistics from the ACS, restricting to individuals aged 18+ living in owner-occupied housing. Panel A contains variables used to re-weight the raw survey sample to match population statistics. Panel B contains variables not used for weighting. See Section 5 for more details about the survey of homeowners.

Table 5: Responses from Nationwide Survey of US Homeowners

	Raw (1)	Weighted (2)
Panel A. Financial distress and debt aversion		
Has had difficulty paying property taxes	0.453	0.471
	(0.011)	(0.014)
Would consider taking out a second mortgage	0.225	0.225
	(0.010)	(0.012)
Would rather skip bills than take out a second mortgage	0.647	0.667
	(0.011)	(0.013)
Panel B. Deferring property taxes		
Would never defer property taxes	0.423	0.411
	(0.011)	(0.014)
Would defer if having trouble paying	0.420	0.437
	(0.011)	(0.014)
Would defer immediately	0.157	0.152
	(0.008)	(0.010)
Panel C. Worst tax		
Property tax	0.328	0.328
	(0.010)	(0.013)
Federal income tax	0.284	0.289
	(0.010)	(0.013)
State income tax	0.114	0.114
	(0.007)	(0.009)
Social Security tax	0.148	0.140
	(0.008)	(0.009)
Sales tax	0.127	0.129
	(0.007)	(0.009)
Panel D. Level of government least like expanded		
Federal	0.631	0.644
	(0.011)	(0.013)
State	0.156	0.148
	(0.008)	(0.010)
Local	0.213	0.208
	(0.009)	(0.011)

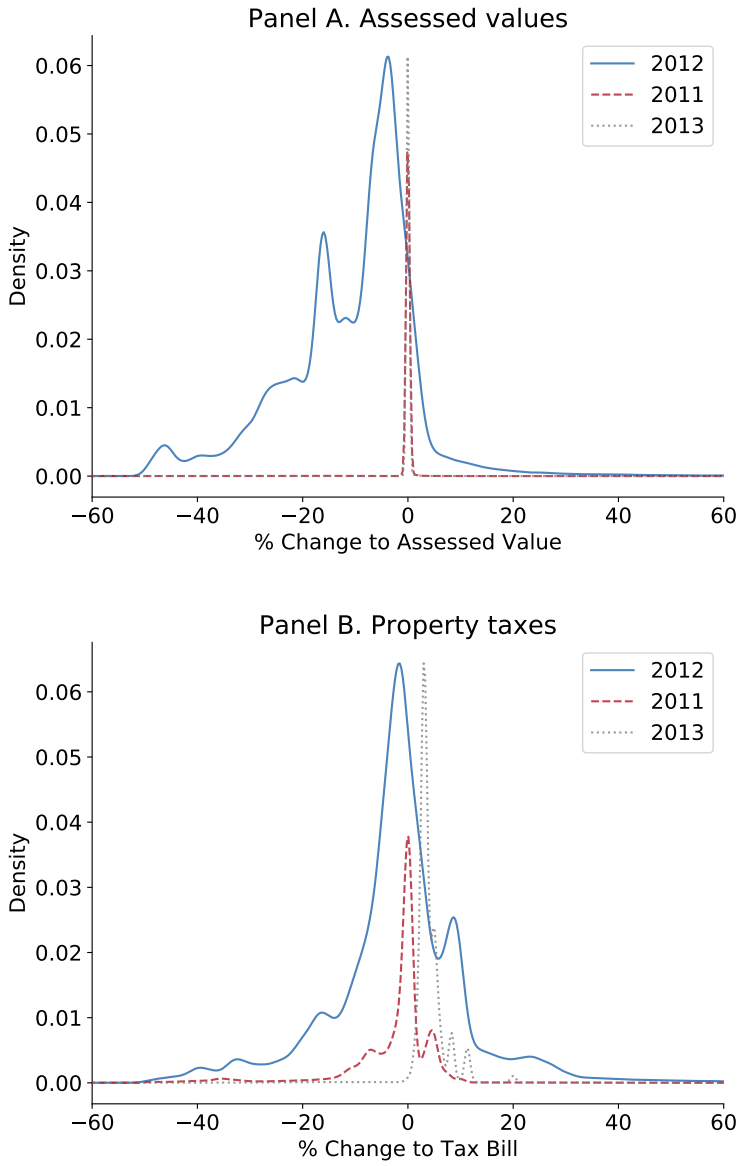
Notes: This table presents responses from Wave 1 of the online survey of US homeowners. Column 1 contains statistics from the raw survey sample. Column 2 contains the corresponding statistics with the sample re-weighted to match population statistics from the 2013-2017 American Community Survey. Each number corresponds to the share of respondents selecting the indicated answer. Standard errors in parentheses. Panel A presents answers to the following questions: (i) Since you first became a homeowner, how often have you had difficulty finding the money to pay property taxes on your primary residence? (ii) Suppose that one year you have a hard time finding the money to pay property taxes. In order to find the money to pay property taxes, would you consider taking out a second mortgage? (iii) Suppose again that one year you have a hard time finding the money to pay your property taxes. In order to find the money to pay property taxes, would you rather take out a second mortgage or would you rather skip paying one or more bills (e.g. credit card, mortgage, utilities)? Panel B presents answers to the question, Suppose you were given the option to defer your property taxes with zero interest. If you defer your property taxes, you only need to pay them when you sell or pass on your property. Which of the following best describes you? Panel C presents answers to the question, Which do you think is the worst tax–that is, the least fair? Panel D presents answers to the question, Which level of government would you least like to see expanded? Wave 1 comprised of responses from 2,000 homeowners across US. Questions about second mortgage and tax deferrals asked only of homeowners not residing in Michigan (N=1,906). See Section 5 for more details.

Table 6: Property Tax Animus, Assessment Limits, and House Price Growth

	Outcome: Property tax is the worst tax		
	(1)	(2)	(3)
Panel A. Level differences			
1{Limit}	-0.073	-0.071	-0.072
	(0.019)	(0.019)	(0.020)
Panel B. Interacted specification			
1{Limit} × HP growth	-1.227	-1.328	-1.314
	(0.571)	(0.578)	(0.583)
1{Limit}	0.648	0.784	0.747
	(0.427)	(0.430)	(0.447)
HP growth	0.003	0.008	0.007
	(0.040)	(0.041)	(0.041)
Individual controls		X	X
Local area controls			X
Outcome mean	0.346	0.345	0.345
N	3586	3523	3521

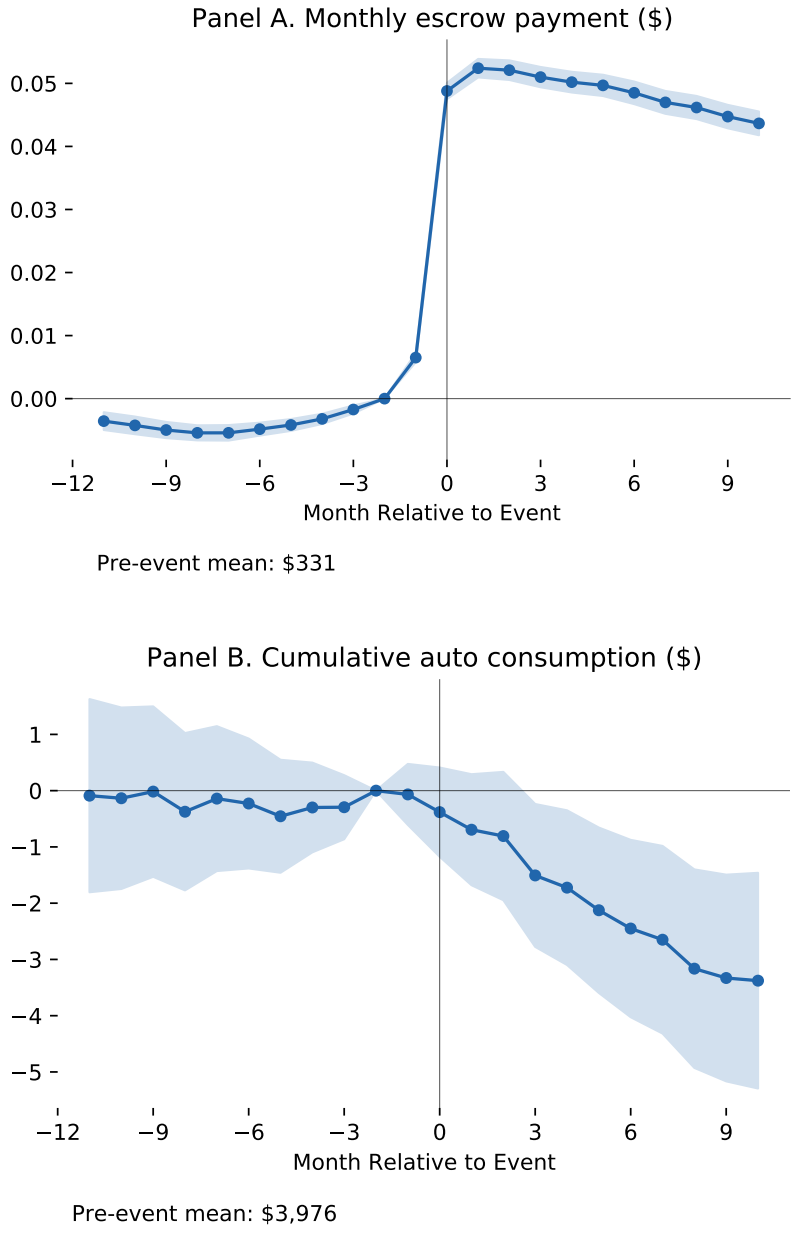
Notes: This table presents the results of 6 separate regressions where the outcome is an indicator for the respondent stating that the property tax is the worst tax. Panel A regresses the outcome on an indicator for the respondent living in a county in which the growth of assessed values is limited (1{Limit}). Panel B regresses the outcome on 1{Limit}, the average 5-year annual house price growth in that respondent's county at the time of the survey (HP growth), and the interaction of those two variables. All regressions include survey year fixed effects. Individual controls include the log of the respondent's income, an indicator for the respondent reporting conservative political preferences, and an indicator for the respondent having completed college. Local area controls include the county unemployment rate at the time of the survey (data from Bureau of Labor Statistics), the white share of the county (data from 2000 Census), and the log per capita income of the county (data from 2000 Census). External time-varying variables for 2019 survey responses are calculated as of 2018 due to limited data availability. Survey data come from responses from Wave 1 of the survey of homeowners combined with microdata from a Gallup survey conducted in 2003 and 2005. Survey weights derived by giving equal weight to the two surveys. Within the Gallup survey, responses are weighted using the accompanying survey weights. Within the survey of homeowners, responses are weighted using the constructed ACS weights. Standard errors reported in parentheses.

Figure 1: Changes to Assessed Values and Property Taxes, Cuyahoga County 2011-2013



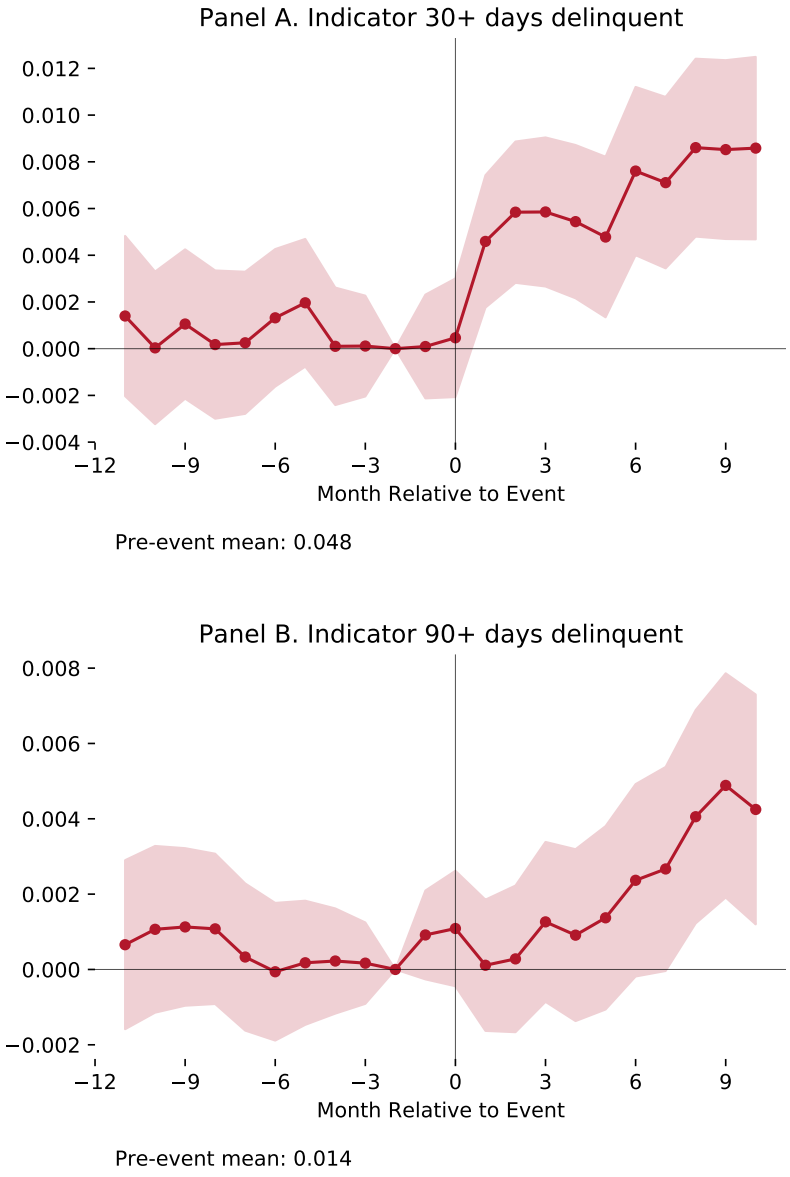
Notes: This figure plots the distribution of changes to assessed values (panel A) and changes to property tax bills (panel B) in the years before, during, and after Cuyahoga County's 2012 reassessment. Cuyahoga county did not reassess property values in 2011 or 2013. The solid lines plot the kernel density of percent changes to assessed values and property tax bills in 2012. The dashed and dotted lines plot the kernel densities for 2011 and 2013, respectively. The scale of the vertical axes pertains to the 2012 distribution. The 2011 and 2013 distributions are scaled differently and axes are omitted for clarity. Data are from annual assessed values and property tax bills in the ATTOM property records. These distributions provide an example of how property reassessments create large variation in changes to both assessed values and property tax bills. This variation is large relative to that in the years before and after.

Figure 2: Auto Consumption Response to Property Tax Increases



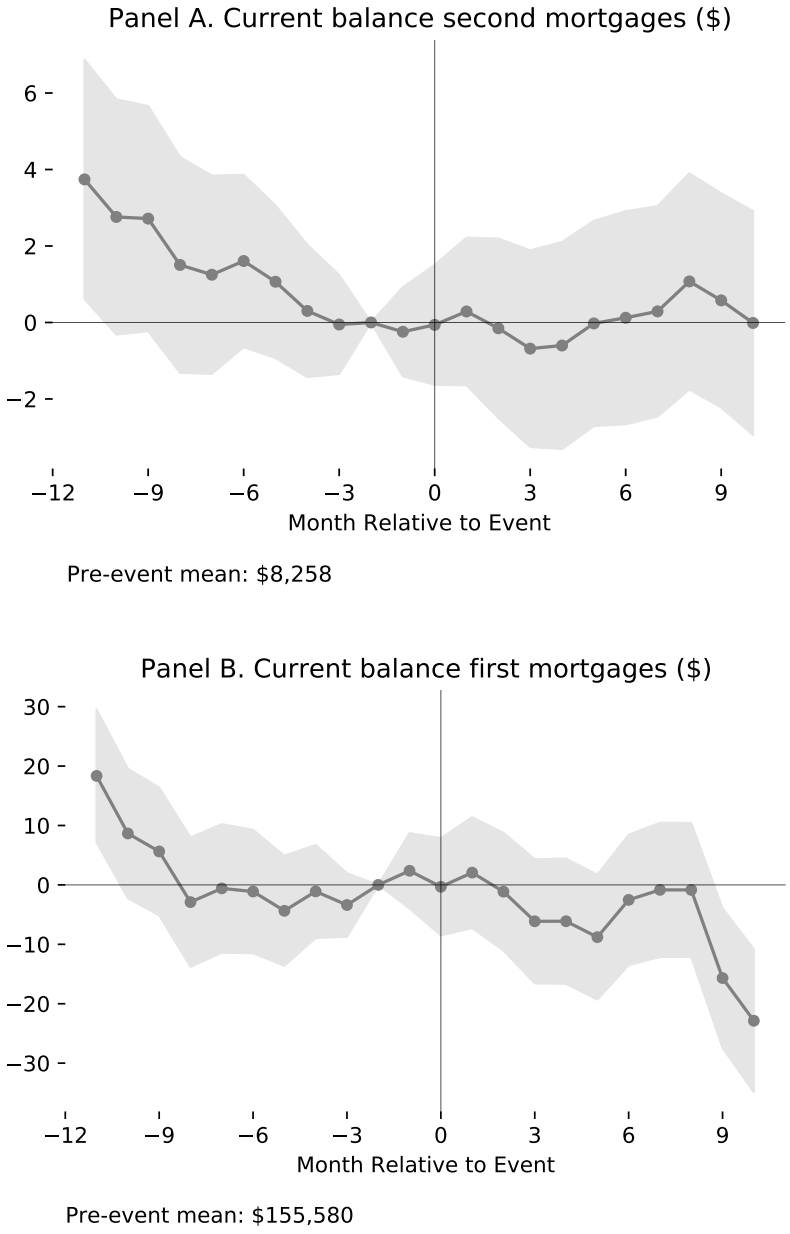
Notes: This figure depicts the time path of monthly tax and insurance payments (panel A) and auto consumption (panel B) around a property tax change that occurs at event time $t = 0$. Panel A presents first stage coefficients, corresponding to OLS estimates from a regression of the monthly escrow payment (i.e. tax and insurance payment) on the percent change in the annual property tax bill interacted with a set of event time indicators (Equation 1). Coefficients are scaled by the mean tax bill and yield an interpretation in levels: a $1 increase in annual taxes raises monthly payments by about $0.05. Panel B presents coefficients from Equation 1 estimated by 2SLS. The percent change in the annual tax bill is used as an instrument for the level change in the monthly escrow payment, interacted with event time indicators. The outcome in panel B is defined as the 12-month running sum of monthly auto consumption. The coefficients indicate that a $1 increase in monthly payments reduces car consumption by $3.38 after 11 months (i.e. $0.31 per month). The shaded region depicts 95 percent confidence intervals, where standard errors are clustered at the loan level. Event coefficients are normalized to zero two months before the change ($t = -2$). Data from main analysis sample is described in Section 2. Variables are described in Section 3.

Figure 3: Delinquency Response to Property Tax Increases



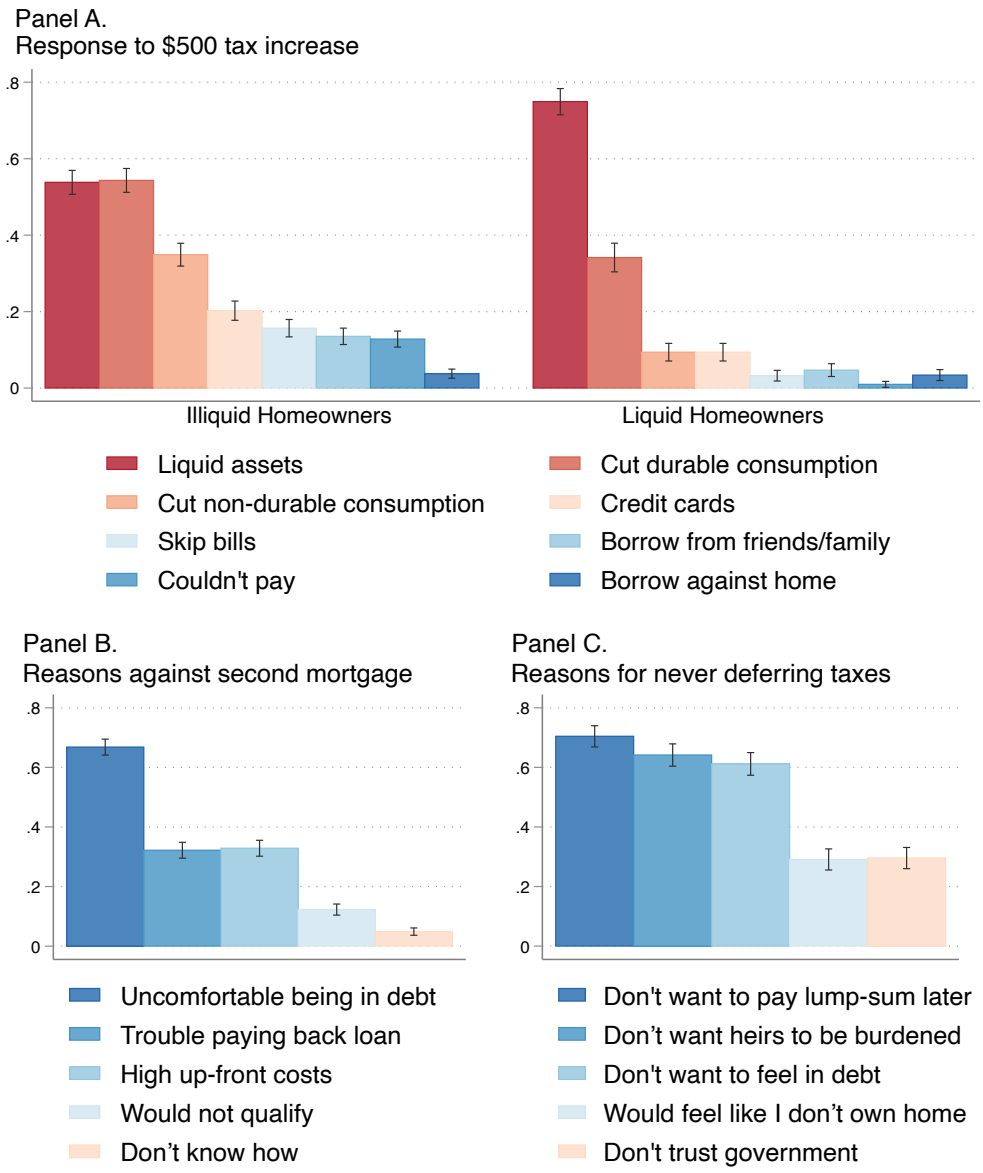
Notes: This figure depicts the time path of monthly delinquency rates (panel A) and default rates (panel B) around a property tax change that occurs at event time $t = 0$. Both panels present coefficients from Equation 1 estimated by 2SLS. The percent change in the annual tax bill is used as an instrument for the level change in the monthly escrow payment (divided by 100 for scaling), interacted with event time indicators. The delinquency outcome in panel A is defined as an indicator that the primary mortgage is 30 or more days past due. Coefficients indicate that a $100 increase in monthly payments increases the likelihood of delinquency by 0.8 percentage points after 11 months (an 18% increase). The default outcome in panel B is defined as an indicator that the primary mortgage is 90 or more days past due. Coefficients indicate that a $100 increase in monthly payments increases the likelihood of default by 0.4 percentage points after 11 months (a 30% increase). The shaded region depicts 95 percent confidence intervals, where standard errors are clustered at the loan level. Event coefficients are normalized to zero two months before the change ($t = -2$). Data from main analysis sample is described in Section 2. Variables are described in Section 3.

Figure 4: Mortgage Borrowing Response to Property Tax Increases



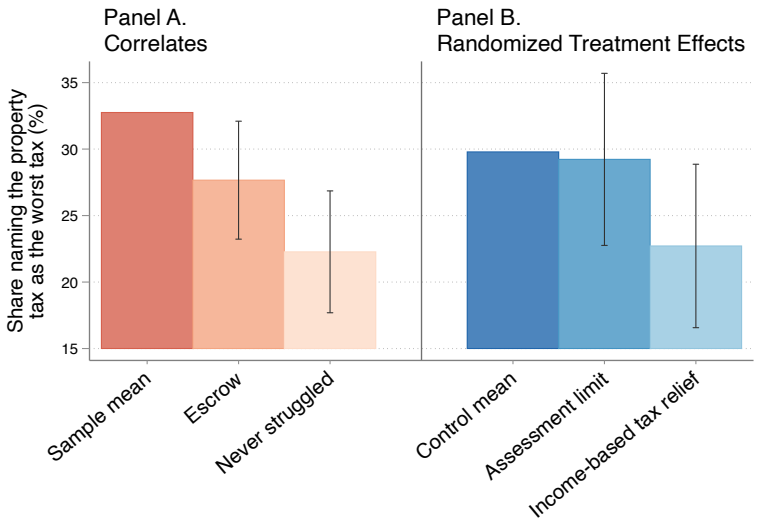
Notes: This figure depicts the time path of monthly second mortgage (i.e. junior-lien) balances (panel A) and first mortgage balances (panel B) around a property tax change that occurs at event time $t = 0$. Both panels present coefficients from Equation 1 estimated by 2SLS. The percent change in the annual tax bill is used as an instrument for the level change in the monthly escrow payment, interacted with event time indicators. The outcome in panel A is defined as the dollar balance of second mortgages. Coefficients indicate that changes in monthly mortgage payments do not result in meaningful changes in second mortgage borrowing (i.e. home equity extraction) after the change in property taxes. The outcome in panel B is defined as the dollar balance of first mortgages. Coefficients indicate that changes in monthly mortgage payments do not result in changes in primary mortgage borrowing that would indicate homeowners draw on their housing wealth in response to tax changes. The shaded region depicts 95 percent confidence intervals, where standard errors are clustered at the loan level. Event coefficients are normalized to zero two months before the change ($t = -2$). Data from main analysis sample is described in Section 2. Variables are described in Section 3.

Figure 5: Survey Evidence on Consumption, Delinquency, and Debt Aversion



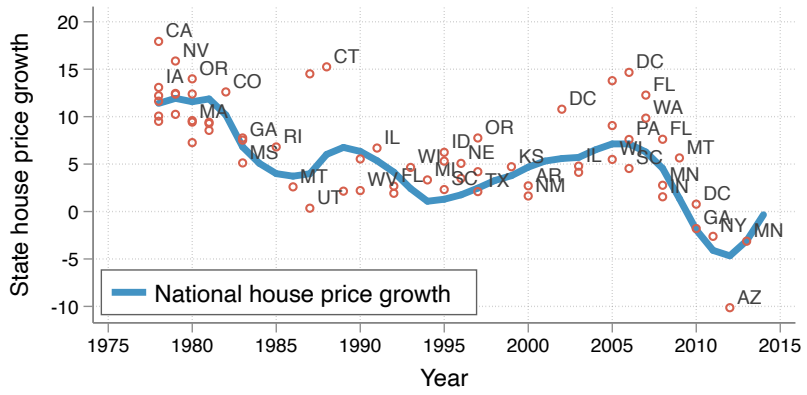
Notes: This figure plots unweighted responses from Wave 1 of the online survey consisting of 2,000 homeowners across the US. Each bar and 95% confidence interval correspond to the share of respondents indicating each answer category. Panel A plots responses to the question, "Suppose that next year your yearly property tax bill increases by $500. How would you pay for this?" The respondent sample is split by liquidity status. Illiquid homeowners are defined as those reporting having more than $500 left over at the end of a typical month. This panel indicates that very few homeowners would draw on their housing wealth to pay for a tax increase and that even liquid homeowners would cut back on consumption. Panel B plots responses to the question, "You indicated that you would not consider taking out a second mortgage. What are your reasons for choosing this option?" Inclusion is conditional on respondent reporting that they would not consider taking out a second mortgage to pay property taxes (N=1,190). Responses indicate that debt aversion is the primary reason why homeowners do not draw on housing wealth in order to pay property taxes. Panel C plots responses to the question, "You indicated that you would never defer paying your property taxes. Which of the following are reasons you chose this option?" Inclusion is conditional on respondent reporting that they would never defer property taxes with zero interest if given the option (N=636). Responses indicate that debt aversion prevents homeowners from taking up a zero-interest loan in the form of an interest-free tax deferral. These questions asked of homeowners living in all US states except Michigan. One in five respondents were randomly presented with free response text box instead of multiple choice answers and are excluded.

Figure 6: Determinants of Attitudes Towards Property Taxes



Notes: This figure presents coefficients from two unweighted regressions in which the outcome is an indicator that the respondent names the property tax as the worst/least fair tax. Panel A uses responses from Wave 1 of the online survey consisting of 2,000 homeowners across the US. The first bar indicates that 33% of respondents name the property tax as the worst tax. The second and third bars add regression coefficients to the sample mean. The regression coefficients correspond to indicators for paying property taxes through escrow and reporting never having struggled to pay property taxes, and are derived from a specification that also includes controls for respondent income, education, political leaning, tenure, parental status, age, financial condition, and property tax rate. The second specification in Panel B presents coefficients corresponding to treatment indicators for receiving randomized information about Michigan policy. The assessment limit treatment provides information on Michigan's limitation on the growth of taxable value of residential property. The income-based tax relief treatment provides information on Michigan's Homestead Property Tax Credit, which provides tax relief for low-income taxpayers. The first bar presents the control mean, while the second and third bars add treatment effects to the control mean. Responses in Panel B derived from the 1,133 respondents in Waves 1 and 2 of the online survey that reside in Michigan.

Figure 7: House Price Growth and Property Tax Limits



Notes: This figure plots the occurrence of state-level limits to local property taxes enacted between 1978 and 2015, relative to state and national house price growth. The vertical axis measures the 5-year average of annual house price growth in each state at the time that each limit was enacted. The solid line depicts national 5-year average house price growth. This figure shows that property tax limits tend to be enacted during times of high house price growth. Data on tax limits is derived from Paquin (2015). House price growth is measured using the FHFA House Price Index and calculated using closest available years when temporal coverage is imperfect.

A Appendix Tables - For Online Publication

Table A1: Distribution of Sample Across States and Reassessment Years

	CT	IL	IN	MO	NC	NH	OH	TN	WA	Total
2006	0.3	0.0	5.3	0.0	0.1	0.0	3.8	0.0	0.0	9.6
2007	1.0	0.0	0.0	4.7	0.4	0.0	0.3	0.0	1.4	7.8
2008	0.8	0.1	0.0	0.0	3.1	0.0	10.0	0.0	0.0	13.9
2009	0.3	3.7	0.0	0.0	0.0	0.0	1.7	2.5	0.0	8.2
2010	0.0	0.3	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.6
2011	0.1	4.0	0.0	0.6	3.2	0.5	14.2	0.3	0.0	22.8
2012	0.0	5.1	0.0	0.0	0.0	0.1	8.3	0.0	0.0	13.5
2013	0.0	0.1	0.0	0.0	1.0	0.3	1.7	3.0	0.0	6.1
2014	0.0	0.0	0.0	0.0	1.0	0.4	9.9	1.4	0.0	12.6
2015	0.7	0.0	0.0	0.0	0.4	0.1	3.3	0.0	0.3	4.9
Total	3.1	13.2	5.3	5.3	9.3	1.6	53.3	7.1	1.7	100.0

Note: This table presents the share of observations in the main analysis sample in each state and reassessment year. The sample is comprised of a panel of merged property records, mortgage servicing records, and credit bureau records. This panel is merged at the loan level. The statistics in this table are calculated for 299,545 loans. Each loan is assigned to the year in which its associated property was reassessed.

Table A2: Mortgage Status Transitions in CRISM

	Status in t						
	Current	30 DPD	60 DPD	90 DPD	120+DPD	Foreclosure	Total
Status in $t+1$							
Current	**98.72**	30.91	9.29	6.75	6.77	2.39	94.21
30 DPD	1.27	**53.43**	17.54	3.96	0.82	0.30	2.93
60 DPD	0.01	15.54	**44.63**	11.92	1.00	0.12	0.91
90 DPD	0.00	0.08	27.31	**30.22**	2.54	0.11	0.38
120+DPD	0.00	0.02	0.18	37.49	**79.16**	4.40	0.77
Foreclosure	0.00	0.02	1.04	9.66	9.70	**92.68**	0.79
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Note: This table presents the transition matrix of monthly mortgage delinquency statuses in this paper's main analysis sample. The sample is comprised of a panel of merged property records, mortgage servicing records, and credit bureau records. This panel is merged at the loan level and contains 299,545 loans. This table illustrates two conceptually different behaviors: mortgage delinquency and mortgage default. Most borrowers that transition into delinquency eventually catch up on payments. A much smaller share of borrowers that transition into deep delinquency (90+ days delinquent) catch up on their payments.

Table A3: Heterogeneous Responses Across Homeowners

	HELOC (1)	**No HELOC** (2)	**High Liquidity** (3)	**Low Liquidity** (4)
Panel A (OLS)				
Escrow Payment	0.052	0.042	0.045	0.047
	(0.003)	(0.001)	(0.002)	(0.002)
	[370.979]	[323.340]	[344.706]	[334.273]
Panel B (2SLS)				
Auto Consumption	1.66	-4.45	-4.01	-5.18
	(2.47)	(1.06)	(1.78)	(2.12)
	[4108.92]	[3951.76]	[3864.81]	[3981.78]
Loan 30+ Past Due	0.0020	0.0102	0.0055	0.0157
	(0.0036)	(0.0023)	(0.0032)	(0.0047)
	[0.0248]	[0.0525]	[0.0377]	[0.0548]
Loan 90+ Past Due	0.0008	0.0051	0.0038	0.0080
	(0.0030)	(0.0018)	(0.0024)	(0.0034)
	[0.0072]	[0.0154]	[0.0103]	[0.0155]
N	45838	253707	103919	63560

Notes: This table presents event study coefficients from 16 separate regressions. Each row corresponds to a different outcome variable. Each column corresponds to a different specification or subsample. Reported coefficients correspond to event time 10 and capture the effect of a property tax increase after 11 months (i.e. β_{10} in Equation 1). Panel A presents coefficients from the first stage: a regression of the escrow payment (i.e. monthly tax and insurance payment in dollars) on the percent change in the annual property tax bill interacted with a set of event time indicators estimated by OLS. Coefficients are scaled by the mean tax bill and yield an interpretation in levels. For example, in Column 2 a 1 dollar increase in property taxes increases monthly payments by 4 cents. Panel B presents second stage coefficients estimated by 2SLS. The percent change in the annual tax bill is used as an instrument for the level change in the monthly escrow payment, interacted with event time indicators. Auto Consumption is defined as the 12-month running sum of monthly auto consumption. Loan 30+ Past Due is defined as an indicator that the primary mortgage is 30 or more days past due. Loan 90+ Past Due is defined as an indicator that the primary mortgage is 90 or more days past due. Auto Consumption coefficients can be interpreted as effects of 1 dollar increase in monthly payments. Loan payment coefficients are scaled by 100 and can be interpreted as effects of 100 dollar increase in monthly payments. Column 1 restricts the sample to borrowers with open home equity lines of credit (HELOCs) in event month -12. Column 2 restricts the sample to borrowers without HELOCs. Column 3 restricts the sample to loans with a back-end debt-to-income ratio (DTI) of less than 40% at origination. Column 4 restricts the sample to loans with a DTI of greater than or equal to 40%. All specifications include loan fixed effects and county-by-month fixed effects. Standard errors are clustered at the loan level.

Table A4: Second Mortgages Information Treatment

	Raw	Weighted
	(1)	(2)
Panel A. Knowledge check		
Identified second and reverse mortgages	0.295	0.318
	(0.020)	(0.025)
	[0.572]	[0.547]
Correct reverse mortgages	0.318	0.340
	(0.019)	(0.023)
	[0.594]	[0.582]
Panel B: Attitudes towards borrowing		
Would consider taking out second mortgage	0.047	0.058
	(0.019)	(0.024)
	[0.201]	[0.196]
Would take out second mortgage for $500 increase	-0.005	-0.001
	(0.009)	(0.010)
	[0.041]	[0.036]
N	1907	1907

Notes: This table presents regression coefficients for 8 separate regressions. Each row corresponds to a different outcome variable, which is regressed on an indicator for the respondent being randomly assigned to receive information on second mortgages and reverse mortgages. This experiment, conducted within the online survey, is described in greater detail in Appendix E. The sample is comprised of respondents in Wave 1 of the survey who live in US states other than Michigan. Each row corresponds to a regression for a separate outcome. Panel A contains the following outcomes: an indicator for correctly identifying second mortgages and reverse mortgages as methods for borrowing against one's home and an indicator for correctly answering a question about the repayment structure of reverse mortgages. Panel B contains the following outcomes: an indicator for the respondent stating they would consider taking out a second mortgage if they had difficulty finding the money to pay property taxes and an indicator for the respondent identifying mortgage borrowing as a way to pay for a 500 dollar property tax increase. See Appendix D for the questionnaire and answer choices. Column 1 contains unweighted regression coefficients and Column 2 contains regression coefficients re-weighted using the ACS. Standard errors are presented in parentheses and control means in brackets.

Table A5: Policy Information Treatment First Stage

	(1) Assessment Limit	(2) Income-Based Tax Relief
5 percent assessment limit	0.560	0.010
	(0.030)	(0.031)
	[0.233]	[0.233]
Assessment limit distribution	0.438	-0.078
	(0.030)	(0.035)
	[0.430]	[0.430]
Average amount of tax relief	0.028	0.316
	(0.029)	(0.033)
	[0.190]	[0.190]
Tax relief distribution	-0.009	0.151
	(0.034)	(0.030)
	[0.686]	[0.686]
N	1133	1133

Notes: This table presents regression coefficients for 4 separate regressions. Each row corresponds to a different outcome, which is regressed on indicators capturing whether the respondent received one of two information treatments on property tax policies in Michigan. The first treatment describes the limit on the growth of taxable value of property (Column 1). The second treatment describes income-based tax relief through the Homestead Property Tax Credit (Column 2). This experiment is described in greater detail in Appendix E. The sample is comprised of respondents in Waves 1 and 2 of the survey who reside in Michigan. Each row corresponds to a regression for a separate outcome. The outcomes are as follows: an indicator for the respondent correctly identifying the maximum assessment growth as 5 percent per year (within 0.1 percentage points), an indicator for the respondent correctly identifying the distributional impacts of the assessment limit, an indicator for the respondent correctly identifying the average amount of income-based tax relief within 100 dollars (the correct answer is 500 dollars), and an indicator for the respondent correctly identifying the distributional impacts of income-based tax relief. Standard errors are presented in parentheses and control means in brackets.

Table A6: Summary of External Model Calibration

Parameter	Value	Source
Risk aversion γ	2	-
Monthly interest rate R	1.0025	-
Mean monthly income μ	\$5,124	SIPP
Log distribution of initial assets a_0	N(0.05,5.66)	SIPP
Monthly income process $\tilde{z}_t$	AR(1)	SIPP
Borrowing constraint $\underline{a}$	-\$20,701	CRISM
Monthly mortgage payment π	\$1,242	CRISM
Distribution of property tax changes τ	N(0,0.22)	CRISM

Notes: This table lists calibrated parameters for the model presented in Appendix Section F. Parameters calibrated using Survey of Income and Program Participation (SIPP) use months in 2009-2012. Parameters calibrated internally from CRISM data use main analysis sample described in Section 2. Distributions of initial assets normalized by monthly income. Non-dollar-denominated values reflect normalization relative to mean monthly income.

Table A7: Calibrated Model Fit

	Standard	Inattentive	Inattentive $\beta - \delta$	Inattentive Debt Averse
	(1)	(2)	(3)	(4)
Model Parameters				
Standard discount factor δ	0.9975	0.8604	0.9975	0.8458, 0.9455
Quasi-hyperbolic discount factor β	1	1	0.0640	1
Cost of delinquency k	0.01	4.164	5.828	3.042
Convexity of delinquency ξ	2	5.380	6.975	1.644
Debt aversion l	0	0	0	361.4
Impatient population share	1	1	1	0.191
Inattentive	No	Yes	Yes	Yes
Model Fit				
Number of moments	131	131	131	131
Number of free parameters	0	3	3	6
Consumption GoF	1.02	0.51	0.51	0.46
Default Rates GoF	1.00	0.30	0.22	0.18
Default Response GoF	1.00	0.29	0.26	0.27
Total GoF	3.02	1.10	0.99	0.91

Notes: This table presents the calibrated behavioral parameters and the resulting model fit for the model described in Appendix Section F. Column 1 presents parameters and fit for a fully attentive agent with standard time preferences and no debt aversion. Column 2 presents parameters and fit for an inattentive agent with no debt aversion. Column 3 presents parameters and fit for an inattentive agent with no debt aversion and with quasi-hyperbolic time preferences. Column 4 presents parameters and fit for a two-agent model where agents are inattentive, debt averse, and differ in their time preferences.

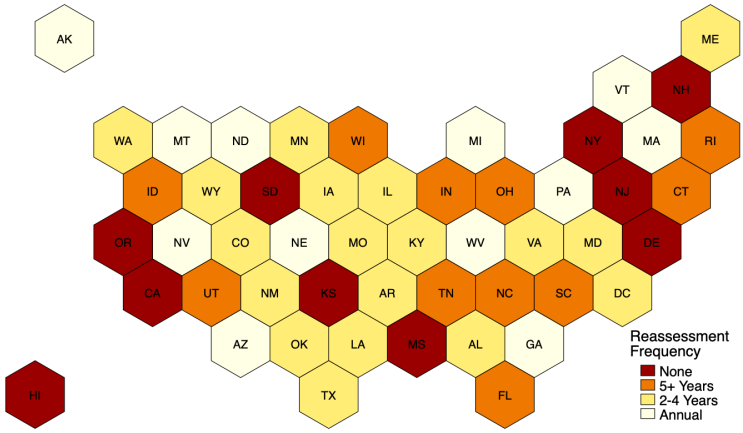
Table A8: Counterfactual Responses Without Debt Aversion

	(1) Consumption Response	(2) Default Response	(3) High Borrowing Share
Empirical Estimate	-0.0450	0.00271	
Model with Debt Aversion	-0.0358	0.00473	0.00
Counterfactual (No Debt Aversion)	-0.0426	-0.00001	0.18
Ratio: Counterfactual/Model	1.1896	-0.00142	

Notes: This table presents the results of a counterfactual exercise conducted with the structural model of consumption and loan repayment. Columns 1 and 2 compare consumption and default responses in the empirical results; for a baseline calibration corresponding to a behaviorally inattentive, impatient, and debt averse agent (see Column 4 of Table A7); and for a counterfactual agent with the same behavioral parameters as the baseline calibration but without any disutility arising from debt aversion. Default corresponds to an indicator for being three or more months past due on the agent's mortgage payment. Each moment corresponds to the mean value of event study coefficients between event time t=1 and t=10. Column 3 reports the share of agents who have drawn down more than half of their borrowing capacity (i.e. within two month's average income of the borrowing constraint at event time t=-2). Results in Column 2 show dramatic reductions in default responses in the absence of debt aversion. Column 3 indicates that no debt-averse agents are close to their borrowing constraint. The model is described in more detail in Appendix Section F.

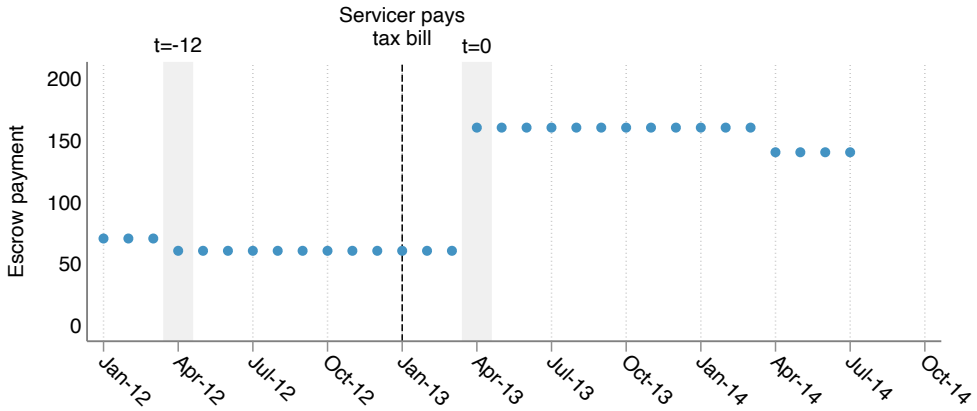
B Appendix Figures - For Online Publication

Figure B1: Property Reassessment Practices Across the US



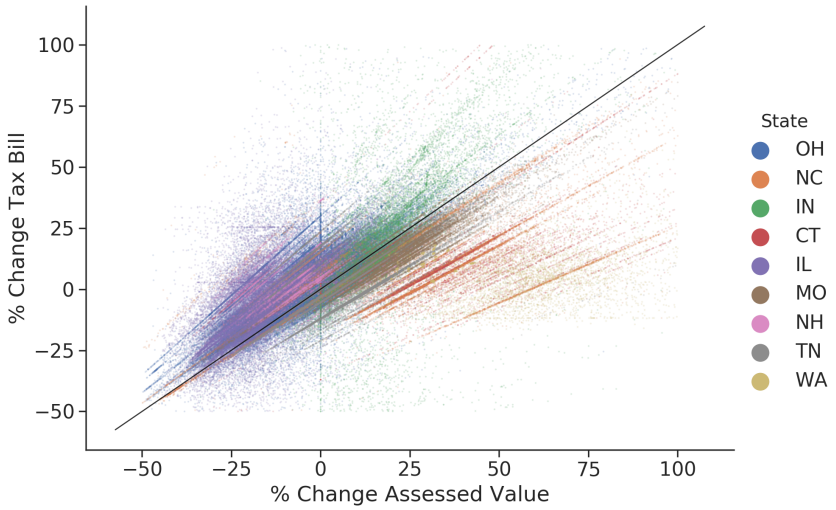
Notes: This figure plots reassessment frequencies mandated by state law across the US. Lighter-colored states require local governments to assess property more frequently. Data for this figure derived from Tax Foundation (2010).

Figure B2: Graphical Illustration of Escrow Payments



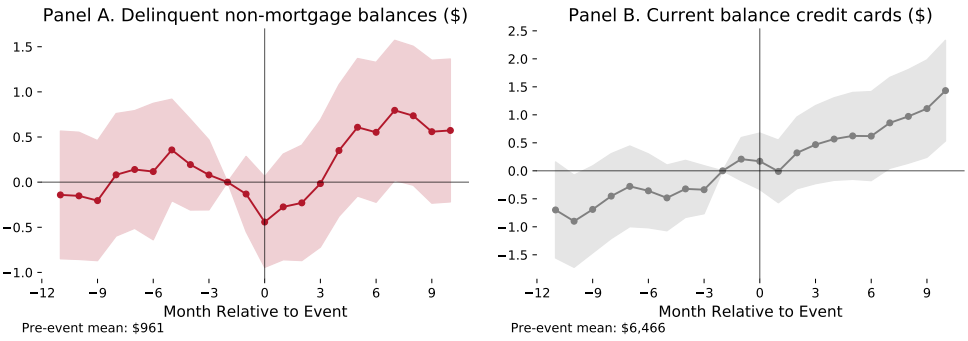
Notes: This figure presents a timeline of tax and escrow payments for a hypothetical homeowner. This hypothetical homeowner has their property reassessed in 2012 and consequently faces a property tax increase in 2013. The property tax bill is due in January 2013 and is paid on the homeowner's behalf by the mortgage servicer. The blue dots represent the homeowner's monthly escrow payments. These payments reflect the property tax increase starting in April 2013. The shaded months represent the corresponding months in event time associated with estimating Equation 1.

Figure B3: Sample Distribution of Changes to Property Taxes and Changes to Assessed Value



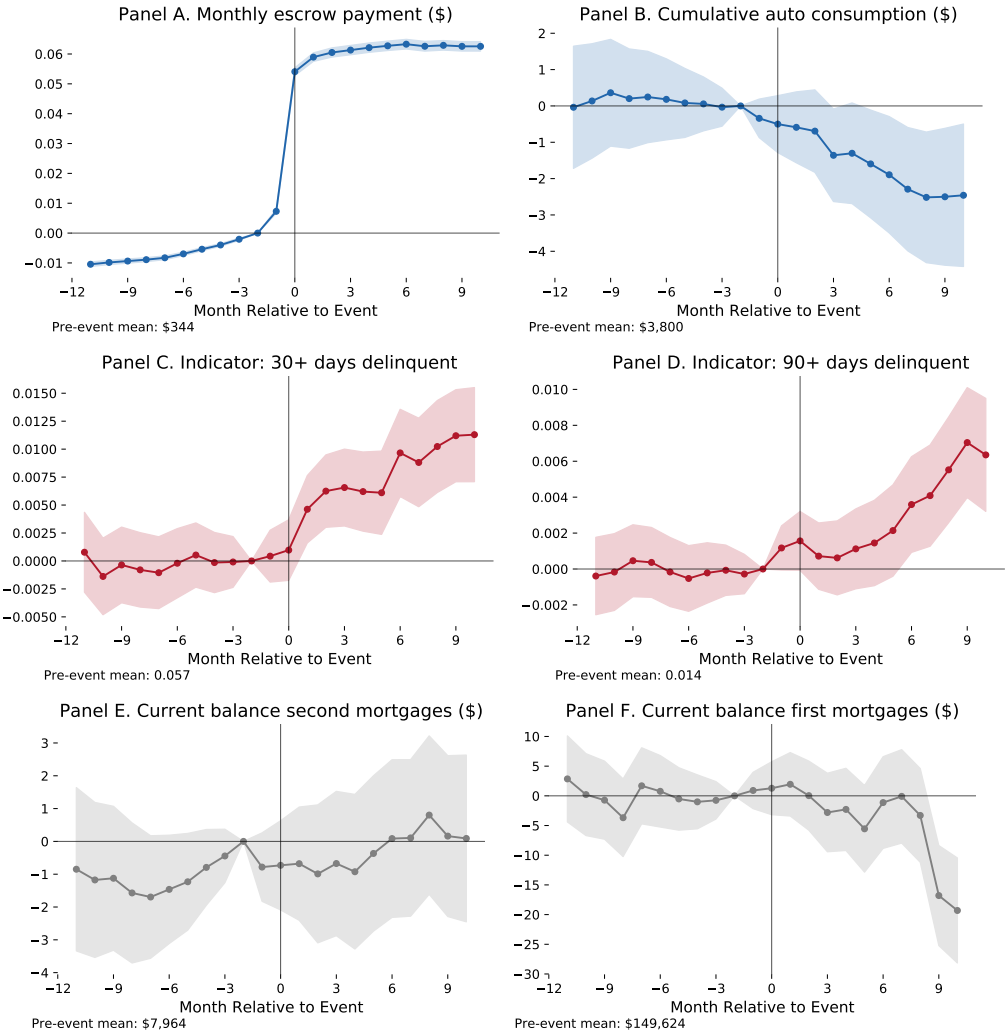
Notes: This figure presents a density heat map of changes to property taxes and changes to assessed values around a property reassessment for the 299,545 loans in the analysis sample. See Section 2 for more details on the data. The vertical axis measures the percent change in the tax bill in the year that the property was reassessed, while the horizontal axis measures the corresponding percent change in the property assessment. The positive relationship between the two changes illustrates how increases in assessed value due to reassessment translate directly into increases in property taxes.

Figure B4: Credit Card and Non-Mortgage Delinquency Responses



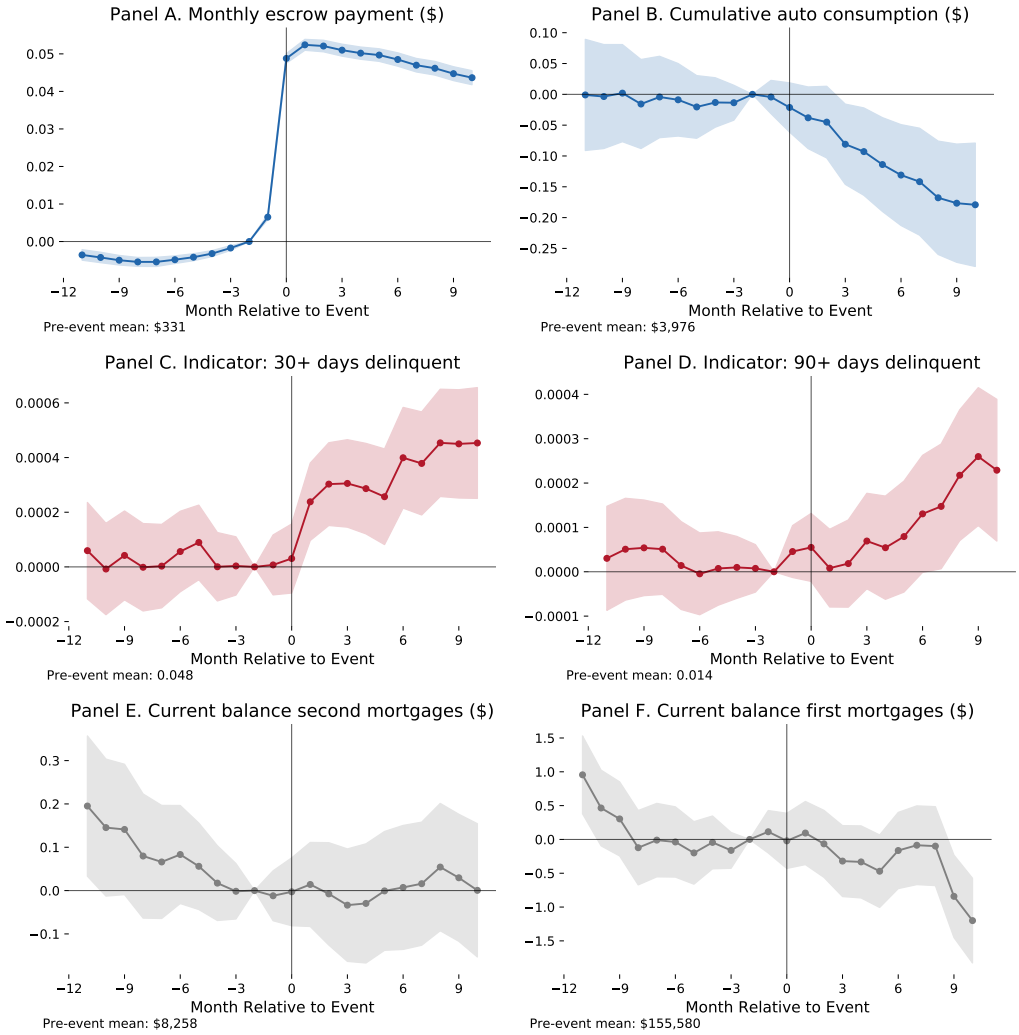
Notes: This figure depicts the time path of delinquent non-mortgage balances (panel A) and the current balance of credit cards (panel B) around a property tax change that occurs at event time $t = 0$. Both panels present coefficients from Equation 1 estimated by 2SLS. The percent change in the annual tax bill is used as an instrument for the level change in the monthly escrow payment, interacted with event time indicators. The outcome variable in panel A is the dollar balance of non-mortgage accounts that is 30 or more days past due. The outcome variable in panel B is the monthly dollar balance of credit cards. Both outcomes are winsorized at the 99th percentile of positive balances. This figure demonstrates that homeowner responses along these margins are quantitatively small relative to consumption responses. The shaded region depicts 95 percent confidence intervals, where standard errors are clustered at the loan level. Event coefficients are normalized to zero two months before the change ($t = -2$). Data from main analysis sample is described in Section 2. Variables are described in Section 3.

Figure B5: Homeowner Responses in Sample Conditioning on Loan Survival



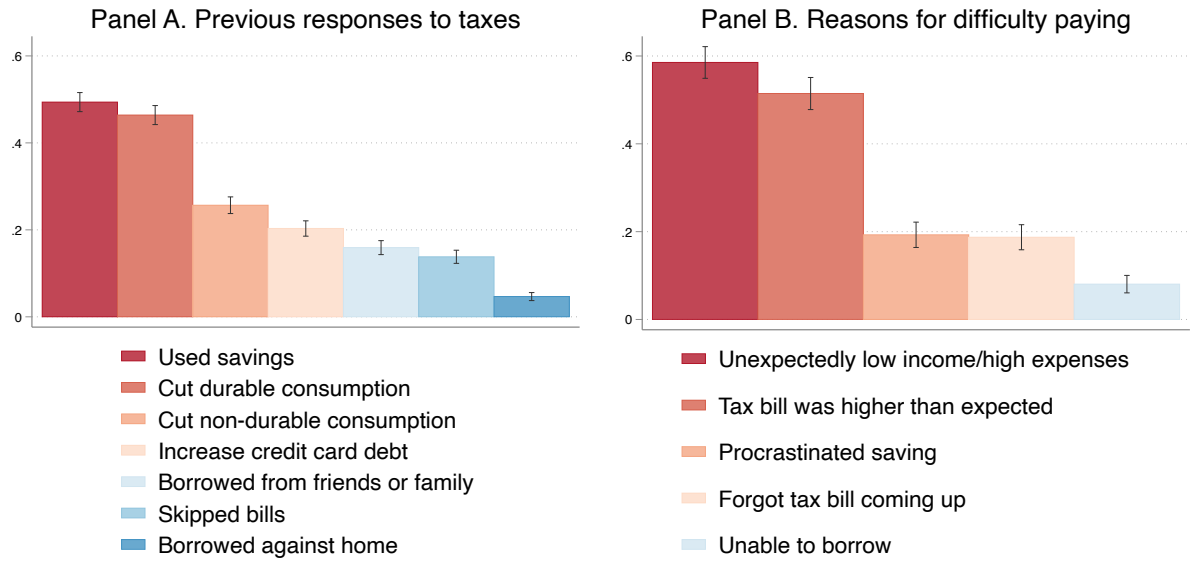
Notes: This figure depicts the time path of monthly tax and insurance payments (panel A), auto consumption (panel B), delinquency rates (panel C), default rates (panel D), second mortgage balances (panel E), and first mortgage balances (panel F), around a property tax change that occurs at event time $t = 0$. These estimates correspond to a sample of loans that are open over a 30-month period in calendar time and in event time $k \in [-12, 11]$. Sample consists of 218,059 loan-events. Panel A presents first stage coefficients, corresponding to OLS estimates from a regression of the monthly escrow payment (i.e. tax and insurance payment) on the percent change in the annual property tax bill interacted with a set of event time indicators (Equation 1). Coefficients are scaled by the mean tax bill and yield an interpretation in levels: a $1 increase in annual taxes raises monthly payments by about $0.06. Panels B through F present coefficients from Equation 1 estimated by 2SLS. The percent change in the annual tax bill is used as an instrument for the level change in the monthly escrow payment, interacted with event time indicators. The shaded region depicts 95 percent confidence intervals, where standard errors are clustered at the loan level. Event coefficients are normalized to zero two months before the change ($t = -2$). Data from main analysis sample is described in Section 2. Variables are described in Section 3.

Figure B6: Results from Reduced Form Specification



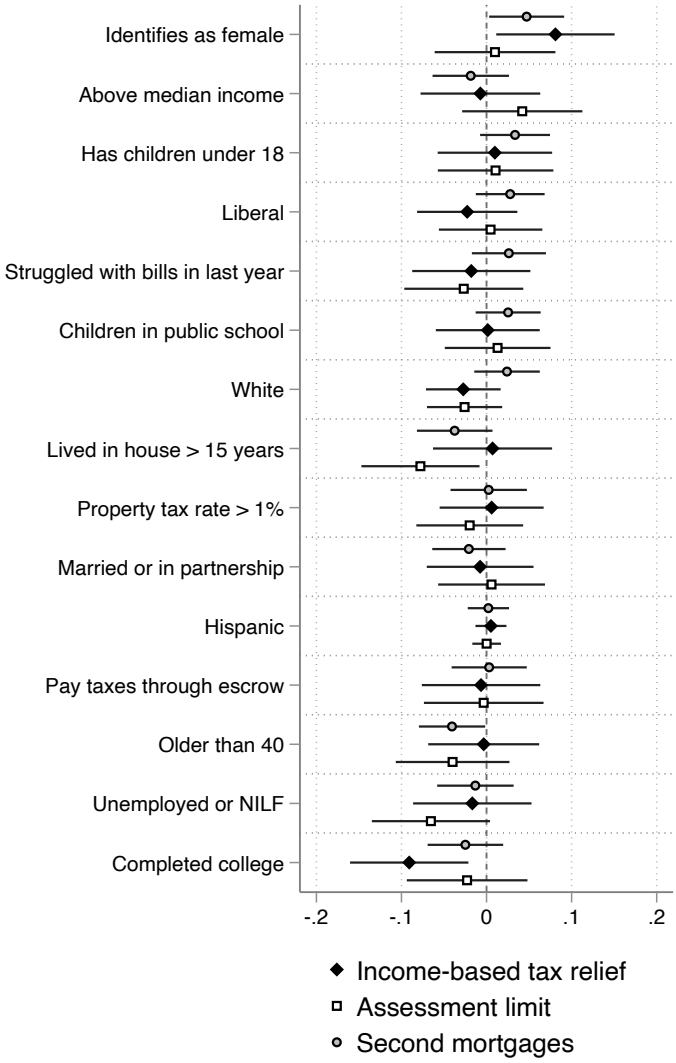
Notes: This figure depicts the time path of monthly tax and insurance payments (panel A), auto consumption (panel B), delinquency rates (panel C), default rates (panel D), second mortgage balances (panel E), and first mortgage balances (panel F), around a property tax change that occurs at event time $t = 0$. All panels present OLS estimates from a regression of the monthly escrow payment (i.e. tax and insurance payment) on the percent change in the annual property tax bill interacted with a set of event time indicators (Equation 1). Coefficients are scaled by the mean tax bill and yield an interpretation in levels. For example, a $1 increase in annual taxes raises monthly payments by about $0.05. The shaded region depicts 95 percent confidence intervals, where standard errors are clustered at the loan level. Event coefficients are normalized to zero two months before the change ($t = -2$). Data from main analysis sample is described in Section 2. Variables are described in Section 3.

Figure B7: Homeowners' Previous Financial Responses to Property Taxes



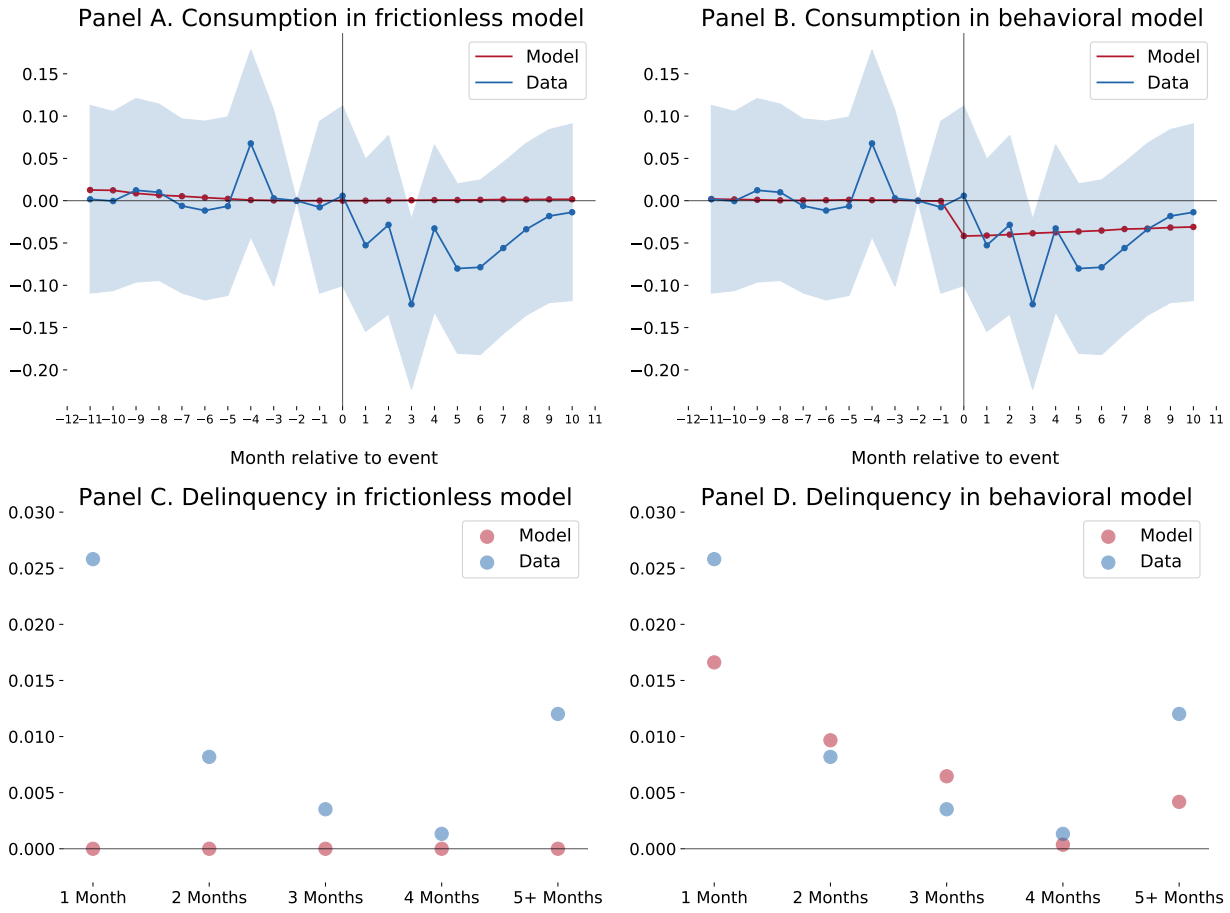
Notes: This figure plots unweighted responses from Wave 1 of the survey of homeowners (N=2,000). Panel A plots responses to the question, "Have you ever done any of the following in order to pay property taxes?" Responses indicate that very few homeowners have ever drawn on their housing wealth in order to pay property taxes. Panel B plots responses to the question, "Thinking back to the years in which you had difficulty finding the money to pay your property tax bill, did any of the following happen to you?" Inclusion in panel B is conditional on reporting having had difficulty paying property taxes in the past (N=721). One in five respondents who were asked this question were randomly presented with free response text box instead of multiple choice answers and are not included in figure. See Section 5 for more details on the survey of homeowners.

Figure B8: Randomized Treatment Balance



Notes: This figure verifies randomization balance for the three randomized information treatments embedded in the online survey of homeowners. This figure presents coefficients from 45 separate regressions. Each is derived from regressing a respondent characteristic on an indicator for receiving a randomized treatment. Circles correspond to a treatment providing information about second mortgages and reverse mortgages. Data come from Wave 1 of the online survey, which included responses from survey of homeowners across US. Inclusion in these regressions is conditional on reporting residing in a state other than Michigan. Squares and diamonds correspond to information treatments concerning property tax relief policy for homeowners residing in Michigan. The first treatment arm provided information on income-based property tax reductions, while the second arm provided information on assessment limits. Data come from responses of individuals in Waves 1 and 2 of the survey residing in Michigan. See Section 5 and Appendix Section E for more details on the survey and experiments.

Figure B9: Model Fit: Standard Agent



Notes: This figure presents the results of simulating the model described in Appendix Section F. Panels A and B plot the model fit for consumption against the empirically estimated consumption responses. The consumption response is defined as non-cumulative monthly auto consumption, scaled to reflect inferred total consumption as described in Appendix Section F. Panels C and D plot the model fit for average delinquency rates against the empirically observed delinquency rates. Panels A and C simulate the model for a fully attentive agent with standard time preferences. Calibrated parameters are presented in column 1 of Table A7. Panels B and D simulate the model for agents who are behaviorally inattentive, impatient, and debt averse. The model allows for heterogeneity in δ, the standard exponential discount factor. Calibrated parameters are presented in column 4 of Table A7.

C Data Appendix - For Online Publication

C.1 State Reassessments

This section describes the reassessment practices for the nine states analyzed in Section 4.

Connecticut: Township governments reassess property on five-year cycles. In order to identify property reassessment events, I define reassessment year based on township cycles. These cycles are available publicly online through the State of Connecticut Office of Policy and Management.

Illinois: Illinois reassessment protocols differ across counties. For instance, in Champaign county, each property is reassessed every four years, with different parts of the county assigned to different reassessment cycles. In each year, one out of four sub-county districts is reassessed (Champaign County 2019). In Cook County, many residential properties were not reassessed despite statutory requirements to do so (Grotto and Kambhampati 2017). In order to identify years in which a property was reassessed, I define a reassessment event as any year in which a property's assessed value stayed constant for two years before changing and staying constant for two more years, or if the property's value stayed constant for three years before changing.

Indiana: In 2006, Indiana reformed its system of property tax assessment. The state required assessors to begin trending the values of properties to correspond to previous market price movements of comparable properties (Krupa 2012). The combination of these reforms, the elimination of property taxes on business inventories, and a statewide property reassessment created large changes to homeowners' property assessments and corresponding property tax bills payable in 2007 (DeBoer 2015). I use the 2006 tax year as the property reassessment year.

Missouri: By law, counties in Missouri reassess properties in odd-numbered years, although the data indicate many deviations from this cycle. In order to identify years in which a property's assessed value was reassessed to conform with statutory reassessment requirements, I select any year in which a property's assessed value stayed constant for two years before changing and staying constant for two more years, or in which a property's value stayed constant for three years before changing.

New Hampshire: Townships in New Hampshire are required to reassess property every five years. Each township operates on a different schedule and the nature of each reassessment varies. Some reassessments involve statistical updates while others involve physical property inspections. Reassessments also vary in their coverage of property types. I use each township's reassessment schedules and select reassessments that have been labeled by the New Hampshire Department of Revenue Administration as full updates, statistical updates, or updates, which covers 89% of reassessment events. Many of the remaining 11% appear to involve reassessments of specific types of property. Schedules are available publicly through the New Hampshire Department of Revenue Administration.

North Carolina: Most counties in North Carolina operate on four- or eight-year reassessment cycles. In order to define property reassessment events, I follow the county cycles. These cycles are available publicly online through the North Carolina Department of Revenue.

Ohio: Counties in Ohio reassess properties in six-year cycles. In the intermediary third year, property values are updated by statistical reassessment. I define both six-year reassessments and statistical reassessments as reassessment events. County reassessment schedules are available publicly online through the Ohio Department of Taxation.

Tennessee: Each county in Tennessee operates on a four-, five-, or six-year reassessment cycle. In order to define property reassessment events, I follow the county cycles. These cycles are available publicly online through the Tennessee Comptroller of the Treasury.

Washington: State law in Washington requires properties to be reassessed at least once every four years (Tax Foundation 2010); however, in practice property reassessments can be irregular (Deshais 2018). In order to identify years in which a property was reassessed, I select any year in which a property's assessed value stayed constant for two years before being updated and staying constant for two more years, or in which a property's value stayed constant for three years before changing.

C.2 Data Construction

This section discusses the construction of the monthly panel used to estimate Equation 1. I begin by selecting counties in the nine sample states in which a large-scale reassessment can be identified, as described in Appendix Section C.1. I impose additional sample restrictions in order to ensure that the sample is comprised of counties that conducted large-scale reassessments. Within each county, I rank loans by the percent change in the property tax at reassessment (ΔT_i), and compute the mean level of escrow payments in the top and bottom deciles of ΔT_i in each month in event time. I drop counties with fewer than 100 loans and where escrow payments appear to change little after reassessment. Specifically, I drop counties in which changes in mean escrow payments in the top and bottom deciles of ΔT_i between event time $k = -6$ and $k = 3$ differ by less than 4 percentage points. This drops approximately 8% of the sample. Appendix Table A1 contains the resulting distribution of the sample across states and reassessment years.

Using these data, I construct a panel of loans covering a thirty-month window in calendar event time, balanced between $k = -12$ and $k = 11$. To define event time, I leverage the fact that escrow updates are conducted in twelve-month cycles. I define event time relative to the first escrow update that occurs before servicers begin to incorporate updated property tax bills into escrow updates. I label this month $k = -12$ in event time. Fixing event month $k = -12$ implicitly predicts that the next escrow update will occur in month $k = 0$. Appendix Figure B2 provides a visual illustration of this definition.

Defining event time in this way avoids creating issues associated with escrow updates in which the timing of the update is affected by homeowner behavior. Mortgage servicers are not legally required to conduct an escrow update if the borrower is currently delinquent on their mortgage; however, once a borrower has become current on their mortgage, mortgage servicers are required to conduct an escrow analysis. Consequently, the timing of an escrow update at $k = 0$ may be influenced by homeowner repayment decisions. Using the regular twelve-month escrow update

cycles to fix $k = -12$ instead of $k = 0$ circumvents this issue. To restrict the sample to loans that conform to regular annual escrow update cycles, I drop loans where the escrow account update observed before reassessment (i.e. at $k = -12$) coincides with a transition out of delinquency.

The resulting analysis sample is comprised of loans in which I observe an escrow update between six and twelve months before the first month in the county in which servicers update escrow accounts to incorporate updated property tax bills. I use the aggregate time series of property tax and escrow payments for each county to identify the month in which servicers incorporate updated property tax bills. This month does not always correspond to a statutorily determined date (e.g. the property tax due date). Despite servicers usually having access to property tax bills several months prior to the due date, the first month in which escrow accounts begin to reflect new tax payments appears to be in the months following the due date. For each year and each county, the first month in which escrow payments reflect new property tax bills can be readily identified from the time series for that county by examining the relationship between monthly escrow payments and ΔT_i in calendar time. I drop loans that update one to five months before this first month to mitigate potential errors in identifying this month. This choice ensures that the thirty-month window yields a sample in which loans are balanced between event months $k = -12$ and $k = 11$.

D Survey Questionnaire - For Online Publication

This section presents the survey questionnaire used for the survey of homeowners. The following questionnaire is presented in a simplified format and omits the logic that decides which questions are presented to each respondent.

Hello, we are researchers at the University of California, Berkeley who are interested in people's experiences with homeownership. It is very important for the success of our research that you answer honestly and read the questions very carefully before answering. Some of the questions in this survey might be difficult to answer, or you might have a hard time coming up with an exact answer. Don't worry, that's just fine! Even if you're not sure of the exact right answer, we would like you to give us your best guess. To ensure the quality of survey data, your responses will be subject to sophisticated statistical control methods. Responding without adequate effort may result in your responses being flagged for low quality.

It is also very important for the success of our research project that you complete the entire survey once you have started. This survey should take about 10 minutes to complete. Before you proceed to the survey, please complete the captcha below. Your participation in this study is voluntary. Your name will never be recorded and you will never be identified in the study results. If you have any questions about this study, please contact us at ucb.home.research@gmail.com.

1. In which state do you currently live?

2. What is your ZIP code?

3. In what year were you born?

4. Are you currently married or living as a partner with someone? {Yes, No}

5. How many children under age 18 live in your household? {0, 1, 2, 3, 4 or more}

6. Will the children in your household be attending kindergarten through grade 12 this year? {Yes, in public school, Yes, in private school, Yes, in both public and private schools, No, children not attending school this year }

7. Please describe the housing arrangement where you currently live. Do you: {Own your home with a mortgage or loan, Own your home without a mortgage or loan (i.e. free and clear), Rent your home, Neither rent nor own your home}

8. In what year did you move into your current home?

9. What is the value of your primary home? That is, how much do you think your primary home would sell for if it were for sale?

10. Which of the following are ways to borrow against your home? Check all that apply. {Second mortgage, Reverse mortgage, Upside-down mortgage, Credit card, Cash-out refinance}

11. Which of the following is true about reverse mortgages? {There is no such thing as a reverse mortgage, A homeowner doesn't have to repay a reverse mortgage before the property changes ownership, Reverse mortgages carry no interest, Reverse mortgages are primarily meant for working-age homeowners}

12. Which level of government would you least like to see expanded? {Federal, State, Local}

13. Which do you think is the worst tax–that is, the least fair? {Federal income tax, Federal Social Security tax, State income tax, State sales tax, Local property tax}

14. You indicated that the federal income tax is the worst/least fair tax. Which of the following are reasons that you feel this way? Please select all that apply. {I cannot control how high federal income taxes are, I do not benefit from the way federal income tax revenues are spent, I sometimes have trouble finding the money to pay federal income taxes, Other people have trouble finding the money to pay federal income taxes, High-income people pay too much/low-income people pay too little, High-income people pay too little/low-income people pay too much, Other:}

15. You indicated that the federal Social Security tax is the worst/least fair tax. Which of the following are reasons that you feel this way? Please select all that apply. {I cannot control how high Social Security taxes are, I do not think I will benefit from Social Security when I retire, I sometimes have trouble finding the money to pay Social Security taxes, Other people have trouble finding the money to pay Social Security taxes, High-income people pay too

much/low-income people pay too little, High-income people pay too little/low-income people pay too much, Other:}

16. You indicated that the state income tax is the worst/least fair tax. Which of the following are reasons that you feel this way? Please select all that apply. {I cannot control how high state income taxes are, I do not benefit from the way state income tax revenues are spent, I sometimes have trouble finding the money to pay state income taxes, Other people have trouble finding the money to pay state income taxes, High-income people pay too much/low-income people pay too little, High-income people pay too little/low-income people pay too much, Other:}

17. You indicated that the state sales tax is the worst/least fair tax. Which of the following are reasons that you feel this way? Please select all that apply. {I cannot control how high sales taxes are, I do not benefit from the way sales tax revenues are spent, I sometimes have trouble finding the money to pay sales taxes, Other people have trouble finding the money to pay sales taxes, High-income people pay too much/low-income people pay too little, High-income people pay too little/low-income people pay too much, Other:}

18. You indicated that the local property tax is the worst/least fair tax. Which of the following are reasons that you feel this way? Please select all that apply. {I cannot control how high property taxes are, I do not benefit from the way property tax revenues are spent, I sometimes have trouble finding the money to pay property taxes, Other people have trouble finding the money to pay property taxes, Property assessments are subjective and/or arbitrary, Property taxes make me feel that I do not own my house, Other:}

19. Does your regular monthly mortgage payment include payments for property taxes on your house? {Yes, taxes included in monthly mortgage payment, No, taxes paid separately, No, have no mortgage}

20. Approximately how much did you pay in property taxes for your house during the 2018 tax year? Simply give us your best estimate. You need not go to the trouble of consulting your records.

21. Before proceeding to the next set of questions, we want to ask for your feedback about the responses you provided so far. It is vital to our study that we only include responses from people who devoted their full attention to this study. Your answer to this question will not affect in any way the payment you will receive for completing this survey. In your honest opinion, should we use your responses, or should we discard your responses since you did not devote your full attention to the questions so far? {Yes, I have devoted full attention to the questions so far and I think you should use my responses for your study. No, I have not devoted full attention to the questions so far and I think you should not use my responses for your study.}

22. Imagine that in next year's election there were a ballot proposal that would increase property taxes to pay for local public school infrastructure improvements. Your taxes would increase by $200. How would you vote on this proposal? {Vote yes, Vote no}

23. How do you feel about the following statement? {"My local government does a good job of accurately valuing my property for tax purposes." {Strongly disagree, Somewhat disagree, Neither agree nor disagree, Somewhat agree, Strongly agree}

24. Since you first became a homeowner, how often have you had difficulty finding the money to pay property taxes on your primary residence? {Never, Once or twice, Occasionally, Very often, Every year}

25. Suppose we were to survey 100 homeowners {across the US, in your state, in your city/town, in your neighborhood}. Out of those 100 homeowners, how many do you think would report that at some point they have had difficulty paying property taxes on their primary residence? {Please enter your answer as a number between 0 and 100.}

26. Have you ever done any of the following in order to pay property taxes?

    Cut back on spending on basic necessities like food or heat

    Cut back on spending on big-ticket items like cars, home improvements, or appliances

    Used money from your savings to pay your tax bill

    Increased your credit card debt

    Taken out a second mortgage or refinanced your existing mortgage

    Borrowed from a friend or family member

    Skipped paying bills (e.g. utility, mortgage, credit card)

27. Each state has its own way of collecting property taxes, and property taxes can be complicated and burdensome to think about. We want to understand how people manage their property tax obligations. We also want to make sure that respondents are paying close attention to the survey questions. It is crucial for the success of this research that we have your full attention for this survey. Instead of answering the following question accurately, please only select Other and enter your favorite number. This will help us to evaluate whether your response allows us to understand homeowners' experiences paying property taxes in the US. Which of the following sources do you use for information about property taxes? {Local TV news, National TV news, Local online news, National online news, Friends and/or family, Local government website, Online resources, Tax attorneys, Other:}

28. Thinking back to the years in which you had difficulty finding the money to pay your property tax bill, did any of the following happen to you? Please check all that apply. {I forgot that my tax bill was coming up, I had unexpectedly low income or high expenses in the months

before my tax bill was due, I wasn't able to borrow the money to pay my tax bill, My tax bill was higher than I expected, I procrastinated coming up with the money to pay my tax bill, Other:}

29. Suppose that next year your yearly property tax bill increases by $500. How would you pay for this? If you would use more than one method to cover these taxes, please select all that apply. {Increase my credit card debt, Pay out of pocket using the money currently in my checking/savings account or with cash, Borrow from a friend or family member, Cut back on spending on basic necessities like food or heat, Cut back on spending on big-ticket items like cars, home improvements, or appliances , Take out a second mortgage or refinance your existing mortgage , Skip paying some bills, I wouldn't be able to pay my property taxes, Other (please specify):}

The following questions were asked only of homeowners who reported residing outside of Michigan.

30. Suppose you were given the option to defer your property taxes with zero interest. If you defer your property taxes, you only need to pay them when you sell or pass on your property. Which of the following best describes you? {I would defer all of my property taxes immediately, I would defer my property taxes if I had trouble finding the money to pay them, I would never defer my property taxes}

31. You indicated that you would never defer paying your property taxes. Which of the following are reasons you chose this option? Please select all that apply. {I don't want to pay a large lump-sum tax bill when I sell my house, I don't want to feel like I'm in debt, I don't want my heirs to be burdened by the deferred taxes, Deferring my taxes would make me feel like I don't own my home, I wouldn't trust the government to correctly implement the deferral, Other:}

32. Imagine that in next year's election there were a ballot proposal that would do the following: {Reduce property taxes by $500 for homeowners that are low-income, Reduce property taxes by $500 for homeowners that are elderly, Reduce property taxes by $500 for homeowners that are struggling to pay their property taxes} Increase property taxes by $100 for all other homeowners. How would you vote on this proposal? {Vote yes, Vote no}

33. Suppose that one year you have a hard time finding the money to pay property taxes. In order to find the money to pay property taxes, would you consider taking out a second mortgage? {Yes, No}

34. You indicated that you would not consider taking out a second mortgage. What are your reasons for choosing this option? {The up-front costs would be too high, I would not qualify for a loan, I don't know how to take out a second mortgage, I am uncomfortable being in debt, I would have trouble paying back the loan, Other:}

35. Suppose again that one year you have a hard time finding the money to pay your property taxes. In order to find the money to pay property taxes, would you rather take out a second mortgage or would you rather skip paying one or more bills (e.g. credit card, mortgage, utilities)? {I would rather take out a second mortgage, I would rather skip paying one or more bills}

36. Many people report that at some point, they have had a hard time finding the money to pay property taxes. In general, which has more to do with why a person has difficulty finding the money to pay property taxes? {Lack of effort on his or her own part, Circumstances beyond his or her control}

The following questions were shown only to homeowners who reported residing in Michigan.

37. Which of the following programs reduce property taxes for homeowners in Michigan? Check all that apply. {Limits on the growth of assessed value of property (assessment limit), Property tax reductions based on household income, Property tax deferral programs, Maximum property tax rates}

38. The assessed value of property is the value used by local governments for tax purposes. The state of Michigan limits how quickly assessed value can increase from year to year. What is the maximum percentage by which the assessed value of property can increase in one year? Please enter your answer as a percent.

39. Which of the following groups do you think currently benefits the most from this limit on assessed value? {Homeowners who bought their home recently benefit the most, Homeowners who bought their home a long time ago benefit the most, All homeowners benefit equally}

40. The state of Michigan offers income-based property tax reductions to homeowners through the Homestead Property Tax Credit. What do you think was the average reduction to property taxes for homeowners who received this credit? Please enter your answer in dollars.

41. Do you think that low-income or high-income homeowners benefit more from the Homestead Property Tax Credit? {Low-income homeowners benefit more, High-income homeowners benefit more, Low-income and high-income homeowners benefit equally}

42. As a result of Michigan's limit on the growth of assessed values, a homeowner who recently purchased a home will pay much higher property taxes than a homeowner who purchased a similar home several years ago in the same neighborhood. Do you approve or disapprove of this feature of Michigan's property tax system? {Approve, Disapprove}

43. Because of Michigan's income-based property tax relief, a low-income homeowner will pay lower property taxes than a higher-income homeowner who owns a similar home in the same neighborhood. Do you approve or disapprove of this feature of Michigan's property tax system? {Approve, Disapprove}

The following questions were asked of respondents regardless of reported location.

44. Now, we would like to ask you a few questions about your household finances.

45. Have you struggled to pay your bills at any point in the past 12 months? {Yes, No}

46. Which best describes how difficult it would be for you to qualify for a second mortgage? {Very difficult, Somewhat difficult, Somewhat easy, Very easy}

47. Do you currently have a second mortgage? {No, neither, Yes, home equity loan, Yes, home equity line of credit (HELOC), Yes, both a home equity loan and a home equity line of credit (HELOC)}

48. At the end of a typical month, approximately how much money do you have left over after paying for your regular expenses? Regular expenses can include food, clothing, mortgage payments, transportation, and utilities. {Less than $100, Between $100 and $500, Between $500 and $1,000, Between $1,000 and $5,000, Between $5,000 and $10,000, More than $10,000}

49. What is your best estimate of the total amount of money that you currently owe on credit cards? Please also include any cards you own jointly with other members of your household. {I don't own a credit card, Less than $500, Between $500 and $1,000, Between $1,000 and $5,000, Between $5,000 and $10,000, More than $10,000}

50. Including what you owe now, what is the maximum amount you could owe on your credit cards? That is, what is your total limit on your credit cards? Please also include any cards you own jointly with other members of your household. {Less than $1,000, Between $1,000 and $5,000, Between $5,000 and $10,000, Between $10,000 and $20,000, More than $20,000}

51. Are you male or female? {Male, Female, Other, Prefer not to answer}

52. How would you describe your political views? {Very liberal, Liberal, Moderate, Conservative, Very conservative}

53. Which category best describes your highest level of education? {Eighth grade or less, Some high school, High school degree / GED, Some College, 2-year college degree, 4-year college degree, Master's Degree, Doctoral Degree, Professional Degree (JD, MD, MBA)}

54. What is your current employment status? {Full-time employee, Part-time employee, Self-employed or small business owner, Unemployed and looking for work, Student, Not employed and not looking for work}

55. For statistical purposes only, we need to know your total household income for last year (2018). Which of the following categories best represents your total household income? {Less than $10,000, $10,000 to $19,999, $20,000 to $29,999, $30,000 to $39,999, $40,000 to $49,999, $50,000 to $59,999, $60,000 to $74,999, $75,000 to $99,999, $100,000 to $149,999, $150,000 to $199,999, $200,000 or more}

56. Would you describe yourself as Spanish, Hispanic, or Latino? {Yes, No}

57. How would you describe your race? Check all that apply. {White, Black or African-American, American Indian or Alaska Native, Asian, Native Hawaiian or Pacific Islander, Other, Prefer not to answer}

58. Were any of the questions we asked in this survey confusing? {Yes, No}

59. On a scale of 1 to 10 (with 1 being extremely easy and 10 being extremely difficult), how difficult was this survey to understand? {1 (extremely easy), 2, 3, 4, 5, 6, 7, 8, 9, 10 (extremely difficult)}

60. Please feel free to give us any other feedback regarding this survey. We are especially interested in knowing if you found any parts of the survey confusing or unclear.

E Randomized Information Treatments - For Online Publication

E.1 Mortgage Information Treatment

Half of survey respondents not living in Michigan were randomly assigned to receive information on second mortgages and reverse mortgages. The treatment is comprised of a series of six slides, presented in Figure E10. This treatment is designed to test whether information frictions deter homeowners from taking out second mortgages in response to property tax increases. Figure B8 shows covariate balance over the random assignment to treatment.

Table A4 presents the results from regressions that estimate the treatment effect of receiving information treatment. Each outcome is regressed on an indicator for being assigned to the treatment group. The outcomes in panel A represent first stage outcomes. Each outcome tests respondent knowledge of second mortgages. Results show that receiving information results in a 30 percentage point increase in the likelihood of correctly identifying second mortgages and reverse mortgages as ways of extracting home equity, and a 32 percentage point increase in the likelihood of correctly answering that reverse mortgages do not have to be repaid until a property is transacted. This indicates that the treatment successfully and substantially increases knowledge of second mortgages and reverse mortgages.

Table A4, panel B examines effects on attitudes towards borrowing. Results indicate that homeowners are 5 percentage points more likely to state that they would consider taking out a second mortgage if they had difficulty paying property taxes; however, homeowners are not more likely to take out a second mortgage if they face a $500 property tax increase next year. This zero effect is estimated precisely. While these results appear contradictory, the fact that the former question asked specifically about second mortgages while the latter allowed homeowners to select from a variety of different options suggest that homeowners responded to perceived surveyor demand for an affirmative answer. Coupled with the fact that 63% of respondents report that it would be

easy or very easy to take out a second mortgage, these results suggest that information frictions are not an important driver of housing wealth illiquidity or of aversion to property taxes.

E.2 Policy Information Treatments

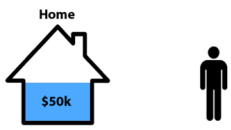
Homeowners in Michigan were randomized into a control group, an information treatment about assessment limits, or an information treatment about income-based property tax reductions. Policy Treatment 1 provides information about assessment limits in Michigan. Michigan limits the growth of assessed value of property to the lower of 5% and inflation. This assessment limit gives homeowners with longer tenures substantial tax advantages relative to newer homebuyers. Policy Treatment 1 is presented in Figure E11. Policy Treatment 2 provides information about Michigan's income-based tax relief. Michigan's Homestead Property Tax Credit provides households with income below $60,000 a refundable credit on their state income taxes. The credit phases out with income but typically provides about 60% of the amount that property taxes exceed 3.5% of income (MLPP 2019). This credit is taken up by over 1 million taxpayers and provides a $500 reduction on average (Michigan Department of Treasury 2018). Policy Treatment 2 is presented in Figure E12. Figure B8 shows covariate balance over the random assignment to treatment.

Table A5 presents the results from unweighted regressions that estimate the treatment effects of receiving the two information treatments on outcomes that test respondent knowledge of policy and thus represent first stage outcomes. Each outcome is regressed on an indicator for being assigned to Treatment 1 and an indicator for being assigned to Treatment 2. Table A5 indicates that Treatment 1 increases the probability that a respondent correctly identifies the maximum assessment limit by 56 percentage points. Similarly, Treatment 2 increases the probability that a respondent correctly identifies the average amount of tax relief provided by the Homestead Property Tax Credit by 32 percentage points. These large effects imply that the two treatments successfully increase respondent knowledge of Michigan property tax relief policies.

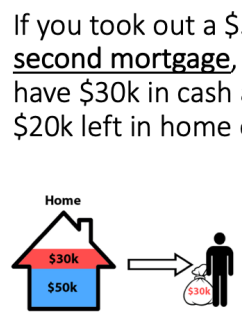
Figure E10: Mortgage Information Treatment

(a) Slide 1

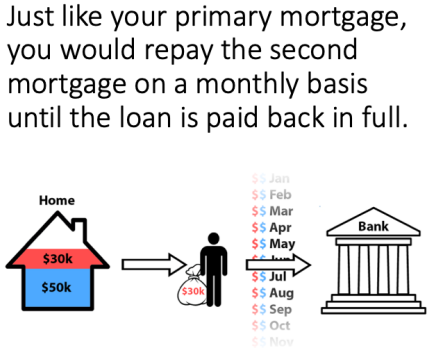
(b) Slide 2



(c) Slide 3

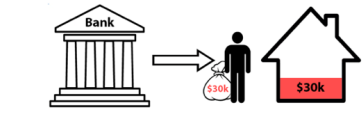


(d) Slide 4



(e) Slide 5

(f) Slide 6



Notes: Figure depicts information treatment randomly presented to homeowners outside of Michigan.

Figure E11: Policy Information Treatment: Assessment Limits

(a) Slide 1

The state of Michigan limits the growth of assessed value of owner-occupied property to 5% per year or to inflation (whichever is lower).

(b) Slide 2

Example 1. John buys a home for $100,000. The next year, his home is worth $110,000. The **assessment limit** means his property assessment can't be more than $105,000.

(c) Slide 3

Because of the **assessment limit**, a homeowner who recently purchased a home will pay much higher property taxes than a homeowner who purchased a similar home several years ago in the same neighborhood.

(d) Slide 4

Example 2. The Johnsons and the Smiths live in the same neighborhood. Their houses are both worth $100,000. The Johnsons recently moved into the neighborhood.

(e) Slide 5

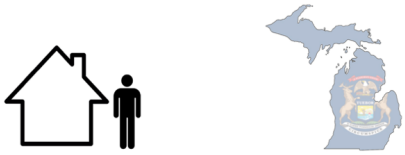
Because the Smiths have lived in the neighborhood much longer, their house is taxed as if it were worth $50,000. The Smiths pay **half as much** in property taxes as the Johnsons, even though their houses are **worth the same**.

Notes: Figure depicts one of two randomized information treatments randomly presented to homeowners in Michigan.

Figure E12: Policy Information Treatment: Income-Based Tax Reductions

(a) Slide 1

The state of Michigan provides income-based **property tax relief** to many taxpayers through the **Homestead Property Tax Credit**.



(b) Slide 2

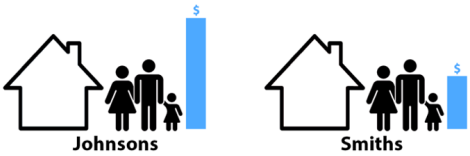
Households with income below $60,000 can benefit from the program by claiming the credit on their state income tax returns.

(c) Slide 3

The Homestead Property Tax Credit provided 1 million Michigan taxpayers with property tax relief in 2016. The average property tax reduction was about $500.

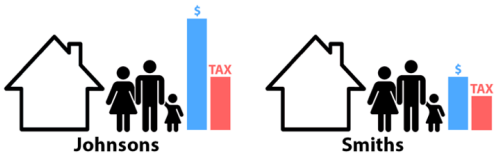
(d) Slide 4

Example: The Johnsons and the Smiths live in the same neighborhood. Their houses are both worth the same, but the Johnsons earn $65,000 a year while the Smiths only earn $30,000.



(e) Slide 5

Because the Smiths have a lower income than the Johnsons, the Smiths' property taxes **are one-third** lower.



Notes: Figure depicts one of two information treatments randomly presented to homeowners in Michigan.

F Model - For Online Publication

This section interprets the empirical results presented in Section 4 through the lens of a calibrated model of consumption and mortgage default. First, the model addresses the puzzling timing of homeowner consumption responses to increased monthly property tax payments shown in Figure 2. Specifically, why do decreases in consumption and increases in delinquency occur in the same month that monthly payments update to reflect new property tax bills? Taxpayers are notified of these increased tax payments many months before they affect monthly escrow payments. It is therefore surprising that homeowners would not anticipate these changes and adjust their consumption and mortgage payment decisions accordingly. Second, the model demonstrates the importance of impatience and non-standard time preferences for explaining the results. Third, the model incorporates a key result from the survey of homeowners presented in Section 5: homeowners do not draw on their housing wealth because they are debt averse. The model accommodates behavioral inattention, impatience, and debt aversion. In this section I show that all three features are necessary to fit the observed empirical patterns.

F.1 Model Setup

Each month, agents choose consumption c_t and decide whether to skip mortgage payments. Delinquency is indexed by $d_t \in \{0, 1, 2, 3, 4, 5\}$, where $d_t = 0$ denotes a borrower who is current, $d_t = 1$ denotes a borrower who is one month past due, $d_t = 2$ denotes two months past due, and so on. I assume that once an agent reaches 4 months past due, her lender forecloses on her property and the agent is excluded from homeownership indefinitely. This choice is designed to reflect the empirical distinction between delinquency and default. As the transition matrix in Table A2 shows, most loans that are one month delinquent eventually cure, in contrast to loans that become deeply delinquent (e.g. four or more months past due).

Each month, agents receive stochastic income draws $\tilde{z}_t$ and earn a rate of return R on assets held at the beginning of each period. Agents make monthly tax payments τ_t and mortgage payments π. Agents' problems are as follows:

$$\max_{\{c_t, d_t\}} u(c_t) - \psi(d_t) - \phi(a_{t+1}) + E\left[\beta \sum_{n=1}^{T-t} \delta^n \Big(u(c_{t+n}) - \psi(d_{t+n}) - \phi(a_{t+n+1}) \Big)\right]$$

$$u(c_t) = \frac{c_t^{1-\gamma}}{1-\gamma}$$

$$\psi(d_t) = k(d_t)^{\xi}$$

$$\phi(a_{t+1}) = \mathbb{1}\{a_{t+1} < 0\} \cdot l(-a_{t+1})$$

subject to the following budget constraint:

$$c_t + a_{t+1} + \tau_t + \pi = Ra_t + z_t$$

In addition, terminal assets must be non-negative and agents face a borrowing constraint $a_{t+1} \geq \underline{a}$. In the agent's objective function, $u(c_t)$ captures utility from consumption, $\psi(d_t)$ captures disutility from delinquency, and $\phi(a_{t+1})$ captures debt aversion. The preference parameter γ reflects risk aversion, k and ξ reflect the magnitude of disutility from delinquency, and l reflects the magnitude of aversion to indebtedness. The model allows for standard time preferences when $\beta = 1$ and for quasi-hyperbolic discounting when $\beta < 1$. The agent is finitely lived and the solution to the aforementioned problem can be solved by backwards induction.

When agents choose to skip a mortgage payment, they do not pay π that month; however, once they repay their missed payment, they pay a 5% late fee. This 5% late fee is standard in real-world mortgage contracts. Once an agent has missed four mortgage payments, she is excluded from homeownership indefinitely, pays monthly rental costs equal to π, and suffers a permanent utility cost equal to $\psi(5)$. The model therefore captures both delinquency and default. In general, delinquency can be thought of as a high-interest loan. Therefore, agents will only make use of mortgage delinquency when they have exhausted their liquid assets or when they do not wish to borrow because of the disutility from debt aversion. Otherwise, borrowing through mortgage delinquency is strictly dominated by reducing liquid assets.

Property tax payments in this model are mandatory and property is reassessed every thirty-six months. From the perspective of $t = 0$, τ_{36} is an uncertain draw from some distribution $\tilde{\tau}$.[41] I let $\tau_t = 0$ for $t \in [0, 35]$, and τ_{36} drawn from a distribution $\tilde{\tau} \sim N(0, \sigma)$. Therefore, τ_{36} represents the change in the property tax bill after reassessment.[42] The model allows for homeowners to be inattentive to changes in their property tax bill. A fully attentive homeowner will update their expectations about τ_{36} to its realized value at $t_u < 36$, where t_u is the month in which they learn about their new property tax bill. I use the empirical distribution of differences in the month in which an escrow account updates and the month in which local taxing authorities mail out property tax bills to calibrate the distribution of t_u in the model. An inattentive homeowner ignores the signal they receive at t_u and instead updates her expectations concerning τ_{36} only when she begins to make the newly updated payments in $t = 36$.

I calibrate various model components to both internal and external sources. I use the primary analysis dataset to calibrate the borrowing constraint $\underline{a}$. For each loan in the data I calculate potential borrowing capacity as the amount a homeowner could borrow against their home until their loan-to-value ratio reaches 90%. I calibrate the stochastic monthly income process using monthly household income from the 2008 Survey of Income and Program Participation (SIPP).

[41] While positive draws of $\tilde{\tau}$ are empirically correlated with increases in house price growth, this model abstracts away from changes to housing wealth. The empirical results in Section 4 indicate that homeowners do not generally draw on their housing wealth in order to pay property taxes. Particularly given that changes to housing wealth appear to have limited influence on how homeowners' short-term responses to changes in property tax bills, this model focus on those short-term responses holding housing wealth fixed.

[42] While the model allows homeowners to go delinquent on their initial property tax bill (which is included in π), I assume that homeowners cannot go delinquent on the change in their tax payment. This assumption is made for tractability. In reality, when homeowners skip mortgage payments, they go delinquent on both π and τ. This is a quantitatively minor assumption given that changes to property tax liabilities are small relative to the total monthly payment.

I fit an AR(1) income process to monthly earnings. Table A6 provides a summary of calibrated parameters. The model calibration and model solution are discussed in more detail later in this section.

I calibrate the behavioral parameters of the model (denoted by θ) to fit the observed empirical responses to property tax increases. The observed model fit for a given set of behavioral parameters $M(\theta)$ is given by

$$M(\theta) = \Big[m(\theta) - \hat{m}\Big]' W \Big[m(\theta) - \hat{m}\Big]$$

In the above, $m(\theta)$ denotes a set of model moments and $\hat{m}$ denotes their empirical counterparts. In order to compute $m(\theta)$, I simulate the model for one hundred thousand agents, taking draws over the calibrated distributions of $\tilde{\tau}_t$ and $\tilde{z}_t$, the empirical distribution of a_0, and the empirical distribution of months in which agents learn of their new property tax payment, t_u. I calibrate the model to fit three sets of empirical moments (i) regression coefficients from Equation 1 where the outcome is consumption (21 moments), (ii) regression coefficients from Equation 1 where the outcomes are indicators for delinquency corresponding to $d_t \in \{1, 2, 3, 4, 5\}$ (105 moments), and (iii) mean rates of delinquency at event time $t = -2$ corresponding to $d_t \in \{1, 2, 3, 4, 5\}$ (5 moments). Moments in (i) and (ii) are computed by running a version of Equation 1 on the data simulated by the model. Moments in (iii) are the share of simulated agents who have $d_t \in \{1, 2, 3, 4, 5\}$, computed two periods before the property tax update. The weighting matrix W gives equal weights to each of the three groups of moments and weights moments equally within those groups.[43]

F.2 Standard Model

I begin by simulating the model for a "standard" agent. Specifically, I allow the agent to be fully attentive and set $\delta = \frac{1}{R}$, $\beta = 1$, and $l = 0$.[44] These parameter values imply that the agent is neither impatient nor debt averse. Panel A of Figure B9 plots the empirical response of auto consumption (converted to units of total consumption) relative to the response simulated by the model. The standard model offers a remarkably poor fit. There is no drop in consumption in the month in which property taxes increase; instead, there is a gradual consumption decline leading up to that month. The reason for this poor fit is that agents in the model rationally anticipate increases in property taxes many periods ahead of the update. In the periods preceding the update, agents reduce their consumption in order to save for the tax increase, leading to a smooth consumption path throughout the update. These results suggest that homeowners are generally inattentive to changes to property tax increases. While agents who possess a level of impatience so high as to be hand-to-mouth but who are fully attentive would also exhibit changes to their consumption path in the month of the tax change, the heterogeneous responses in Section 4 indicate that even higher-

[43] An alternative choice of weights would be to weight the moments using the empirical variance-covariance matrix; however, because mean delinquency rates are estimated with substantially less error than the regression coefficients, weighting by variances would fit the model almost exclusively to moments computed from means.

[44] The remaining calibrated parameters are presented in Table A7.

resource individuals (e.g. those with higher credit scores) exhibit large consumption responses. It is implausible that these higher-resource types would be so impatient so as to exhibit hand-to-mouth type behavior.

The standard agent is also unable to fit observed delinquency and default responses. Panel B of Figure B9 demonstrates the absence of mortgage delinquency for standard agents. This absence is in stark contrast with the empirical moments. In the data, about 2.5% of borrowers are one month past due on their mortgage payments at any given time. The primary reason that standard agents never miss mortgage payments is that, consistent with canonical models of consumption under uncertain income, agents anticipate the possibility of a sequence of low income draws and build up a buffer stock of savings in order to avoid the risk of low consumption. Because delinquency carries an implicit 5% monthly interest rate, drawing down assets or borrowing (particularly in the absence of debt aversion) strictly dominates delinquency. Therefore, a sufficiently patient agent will effectively never go delinquent.[45]

Taken together, the results from simulating a standard agent imply that in order to fit the data, agents must be both inattentive and impatient. Impatience itself is not enough in order to explain the results, because even highly impatient agents will display a smooth consumption path throughout the month where their property tax changes. Inattention is also not sufficient, because agents who are inattentive but sufficiently patient will still build up a buffer stock of liquid assets in order to avoid delinquency.

F.3 Behavioral Model

In order to better match the data, I now turn to a model that incorporates three behavioral factors: inattention, impatience, and debt aversion. The previous subsection demonstrates the importance of including inattention and impatience. This subsection demonstrates the need for agents to be debt averse in order to fit the data. Table A7 presents results from simulating the model for agents with these behavioral biases. Column 1 presents the model fit for the simulated standard agent. The second and third columns present the model fit for agents who are inattentive and impatient but who are not averse to being in debt (i.e. $l = 0$). I capture impatience in two ways. Column 2 allows impatience to load onto the standard discount factor δ but holds the quasi-hyperbolic discount factor β fixed at $\beta = 1$. Column 3 sets $\delta = \frac{1}{R}$ and allows $\beta < 1$. While the results provide a substantially better fit than the standard model, the fitted time preferences are extremely low. The monthly discount factor $\hat{\delta} = 0.86$ corresponds to an annual discount factor of 0.16, while the quasi-hyperbolic discount factor is similarly low with $\hat{\beta} = 0.06$. Because using mortgage delinquency to generate liquidity is strictly dominated by drawing down on liquid assets due to the high interest rate associated with mortgage delinquency, substantial rates of delinquency can only be generated when many agents are at the borrowing constraint. Only highly impatient agents are willing to

[45] Note that this holds when delinquency costs are arbitrarily small but default costs are meaningful. In the absence of any disutility from default, all agents would eventually default in order to receive a transfer in the form of four unpaid mortgage payments. This behavior is at odds with behavior observed in the data.

forgo acquiring liquid savings in the face of substantial income uncertainty.

The parameters calibrated for agents in Columns 2 and 3 are problematic for two reasons. First, the discount factors are implausibly low and far outside the range of rates of time preference estimated in other settings (Ganong and Noel 2019). Second, this level of impatience induces the majority of homeowners to draw down their assets until they are close to the borrowing limit, but few real-world homeowners engage in such behavior. In the simulated data, 48.1% of low-δ and 48.5% of low-β agents have utilized over half of their borrowing capacity at event time $t = -2$. Thus, this level of impatience implies that the majority of homeowners should take out second mortgages in order to convert their housing wealth into consumption, a prediction that is clearly rejected by observed borrowing patterns.[46]

These patterns imply the existence of additional factors that deter impatient agents from drawing down their housing wealth. While previous research has highlighted the importance of a variety of plausible factors like fixed costs (Chetty and Szeidl 2007, Kaplan and Violante 2014), I follow the results from Section 5 which suggest that debt aversion is a key factor that deters homeowners from drawing on their housing wealth. In particular, Figure 5 indicates that while two-thirds of respondents indicate that they would not want to take out a second mortgage if they had a hard time finding the money to pay property taxes because they are uncomfortable being in debt, only one-third of respondents indicate that they would not do so because of up-front costs. To my knowledge, this is the first study to incorporate preference-based debt aversion into a model of consumption and loan repayment.

Motivated by the evidence from the survey of homeowners, I now demonstrate that a model in which inattentive and impatient agents are also debt averse can fit the data without creating agents who rapidly draw down their assets. Column 4 of Table A7 presents the fit from a model in which homeowners differ in their rate of discounting δ (similar to Ganong and Noel 2019), and also have positive amounts of debt aversion $l > 0$. The calibrated parameters generate a sharp reduction in consumption when taxes increase as well as positive equilibrium rates of mortgage delinquency and default (panel C of Figure B9). These agents also fit the increases in delinquency and default observed in the event studies (panel D of Figure B9). Notably, this model provides a quantitatively better fit than the models in Columns 2 and 3.

The calibrated debt aversion parameter, $\hat{l} = 359.5$ implies a very high degree of debt aversion. The single-period disutility from drawing down 10% of borrowing capacity is equivalent to the difference in single period utility from a 95% reduction in consumption relative to the mean.[47] This large value implies that debt aversion is pivotal in generating the observed delinquency and default responses. Table A8 provides counterfactual calibrations of the consumption and default responses with preference parameters as previously calibrated, but without debt aversion (i.e. $l = 0$). The default response is essentially non-existent (the size of the event study coefficient without debt aversion is 0.01% that of the coefficient of the model with debt aversion). Notably, the consumption

[46] As reported in Table 1, only about one-fifth of homeowners in the sample have any second mortgage.

[47] Mean consumption at $t = -2$ is \$2956, or 0.577 when normalized by mean monthly income.

response is largely unchanged. The reason is because the consumption response is driven by all agents who adjust their precautionary savings, while the default response is only driven by agents who are close to their borrowing constraint or close to incurring disutility from debt aversion. The inclusion of debt aversion brings the model closer to reality in that most agents do not draw down their housing wealth by borrowing. With debt aversion, no agents draw down more than half of their borrowing capacity.[48]

The inclusion of debt aversion also allows agents to be substantially less impatient than in Columns 2 and 3 of Table A7. Notably, the agents in the model in Column 4 still exhibit a substantial amount of impatience. Nonetheless, the inclusion of debt aversion allows agents in the model to exhibit levels of time preferences that are much closer to estimates in other settings. Debt aversion is therefore valuable for modeling homeowners who maintain substantial amounts of home equity, but who still engage in high-cost borrowing through delinquency. Importantly, all three behavioral features (inattention, impatience, and debt aversion) are necessary to explain the observed patterns. If agents are debt averse but not inattentive and impatient, they do not miss mortgage payments and they do not change their consumption paths in the month that their property tax bills increase.

F.4 Calibration

This section provides additional details on the structural model of consumption and mortgage delinquency presented in Section F. In the model, dollar values are normalized to mean monthly income. Numerical values are discussed accordingly.

Income Process: I calibrate the monthly volatility of income to match the volatility of monthly income in SIPP for homeowners with mortgages for the four years in 2009-2012 by estimating an AR(1) process. Specifically, I estimate a model of the following form:

$$y_{it} = \alpha_i + \eta_{it} + \epsilon_{it}$$
$$\eta_{it} = \rho\eta_{it-1} + \nu_{it}$$

In the above, y_{it} is log income. I assume α, ϵ, ν, and η_0 are all mean zero with some variance to be estimated. The parameters to be estimated are $\theta = \{\rho, \sigma^2_\alpha, \sigma^2_\epsilon, \sigma^2_\nu, \sigma^2_{\eta 0}\}$.

Property Taxes: To parametrize the distribution of changes to property taxes (τ) within the model, I take the empirical distribution of percent changes to escrow payments between event time $t = -2$ and event time $t = 1$. I condition on non-zero escrow payments, and on having a non-zero change to the escrow account. First, I calculate a standard deviation as follows:

[48] Specifically, as of $t = -2$, no agents have borrowed more than \$10,350, half of the calibrated borrowing constraint (Table A6)

$$\sigma_e = sd\left(\frac{escrow_2}{escrow_{-1}} \times \bar{escrow}\right)$$

In the above, $\bar{escrow}$ represents the mean escrow payment. To convert this into units of the regressor, I divide σ_e by the point estimate of the first stage, \$150.

Borrowing Constraint: I assume that homeowners are generally able to borrow up to 90% CLTV. I compute the mean borrowing capacity for homeowners in the sample as the difference between LTV at $t = 0$ and 90% LTV (dropping loans above the 99th percentile of LTV), in dollar terms by scaling by the house value. I then normalize this value by mean monthly income. This calibration yields a borrowing constraint $\underline{a} = -4.04$ (i.e. homeowners can borrow up to four times mean monthly income). In dollar terms, the borrowing capacity for agents in the model is \$20,701.

Initial Distribution of Assets: To calibrate the initial distribution of assets (a_0), I take the mean and standard deviation of the distribution of $\log\left(\frac{\text{liquid assets}}{monthlyHHincome}\right)$ from months in SIPP in 2009-2012. I simulate draws from a log-normal distribution to generate the starting values for a_0. I topcode these values at 20.

Measuring Total Consumption: The data provides estimates of effects on auto consumption. To convert these estimates into estimates of total consumption, I follow the procedure in Di Maggio et al. (2017). Their approach uses state-level consumption data from BEA to estimate the sensitivity of auto sales growth and total consumption to state-level Bartik shocks. They find that the ratio of responses to auto sales relative to total consumption, in response to Bartik shocks is about 2.3 to 0.7. Therefore, in order to interpret an increase of \$X in monthly car expenditure, I use the fact that auto sales account for about 4.5% of overall household consumption, and convert as follows:

$$\Delta(c_t) = \frac{1}{0.045} \times \frac{0.7}{2.3} \times \$\text{X}$$

Miscellaneous: I provide agents with a minimum amount of consumption $\underline{c} = 0.001$. I assume agents live for 150 months.

F.5 Solution

This subsection presents the solution method for an agent with standard time preferences ($\beta = 1$) and no debt aversion ($l = 0$). The solution characterizes policy functions $c(t, a_t, d_{t-1}, z_t)$ and

$d(t, a_t, d_{t-1}, z_t)$, as well as value function $V(t, a_t, d_{t-1}, z_t)\ \forall t \in [0, T]$. At time t, agents solve:

$$\max_{\{c_t, d_t\}} u(c_t) - \psi(d_t) + E\left[\sum_{n=1}^{T-t} \delta^n \Big(u(c_{t+n}) - \psi(d_{t+n}))\Big)\right]$$
$$u(c_t) = \frac{c_t^{1-\gamma}}{1-\gamma}$$
$$\psi(d_t) = k(d_t)^{\xi}$$

Subject to the following constraints:

$$c_t + a_{t+1} = Ra_t + z_t + b(d_t) - p(d_t, d_{t-1}) - \tau_t$$
$$c_t \geq 0$$
$$a_{t+1} \geq \underline{a}$$

In the above, $b(d_t)$ is the extra liquidity from being in state d_t, while $p(d_t, d_{t-1})$ is the late penalty from being in state d_t, after being in d_{t-1}. The Euler equation for consumption analytically determines the consumption function. Differentiating the objective function yields the equation:

$$c_t = \Big(\beta\delta E\big[Ru'(c_{t+1})\big]\Big)^{-\frac{1}{\gamma}}$$

In the above, expectations are taken over income and property tax realizations. The delinquency decision d_t is discrete. Let V_t^d be the value function for the agent who chooses delinquency status d in this period. Specifically,

$$V_t^d(a_t, d_{t-1}, z_t, \tau_t) = \max_{c_t} u(c_t) - \psi(d) + \delta E\Big[V_{t+1}^d(a_{t+1}, d, z_{t+1}, \tau_{t+1})\Big]$$

Having computed the policy function c_t from the Euler equation, d_t can be computed as:

$$d_t = \arg\max_{d \in \mathcal{D}} \{V_t^d(a_t, d_{t-1}, z_t, \tau_t)\}$$
$$V_t(a_t, d_{t-1}, z_t) = \max_{d \in \mathcal{D}} \{V_t^d(a_t, d_{t-1}, z_t, \tau_t)\}$$

Where $\mathcal{D}$ is the set of allowable delinquency statuses given d_{t-1} (e.g. $\mathcal{D} = \{0, 1, 2\}$ if $d_{t-1} = 1$). Agents in the model are finitely lived and the model is solved by backwards induction. The policy and value functions are linearly interpolated between asset grid points. I use 5 grid points for monthly income z_t and 5 grid points for monthly tax payments τ_t. When an agent is not debt averse, I use 20 grid points for a_t, with grid points more densely clustered around $\underline{a}$. When agents are debt averse (and therefore tend to go delinquent around $a_t = 0$ instead of $a_t = \underline{a}$, I use a grid of 35 points with grid points more densely clustered around $a_t = 0$.

One issue that arises is when agents have substantial amounts of liquidity and when the disutility from delinquency ψ is small, meaning that the choice between delinquency statuses (e.g. $d_t = 0$

vs. $d_t = 1$) has a very small impact on total lifetime utility. Under these conditions, interpolating between asset grid points can generate erroneous solutions in which agents choose to go delinquent, even though this choice is strictly dominated by staying current on mortgage payments in the analytical solution. To minimize noise from interpolation error, I impose two restrictions on the agent solution. The first restriction is as follows. Consider a set of state variables and a potential choice in which an agent (i) chooses delinquency status $d_t \in \{1, 2, 3, 4\}$ and (ii) chooses positive assets in the next period ($a_{t+1} > 0$) that are larger than the pecuniary cost of choosing a delinquency status $d'_t = d_t - 1$ (i.e. paying back one missed mortgage payments plus the late fee). I impose that this choice must be strictly dominated by d'_t. That is, if agents have sufficient cash on hand available, then they must pay back their missed mortgage payments.[49] This restriction aligns with the analytical solution. If agents have sufficient liquidity to catch up on their mortgage payments, then repayment strictly dominates continuing to incur both the disutility from delinquency ψ and additional late fees.[50] The second restriction is that for asset values greater than 1.4, I impose that agents with $d_{t-1} \in \{1, 2, 3, 4\}$ must choose $d_t = 0$. While imposing this second restriction does not change the solution conditional on the first restriction, it has the benefit of increasing computational efficiency.

[49] When agents are not debt averse (i.e. $l = 0$), I apply this restriction for $a_{t+1} > \underline{a}$ under the same reasoning.

[50] Note that one exception in the analytical solution to the model is when k and ξ are small enough such that agents would prefer to progress to foreclosure ($d_t = 5$) so as to receive liquidity in the form of four unpaid mortgage payments which go unpaid indefinitely; however, these parameter values are highly unrealistic given the substantial burden that the foreclosure process imposes in practice.